Collaborative problem-solving, collaboration formats and creativity: a field study of video game design by professionals

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COLLABORATIVE PROBLEM-SOLVING, COLLABORATION FORMATS AND CREATIVITY: a field study of video game design by professionals

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A dissertation submitted in partial fulfillment of the requirements for the degree of

PhD in Sciences de l’Homme et Humanités
Speciality Ergonomic Psychology

Commity in charge

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Paris, June 2012

Acknowledgements

I express my gratitude and sincere consideration for all persons who have helped and supported me during the completion of this work. My special thanks go to:

Françoise Détienne, research director at Télécom ParisTech who supervised my work for four years and a half. I want to thank you for giving me the chance to count amongst your PhD students. I am highly grateful for the trust and the precious time you have given me, for your guidance, support and understanding along this journey. A special thank, as you always act humanely toward me.

Christian Licoppe, professor at Télécom ParisTech who co-supervised my work. I want to thank you for giving me the opportunity to join the department, to evolve in a stimulant environment and for your trust.

Members of the jury for agreeing to evaluate this PhD thesis. I am honored. My first thanks go to Mrs Nathalie Bonnardel and Mr. Jean-Marie Burkhardt, the reporters of this dissertation. I also thank Mr. Stéphane Natkin for agreeing to review this work.

Olivier, Marc and all the other designers. I want to thank you for your warm welcome at Mekensleep, your availability and the one year and a half experience.

My family, friends and colleagues for their considerable support during this long journey and their encouragements

COLLABORATIVE PROBLEM-SOLVING, COLLABORATION FORMATS AND CREATIVITY: a field study of video game design by professionals

This Phd thesis concerns group creativity in a musical video game design. Our aim is to identify and characterize collaborative and design processes, and more specifically those involved in the generation of creative solutions. At a second level, our aim is to characterize creative solutions.

During an ethnographic study in a video game studio, collaborative meetings were video-recorded and interviews combined with a questionnaire were conducted. With these data, we adopted an original approach that crosses two focuses of creativity; the processes focus with a third-person perspective, *i.e.* our analyses as observer, and the products focus with a first-person perspective, *i.e.* perspective of designers themselves.

To analyze processes, we combined three approaches applied on corpora of video-recorded excerpts. First, a content approach aimed to highlight basic activities, and problems and solutions. Second, an interactional approach aimed to stress and characterize collaboration formats, *i.e.* recurrent adjacent pairs of collaborative design activities. Third, a longitudinal approach was conduct to underline the temporality of collaborative problem solving in meetings, more precisely the socio-cognitive design processes, *i.e.* design processes distributed amongst the designers and participants, and collaboration formats.

To consider products, solutions were evaluated by the designers themselves on the basis of two creativity dimensions, *i.e.* novelty and feasibility. Thus, the most creative solutions were distinguished from the less creative ones. In addition, justifications of the evaluation given by the designers were invested further to characterize creative solutions.

Lastly, our main research aim was reached by crossing processes and products. This crossing aimed to highlight and characterize the specific collaboration formats and design processes involved in the generation of creative solutions.

This original approach stressed three multi-functional collaboration formats: (1) the directive formats, *i.e.* specific forms of collaborative design activities serving to trigger evolution and definition of the design spaces –problems and solutions–; (2) the relational formats, *i.e.* construction of relations between a design idea under discussion with other ones –reified or not– within or outside the design project; (3) the representational formats, *i.e.* co-construction of representations of a design idea under discussion in order to develop it through multiple points of view. In a meeting temporality, we highlighted that problem framing, analogical reasoning and the directive formats were at the beginning, and the combination at the end. This highlighted a meeting temporality that starts with convergence on problem and then, divergence in the solution space is carried on.

Regarding the products, we stressed both characteristics of creative products and of creative design processes. Our results underlined several characteristics as well as design processes from the literature and two original ones, *i.e.* ‘ownership’ and ‘deepening’.

The crossing of the processes and creative products highlighted that the relational formats as well as the analogical reasoning process are involved in the generation of creative solutions.

Résolution collective de problème, formats de collaboration et créativité: une étude de terrain de la conception d'un jeu vidéo par des professionnels

Introduction

Un nombre considérable d'études ont porté sur les activités de conception, de collaboration et de créativité. Par contre, peu d'entre elles ont entrepris des recherches qui prenaient en compte l'articulation de ces trois activités. Cette direction sera celle qui est développée dans ce travail de thèse.

Dans cette lignée, un grand nombre de recherche s'appuie sur un cadre expérimental qui réduit la valeur écologique d'une part et peut impliquer des sujets non-concepteur professionnels d'autre part. De plus, dans la communauté scientifique centrée sur la créativité, peu ou pas de chercheurs se sont focalisé sur les interactions collaboratives de professionnels réels (Gero, 2010).

En considérant ces limites, nous proposons d'investir les activités de conception collaboratives qui soient créatives avec des concepteurs professionnels dans leur milieu écologique de travail pour répondre à notre question de recherche principale qui est la suivante : quelles sont les formes de collaboration et processus cognitifs de conception spécifiquement impliqués dans la génération de solutions les plus créatives ?

État de l'art

1. De la conception à la créativité

Dans ce chapitre premier chapitre de l'état de l'art, nous avons défini la notion de 'conception' comme étant la spécification d'un artefact (le produit artefact), avec des besoins qui indiquent – définis généralement de manière non explicite ni complète, une ou plusieurs fonctions à remplir, et les besoins et les objectifs à satisfaire par l'artefact, sous certaines conditions (exprimées par des contraintes) »(Visser, 2006a). Cette définition est située dans le paradigme de conception de la résolution de problèmes impliquée avec des facteurs socioculturels ainsi que des aspects cognitifs. Dans une tâche de conception, un concepteur procède à des activités de conception de (re)-formulation du problème, de génération et d'évaluation de solutions.

En ce qui concerne du cadre collectif, la conception collaborative implique que la tâche est partagée par les co-concepteurs. De plus, elle implique une symétrie des positions d'interaction entre les co-concepteurs, autrement dit, chaque co-concepteur contribue à générer et évaluer des solutions (i.e. Burkhardt et al. 2009). En plus, les co-concepteurs vont élaborer et évaluer des solutions en utilisant des modalités d'interaction complémentaires (Détienne et Visser, 2006). Dans ce contexte de collaboration, les concepteurs vont exercer des activités de conception supplémentaires aux activités de conception individuelles telles que des activités de communication, de synchronisation, de coordination, de gestion des points de vue et de résolution des conflits à travers des activités argumentatives (Visser, 2002).

Les activités de conception peuvent conduire à des résultats créatifs. La créativité est la capacité à produire des idées sous une forme observable ou de réaliser une production qui sont à la fois nouvelle et adaptée à la situation dans laquelle elle se produit (Bonnardel, 2006, 2009; Bonnardel et Zenasni, 2010; Sternberg et Lubart, 1996 cité par Sternberg et Lubart, 1999).

La créativité peut être H-créativité (créativité historique) ou P-créativité (créativité psychologique). Cette dernière peut être retrouvée dans l'innovation, dans les phases conceptuelles et en fonction du lien entre le problème et la conception. Ce type de créativité peut être étudié à travers quatre ‘focus’, à savoir (1) des personnes, (2) des lieux, (3) des produits et (4) des processus. Cependant, peu d'études ou pas ont développé en détail plus d'un ‘focus’. Ce défi sera entrepris dans cette thèse, c'est-à-dire de prendre en considération et d'examiner les processus, les produits et à un moindre degré les lieux.

2. La conception individuelle

La créativité individuelle a fait l'objet d'un nombre considérable d'études qui ont porté notamment sur les processus cognitifs de conception. En effet, la pensée divergente et convergente, la délimitation du problème et la co-évolution de problème-solution impliquées dans l'évolution du processus de conception sont largement développées dans la littérature sur la créativité. De plus, la combinaison, le raisonnement analogique et la composition impliqués dans l'évolution des solutions sont également bien représentés dans cette littérature. Jusqu’à maintenant, la majorité des études s'accordent pour dire que ces processus cognitifs de conception sont impliqués dans la génération de solutions créatives.

La plupart de ces études reposent sur un cadre expérimental. Ils utilisent des variables telles que l'utilisation de représentation/s externes/s - principalement des croquis -, le niveau d'expertise des participants et les composantes impliquées dans le processus, par exemple des sources analogiques intra- ou inter-domaine.

Tant dans la littérature sur la conception que la conception créative, les représentations externes ont plusieurs fonctions qui comprennent les conversations avec les représentations externes, la construction et la communication d'une expérience, et le stockage d’informations. De plus, ces représentations externes servent de soutien aux processus cognitifs de conception présentés dans ce chapitre. Dans cette thèse, nous allons étendre la gamme des systèmes sémiotiques pris en compte, nous allons tenir compte non seulement des esquisses, mais aussi divers autres systèmes sémiotiques, par exemple des prototypes.

D'après les études que nous avons présentées dans ce chapitre, nous avons pu souligner quelques critiques relatives aux évaluations de la créativité. Tout d'abord, le manque d’accord commun sur les dimensions utilisées pour évaluer la créativité peut mettre en péril la généralisation des résultats et les comparaisons entre les études. À cet égard, nous adopterons dans cette thèse une évaluation de la créativité en fonction des dimensions de la créativité connues et acceptées dans la littérature à savoir la nouveauté et de la faisabilité. Deuxièmement, se focaliser uniquement sur des systèmes de notation peut s'avérer inefficace pour mettre en lumière les caractéristiques des produits créatifs. Dans cette veine, nous baserons notre évaluation de la créativité sur un système de notation, soit échelle de Likert, complété par des explications et des justifications pour chaque produit évalué.

3. La conception collaborative

Dans ce troisième chapitre de l'état de l'art, nous avons développé la notion de créativité collaborative. Nous avons commencé par définir certains processus sociocognitifs de conception qui peuvent conduire un groupe à générer des résultats créatifs. Nous avons élaboré brièvement dans ce cadre la pensée divergente et convergente, la délimitation du problème, la co-évolution de problème-solution, la combinaison et le raisonnement analogique.

Dans certains contextes, plusieurs études suggèrent que la créativité en groupe (groupe réel) n'est pas nécessairement plus efficace en termes de créativité que la somme des individus qui n'interagissent pas (groupe nominaux). Ceci a conduit un nombre considérable d'études à s'intéresser aux processus de collaboration neutralisant la créativité, qui sont appelés «pertes de production». Nous avons défini différents types de pertes de production à savoir le blocage de production, l'appréhension d'évaluation, la paresse sociale et le biais de conformité.

Pour contrer ces pertes de production, une technique de conception populaire afin d'atteindre des résultats créatifs en conception collaborative est proposée: alterner le brainstorming individuel et collectif. Dans un autre volet de la recherche, certains dispositifs sociotechniques sont rapportés comme étant bénéfiques pour la créativité, comme le 'brainwriting' et le brainstorming électronique. À un niveau plus organisationnel, la composition des groupes a été également étudiée. Plusieurs études s'accordent sur les avantages d'un groupe d'une grande diversité.

La conception collaborative et la créativité peuvent impliquer des représentations externes avec les fonctions trouvées dans la conception individuelle. En complément de ces fonctions, d'autres fonctions sont orientées plus vers la communication. À cet égard, les représentations externes peuvent remplir la fonction de soutenir la communication des concepteurs les uns avec les autres, entre les concepteurs et les utilisateurs, et de faciliter et accueillir les contributions des autres concepteurs. D'autres fonctions sont liées aux représentations externes comme vecteur de coordination et de coopération.

Un nombre considérable de travaux de recherche présentés dans ce chapitre a été réalisé avec une approche expérimentale. En conséquence, la valeur écologique n'est pas conservée. De plus, dans certaines études, les sujets ne sont pas toujours les concepteurs en soi. Dans cette thèse, nous allons nous focaliser sur les interactions entre de véritables concepteurs professionnels dans leurs milieux écologiques. Cela se fera avec une approche interactionnelle.

4. Jeux vidéo

Dans ce dernier chapitre de l'état de l'art, nous avons défini les jeux vidéo avec deux concepts clés qui sont '*play*' et '*game*'. Ces deux concepts ont été définis par les sociologues et les communautés de '*game design*', respectivement.

Le modèle que nous utilisons pour décrire les principales composantes d'un jeu vidéo a ensuite été introduit. Nous avons défini le '*game design*', le '*level design*' et le '*gameplay*'. Ces trois éléments peuvent être développés grâce à des méthodes de conception prescriptives comme les méthodes de conception ‘*waterfall*’, itérative et participative qui sont utilisées entre autres dans la conception d’interaction homme-machine (IHM). Cependant, il y a une distinction entre les applications de production IHM et les jeux vidéo qui eux mettent l'accent sur l'expérience utilisateur.

Nous avons également développé ce concept de l'expérience utilisateur grâce à plusieurs notions, à savoir le divertissement, l'amusement et le plaisir, qui s'étendent sur plusieurs sphères dont l’émotion, les sensations, la cognition et les comportements.

Suite à cela, nous avons décrit quelques méthodes utilisées pour évaluer l'expérience utilisateur: guide d’utilisabilité, mesures biométriques, entretien et test ouvert avec joueur/s. Ce dernier peut être réalisé avec différents types d'utilisateurs/joueurs et peut conduire à différents niveaux de contribution des utilisateurs/joueurs. De plus, dans ces tests ouverts, les prototypes considérés comme des représentations externes permettent la communication des concepteurs entre eux ainsi qu'entre les concepteurs et les utilisateurs/joueurs.

Ce chapitre se termine par une brève description de quelques études portant sur la créativité dans le domaine des jeux vidéo. La créativité a été peu étudiée dans ce domaine. Dans cette thèse, nous avons l'intention d'étudier la créativité dans le processus de conception d'un jeu vidéo.

Contexte et cadre de recherche

1. Contexte du terrain de recherche

Notre terrain de recherche présentait un fort potentiel créatif. En effet, le studio de jeu vidéo Mekensleep a été choisi pour ses objectifs, son groupe de conception et son passé particulièrement créatif. Premièrement, Mekensleep avait pour but de concevoir un nouveau concept de jeu vidéo musical. Ce but a été porté par un groupe de conception pluri-disciplinaire travaillant dans un contexte ayant peu de contrainte financière et temporelle propice à l’étude de la créativité (Runco, 2004). De plus, Mekensleep a mené a bien un projet de jeu vidéo qui a reçu plusieurs prix dont ceux du meilleur jeu et le jeu le plus créatif pour son projet *Soul Bubbles*.

Lors d’une période d’un an d’immersion en tant qu’observatrice dans le studio de jeu vidéo, nous avons pu observer un processus de conception caractérisé par le développement de plusieurs prototypes conçus au moyen de méthodes de conception itérative et participative. Pour chaque prototype, plusieurs cycles itératifs ont été menés par les concepteurs.

Les cycles itératifs menant à de nouveaux prototypes pouvaient être de type ‘incrémental’, *i.e.* les concepteurs procèdent à un approfondissement du jeu vidéo ou de type ‘rupture conceptuelle’, *i.e.* le jeu vidéo prend une nouvelle direction non anticipée par les concepteurs. De plus, les étapes du cycle itératif (approfondissement, prototypage, test et analyse (Salen et Zimmerman, 2003)) se sont déroulées avec différents concepteurs/participants. En effet, l’approfondissement a été pris en charge par les différents concepteurs et participants externes ; le prototypage par les concepteurs codeurs ; les tests par des joueurs/‘play-testeurs’ et donc des participants externes ; l’analyse par les différents concepteurs et participants externes.

Plusieurs domaines de connaissances ont été représentés par les concepteurs et participants externes tels que le domaine des jeux vidéo, *i.e. game designer, level designer,* codeur, développeur, éditeur et différents types de joueurs, *i.e. hardcore gamers, casual gamers, hardcore gamers* de jeu vidéo musical, etc. ; le domaine de l'art, *i.e.* directeur artistique, designer graphique, artiste graphique, infographiste ; le domaine de la musique, *i.e. music designer* et musicien ; autre domaine, *i.e.* historien et relations publiques.

2. Cadre théorique et méthodologique

2.1 Approche centrée sur les processus et les produits créatifs

La littérature développée dans le domaine de la créativité s'est largement penchée sur des problématiques qui ont été développées au travers de protocoles expérimentaux, et ce beaucoup plus dans un contexte de créativité individuelle que collective. De plus, jusqu'à ce jour, peu de recherches se sont focalisées sur la collaboration entre participants en termes de créativité avec de réels concepteurs (Gero, 2010).

Ainsi, l'objectif de cette étude est de chercher à identifier les spécificités du contexte de génération de solutions et plus précisément de solutions créatives en termes de processus collaboratifs, *i.e.* les formes de collaboration et les processus sociocognitifs de conception. De plus, notre étude cherche à identifier les spécificités des solutions créatives dans un deuxième temps.

Les objectifs recherche sont abordées par une approche originale consistant à croiser les points de vue du chercheur et des concepteurs eux-mêmes d'une part et d'autre part, en prenant en compte différents 'focus' de la créativité tels que les processus, les produits et à un moindre niveau les lieux (*i.e.* environnement sociotechnique).

2.2 Questions de recherche

Plusieurs questions de recherche ont été abordées sous différents points de vue. D'une part, les processus ont été approchés par une perspective troisième-personne, *i.e.* la perspective du chercheur. D'autre part, les produits ont été pris en compte avec une perspective première-personne, *i.e.* la perspective des concepteurs eux-mêmes.

Premièrement, les questions de recherche se rapportant aux **processus** ont pour but d'identifier et de comprendre :

- Les formes de collaboration, *i.e.* les formats de collaboration en tant que paires adjacentes récurrentes d'activités de conception collaboratives retrouvées autour de génération de solutions et/ou problème pouvant apparaitre avant, pendant et suivant la génération ;

- Les processus sociocognitifs de conception, *i.e.* processus cognitifs de conception distribués parmi plusieurs concepteurs/participants ;

- L’influence de l’environnement sociotechnique sur les formats de collaboration et processus sociocognitifs de conception.

Deux questions de recherche ont par conséquent émergé :

- Quels sont les formats de collaboration et les processus sociocognitifs de conception dans une conception collaborative et comment sont-ils caractérisés ? ;

- Quelle est l’influence du contexte sociotechnique sur les formats de collaboration et les processus sociocognitifs de conception ?

Deuxièmement, les questions de recherche se rapportant aux **produits** ont pour but d’identifier et de comprendre :

- Les solutions jugées créatives par les concepteurs eux-mêmes ;

- Les caractéristiques utilisées pour décrire les solutions jugées créatives.

Par conséquent, une question de recherche a été traitée :

- Quelles sont les caractéristiques des solutions jugées créatives ?

Troisièmement, les recherches concernant le **croisement processus et produits** ont pour objectif de répondre à notre questionnement principal qui porte sur :

- Quels sont les formats de collaboration et processus sociocognitifs de conception spécifiques à la génération de solutions créatives en comparaison avec la génération de solutions moins créatives ?

2.3 Une approche originale croisant ‘processus’ et ‘produits’

La problématique est approchée par une étude ethnographique avec une immersion dans les locaux d’un studio de jeu vidéo parisien qui a eu lieu entre février 2009 à mars 2010. Cette immersion a eu pour but de suivre le processus de conception du projet de jeu vidéo musical appelé « Hanabi ».

2.3.1 Procédure : immersion dans le studio de jeu vidéo Mekensleep

Une étude ethnographique a été conduite par une immersion en tant qu’observateur dans le studio de jeu vidéo Mekensleep. Une première immersion, de février à Mai 2009, a eu pour but de gagner en connaissance sur ce qu’implique la conception de jeu vidéo et de s’adapter au studio de jeu vidéo. Ensuite, une immersion en tant qu’observateur, de Mai 2009 à Mars 2010, avait pour but de suivre la conception d’un jeu vidéo musical comportant un nouveau concept. Durant cette dernière période, plusieurs moyens de collecter des enregistrements vidéo de réunions collaboratives ont été utilisés tels que le système de webcam d'un ordinateur (5 mai au 24 juin 2009), un multiplexeur avec quatre entrées audio-vidéo (25 juin au 20 juillet 2009) et le système de webcam d'un ordinateur complété par une caméra vidéo (21 juillet 2009 au 22 mars 2010). Nous avons utilisé seulement les données provenant du système de webcam d'un ordinateur complété ou non par une vidéo caméra étant donné l'incapacité rencontré de sortir les données du multiplexeur. Durant notre immersion, les concepteurs ont été disponibles pour répondre à toutes nos questions.

Neuf mois après notre immersion, nous avons conduit des entretiens individuels semi-structurés complétés par un questionnaire avec deux concepteurs présents tout au long du processus de conception. D'une part, l'entretien semi-structuré avait pour but d'appréhender la représentation du processus de conception global des concepteurs. D'autre part, le questionnaire était composé des problèmes et solutions soulevés dans les extraits vidéo sélectionnés. Les concepteurs devaient évaluer à l'aide d'une échelle de Likert des solutions sur la base de deux dimensions de la créativité, *i.e.* la nouveauté et la faisabilité, et de justifier leur évaluation. Ceci pouvait répondre à nos objectifs de distinguer les solutions les plus créatives des moins créatives ainsi que de saisir comment les concepteurs caractérisaient les solutions jugées créatives à partir des justifications.

Pendant les entretiens conduits dans le même ordre avec les deux concepteurs, ceux-ci avaient la possibilité de demander des clarifications. De plus, les concepteurs pouvaient valider et rectifier si besoin, les problèmes et solutions que nous leur ont présentés.

2.3.2 Collection de données : observation et entretiens

Durant l'immersion, nous avons collecté des enregistrements vidéo de réunions collaboratives. De plus, tout au long du processus de conception, des entretiens informelles, des données IM sur différents canaux, des dessins, un wiki, des 'to-do lists' ont été collectés. Finalement comme nous venons de le mentionner, à la fin du processus de conception un entretien semi-directif complété par un questionnaire ont été conduits avec deux concepteurs.

2.3.3 Sélection des données pour les analyses : corpora d'extraits et de réunions

Avec l'ensemble des enregistrements vidéo, nous avons composé deux corpora. Un premier corpus est celui d'extraits qui a pour but de représenter une diversité d'extraits et un deuxième corpus, celui de réunions, a été composé en vue de procéder à une analyse longitudinale (voir section suivante 2.3.4) et se compose de réunions conceptuelles collaboratives seulement.

Pour le **corpus d'extraits**, les enregistrements vidéo ont été sélectionnés à partir des critères suivants : (1) les concepteurs/participants génèrent une ou des solutions pour le problème de conception, (2) la présence de différentes affiliations des concepteurs/participants, (3) l'utilisation de différentes représentations externes et (4) différents moments dans le processus de conception, *i.e.* phases conceptuelles ou non et différentes étapes du cycle itératif. Avec ces critères, nous avons sélectionné dix-huit extraits.

Pour le **corpus de réunions**, les extraits proviennent de réunions conceptuelles, *i.e.* suivant un ‘shift conceptuel’ où les concepteurs doivent comprendre un nouveau problème et définir les nouvelles caractéristiques générales du produit à concevoir. Nous avons identifié deux réunions conceptuelles. A partir de ces réunions, nous avons composé notre corpus de réunions avec les critères de sélection suivants : (1) les concepteurs/participants génèrent une ou des solutions pour le problème de conception, (2) l’utilisation de différentes représentations externes et (3) différents moments dans chaque réunion. Ces critères ont permis de sélectionner douze extraits.

Ces corpora ont été transcrits et enrichis par l’ajout d’informations en lien avec les gestes et l’utilisation de représentations externes.

2.3.4 Analyses

Plusieurs points de vue ont été utilisés pour les analyses de nos corpora. En effet, nous avons mentionné que le ‘focus’ processus a été traité avec un point de vue troisième personne et les produits, avec un point de vue première personne. Dans cette section, nous allons préciser les analyses conduites pour chaque ‘focus’ et leur point de vue.

Pour le **‘focus’ processus**, trois analyses ont été conduites. Une analyse primaire de contenu a été conduite sur la base des études de Baker, Détienne, Lund et Séjourné (2009) et Détienne, Boujut et Hohmann (2004) en ingénierie et architecture respectivement qui intègrent un codage avec l’identification des (1) activités de conception, i.e. liées au contenu et l’interaction, et les problèmes/solutions générées, (2) les locuteurs/énonciateurs, i.e. la personne qui parle et la personne dont la voix est rapportée par un locuteur respectivement, et (3) les perspectives défendues par les interactants. Cette analyse primaire est à la base des analyses suivantes et alimente les analyses du ‘focus’ produit.

Une analyse secondaire interactionnelle a été menée. Cette analyse a consisté en l’identification de séquences interactionnelles en termes de paires adjacentes récurrentes d’activités de conception par au moins deux concepteurs/participants lors de génération solutions, mais aussi de problème. Afin d’identifier ces séquences interactionnelles, nous nous sommes focalisé sur la génération de solution et plus précisément ce qui se produit en termes de séquences récurrentes avant, pendant et après la génération de solutions.

Finalement, une analyse tertiaire longitudinale a été exécutée afin d’identifier et de décrire les processus sociocognitifs de conception ainsi que les formes de collaboration mis en place dans la temporalité de deux réunions conceptuelles. Pour ce faire, nous avons opérationnaliser plusieurs processus sociocognitifs de conception tels que la délimitation du problème, la co-évolution problème-solution, la combinaison, le raisonnement analogique et la composition afin de les identifier dans les deux réunions. Ensuite, nous avons regardé autour des générations de problème/solution si ces processus sociocognitifs de conception opérationnalisés et les formes de collaboration s’y trouvaient.

Pour le **‘focus’ produit**, des entretiens individuels semi-directifs ont été conduits avec deux concepteurs dans le but de collecter des informations générales sur le processus de conception du jeu vidéo musical. De plus, un questionnaire venait complémenter l’entretien afin d’identifier les solutions que les concepteurs jugeaient créatives à partir de deux dimensions de la créativité, *i.e.* la nouveauté et la faisabilité. Ces deux dimensions ont été évaluées sur une échelle de Likert et une justification de l’évaluation était demandée aux concepteurs. Cette procédure est soutenue par le fait que demander comment les solutions sont nouvelles et de quelle manière permet de souligner les subtilités de celles-ci (Boden, 2004). Les résultats quantitatifs de l’évaluation sur la base de l’échelle de Likert a fait l’objet d’analyses quantitatives. En complément, une analyse thématique a été conduite afin d’identifier comment les concepteurs caractérisent les solutions créatives. Cette analyse a pris en compte les verbatim des concepteurs dans l’entretien et leur justification des évaluations sur les échelles de Likert.

Pour le **croisement processus et produits**, les résultats des ‘focus’ processus et produits ont été croisés grâce à des analyses quantitatives utilisant les taux de liaison. Ceci nous a permis de mettre en lumière les processus spécifiques impliqués dans la génération de solutions créatives. Les taux de liaison caractérisent la force d’association entre variables. Ici, les variables étaient les formes de collaboration, les processus sociocognitifs de conception et les degrés de créativité.

Résultats

1. Formes de collaboration: analyse interactionnelle

Ce chapitre ouvre le point de vue troisième personne, i.e. le point de vue de l’analyste, dans lequel nous allons développer l’approche interactionnelle. Notre objectif est d’identifier et de caractériser les formes de collaboration qui émergent des interactions de conception entre les concepteurs et participants.

1.1 Le concept de ‘formats de collaboration’

Nous avons mis en lumière le concept de ‘formats de collaboration’. Ce concept est définit comme des paires adjacentes récurrentes multifonctionnelles d’activités de conception entreprises par au moins deux concepteurs (présent ou absent) principalement initiées par la génération de solution dans les échanges verbales mais aussi utilisant d’autres modalités d’interaction, e.g. gestuelle, graphique, etc.

1.2 Trois formats de collaboration : directif, relationnel et représentationnel

Nous avons identifié et caractérisé trois types de formats de collaboration : directifs, relationnels et représentationnels. Les trois formats de collaboration peuvent être définit comme il est résumé dans le tableau suivant (tableau 1).

Types de format	*Description*
Directifs	Formes spécifiques d'activités collaboratives de conception servant à déclencher l'évolution et la définition des espaces de conception, i.e. problème et solution.
Relationnels	La construction de relations entre une idée de conception en discussion avec une autre idée, réifiée ou non, provenant de l'intérieur ou l'extérieur du projet.
Représentationnels	Co-construction de représentations d'une idée de conception en discussion afin de développer plusieurs points de vue autour de cette idée.

Tableau 1.Les trois formats de collaboration

Ces formats de collaboration se retrouvent en différentes proportions dans notre corpus. En effet, nous avons retrouvé soixante-cinq occurrences dans dix-sept extraits pour les formats représentationnel, vingt-six dans seize extraits pour les formats relationnel et dix-neuf dans douze extraits pour les formats directifs (tableau 2). Nous pouvons souligner que les formats représentationnels sont les plus nombreux.

Formats	*Nombre d'extraits*	*Total occurrences*
Directifs	12	19 (17%)
Relationnels	16	26 (24%)
Représentationnels	17	65 (59%)

Tableau 2. Occurrences des formats de collaboration

Nous allons maintenant introduire et décrire chaque types de formats de collaboration.

1.2.1 Formats directifs

Les formats directifs peuvent être définit par l'exécution d'une forme d'activité de conception spécifique telle que la génération de solution, i.e. solution générée dans une forme particulière, ou l'allocation d'une tâche par un concepteur *x*. Ensuite, cette forme d'activité de conception déclenche ou suscite chez un concepteur *y* la délimitation du problème, la génération de solution alternative ou la cristallisation d'un accord. Trois formes de formats directifs ont été identifiés : (1) déclencher la délimitation du problème, (2) susciter la génération de solution alternative et (3) déclencher la cristallisation d'un accord (tableau 3).

Formats directifs	*Description*
Déclencher la délimitation du problème	Génération spécifique de solutions, i.e. énumération d'un flux de solutions potentiels par un concepteur *x*. Ceci peut suggérer au concepteur *y* de délimiter le problème traité.
Susciter la génération de solution alternative	Génération spécifique de solutions, i.e. solutions avec marques de délai, par un concepteur *x*. Ceci peut encourager un autre concepteur *y* à contribuer en générant une solution alternative.
Déclencher la cristallisation d'un accord	Allocation de tâche par un concepteur *x*. Cette tâche allouée - implémentation d'une solution- transmet un accord commun implicite autour d'une solution. Ceci peut déclencher un concepteur *y* à cristalliser un accord sur la solution lorsque celui-ci accepte la tâche allouée.

Tableau 3. Formats directifs

1.2.2 Formats relationnels

Nous avons définit les formats relationnels comme suit : la génération d'une idée de conception par un concepteur *x* est mise en relation par un concepteur *y* avec une autre idée de conception réifiée ou non provenant ou pas du projet de conception. Par conséquent, les formats relationnels consistent en la mise en relation d'une idée de conception en discussion et une autre existante ou discutée antérieurement. Les formats relationnels comprennent (1) relations à une solution réifiée et (2) relations à une solution discutée antérieurement (tableau 4).

Formats relationnels	*Description*
Relations à une solution réifiée	Un concepteur *x* et *y* construisent des relations entre une solution de conception en discussion et une idée réifiée provenant du même domaine ou d'un autre.
Relations à une solution discutée antérieurement	Un concepteur *x* construit des relations entre une idée de conception en discussion et une idée de conception évoquée antérieurement dans le projet de conception par un concepteur *y*.

Tableau 4. Formats relationnels

1.2.3 Formats représentationnels

Les formats représentationnels sont définit par un concepteur *x* représentant une idée de conception en discussion et un concepteur *y* élaborant plus loin la représentation avec un point de vue complémentaire. Donc, les formats représentationnels se réfèrent à une co-construction de représentations. Ils subsument (1) l'alternance des perspectives joueur et concepteur et (2) l'utilisation de modalités d'interaction complémentaires (tableau 5).

Formats représentationnels	*Description*
Alternance des perspectives joueur et concepteur	Les concepteurs *x* et *y* co-construisent séquentiellement les représentations d'une idée de conception au travers l'alternance de perspectives - joueur et concepteur - .
Utilisation de modalités d'interaction complémentaires	Les concepteurs *x* et *y* co-construisent séquentiellement ou de manière synchrone les représentations d'une solution de conception au travers de multiple modalités d'interaction complémentaires.

Tableau 5. Formats représentationnels

1.3 Contextes sociotechniques influençant les formats de collaboration

Les formats de collaboration peuvent émerger dans différents contextes sociotechniques impliquant différents rôles institutionnels, i.e. responsabilité dans le processus de conception, et niveaux d'expertise, et différentes représentations externes. Nous avons observé que certains formats de collaboration provenant des trois types de formats étaient influencés par des contextes sociotechniques particuliers. En effet, les formats directifs avec des fonctions liées à la convergence semblent influencés par le rôle institutionnel de chef de projet et les formats relationnels par le rôle de facilitateur. Différemment, un des formats représentationnels est influencé par les représentations externes utilisées par les concepteurs et participants.

1.4 Conclusion

Nous avons identifié et caractérisé trois types de formats de collaboration et les influences des contextes sociotechniques sur ceux-ci. Nous avons pu souligner également quelques fonctions propres à chacun des types de formats de collaboration.

Nous avons mis en lumière des fonctions liées à la divergence et convergence pour les formats directifs. En effet, le format 'susciter la génération de solution alternative' implique une fonction qui encourage et invite les co-concepteurs à contribuer sous formes de solutions alternatives. Par conséquent, ce format directif aide à augmenter l'ensemble des solutions dans le projet de conception. Différemment, les deux autres formats directifs, 'déclencher la délimitation du problème' et 'déclencher la cristallisation d'un accord', soutiennent quant à eux des fonctions liées à la convergence.

Pour ce qui en est des formats relationnels, nous les avons décrits majoritairement comme des sources d'inspiration et/ou d'évaluation. Ceci renvoie au fait que la conception peut être construite sur ce qui a été fait auparavant (Visser, 2002) dans le même domaine ou d'autres pour ce qui en est des solutions réifiées, mais aussi sur ce qui a été dit auparavant dans le projet de conception renvoyant au contexte polyphonique (Baker et al., 2009). Par conséquent, les formats relationnels ont été de manière générale décrits comme ouvrant l'espace de recherche.

Finalement pour les formats représentationnels, nous avons souligné que diverses perspectives pouvaient être prises par les concepteurs et que celles-ci pouvaient enrichir le processus de conception. Cette enrichissement peut provenir des différentes perspectives associées à l'objet conçu qui renvoie aux joueurs mais également aux concepteurs ainsi qu'aux différentes modalités d'interaction qui procurent différents canaux de communication. Ainsi les concepteurs peuvent prendre différentes perspectives et modalités d'interaction et donc co-construire des représentations complémentaires.

2. Résolution collective de problème : analyse longitudinale

Ce deuxième chapitre dédié au point de vue troisième personne a pour objectif d'identifier et de décrire la temporalité de la résolution collective de problème. Pour cela, nous avons procédé à une analyse longitudinale. Cette approche a été appliquée à deux réunions conceptuelles traitées distinctivement. Par ailleurs, nous avons aussi comme objectif de souligner la temporalité des formats de collaboration.

Nos résultats ont mis en lumière plusieurs processus cognitifs de conception observés durant les réunions conceptuelles, i.e. délimitation du problème, co-évolution problème-solution, raisonnement analogique, combinaison et composition. Ces processus cognitifs de conception étaient distribués parmi les concepteurs et participants. Ceci souligne que les processus sociocognitifs sont construits dans et par la temporalité de l'interaction. De plus, les trois types de formats de collaboration ont été retrouvé dans ces deux réunions conceptuelles.

2.1 Réunion conceptuelle avec les mêmes concepteurs

Nos résultats ont également mis en lumière une temporalité spécifique des processus sociocognitifs de conception et des formats de collaboration (figures 1 et 2). Pour la première réunion conceptuelle (M7, i.e. réunion 7), nos résultats mettent en lumière que la délimitation du problème et le raisonnement analogique sont retrouvés au début de la réunion et le processus de combinaison, à la fin de la réunion. Ceci souligne une différence par rapport à la technique du brainstorming ; la réunion a débuté avec un mouvement de convergence dans l'espace problème ce qui est différent du brainstorming qui débute avec un mouvement de divergence dans l'espace solution. De plus, nos résultats soulignent que la co-évolution problème-solution est retrouvée tout au long de la réunion.

Pour ce qui en est des formats de collaboration, les formats directifs et relationnels ont été retrouvés en début de réunion (figures 1 et 2). Ceci pourrait être mis en relation avec les processus sociocognitifs de délimitation du problème et le raisonnement analogique respectivement qui ont été également retrouvés en début de réunion. Finalement, nous avons trouvé les formats représentationnels tout au long de la réunion. Ce résultat conforte la définition de la conception comme une construction de représentations (Visser, 2006a; Visser, 2006b).

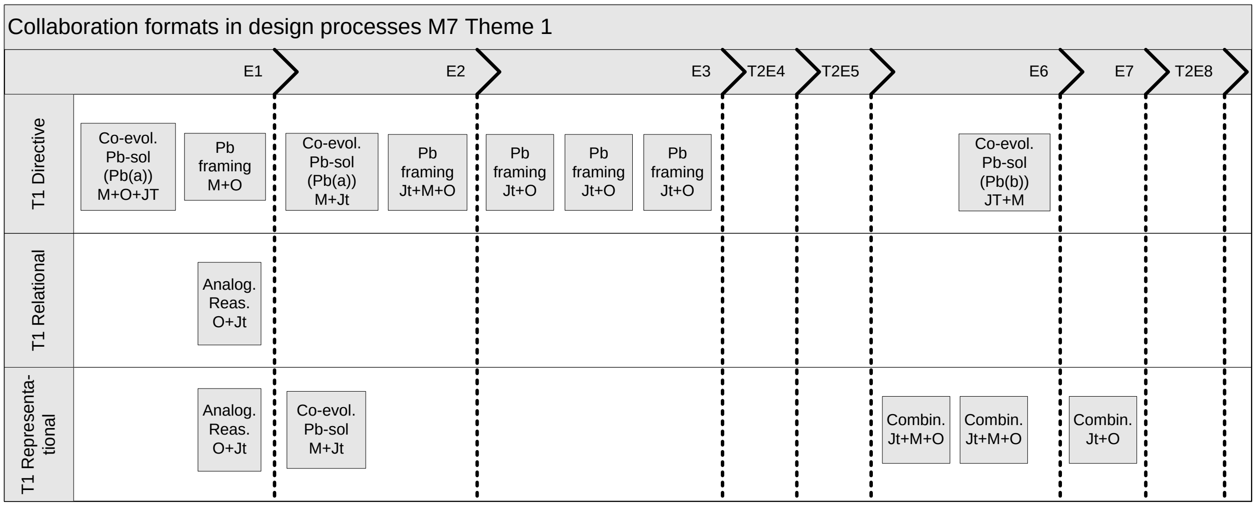

Figure 1. Formats de collaboration dans le M7 pour le thème 1

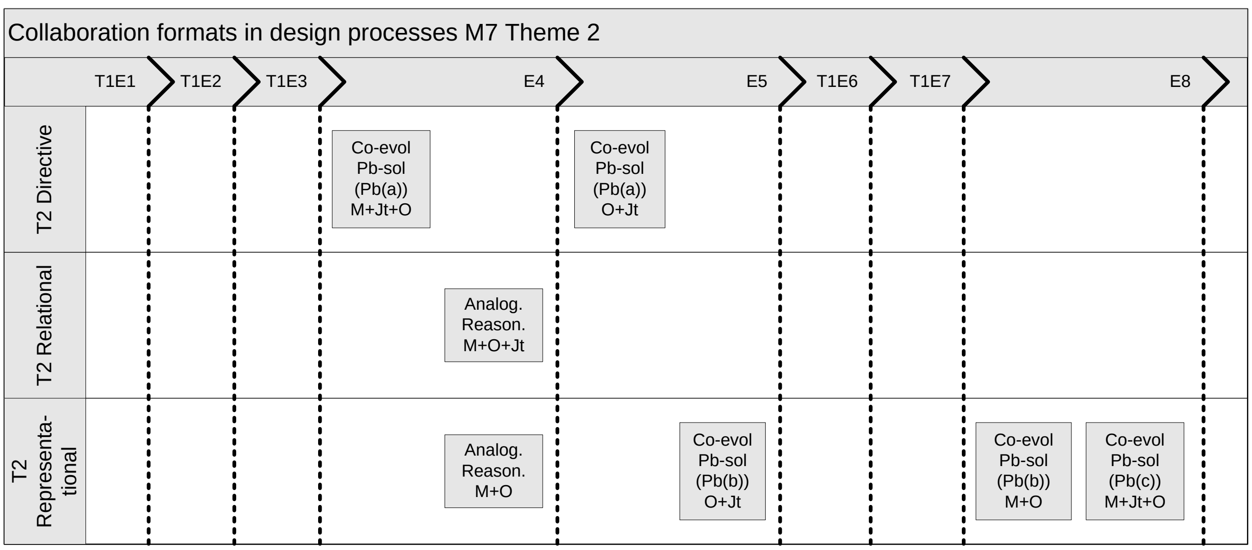

Figure 2. Formats de collaboration dans le M7 pour le thème 2

2.2 Séquence de réunions conceptuelles avec plusieurs concepteurs et participants

Une temporalité spécifique à la deuxième réunion a été mise en exergue (M8, i.e. séquence de réunions 8). En effet, tout au long de la serie de sous-réunions dans la deuxième réunion, nous avons retrouvé le format relationnel ‘relation à une solution discutée antérieurement’ avec les discours rapportés (figure 3). Ce résultat est consistent avec le fait que les concepteurs construisent sur les idées générées par les autres concepteurs (Maiden et al., 2004; Matthews, 2009; Nijstad et al., 2003; Paulus and Nijstad, 2003) durant des processus de conception.

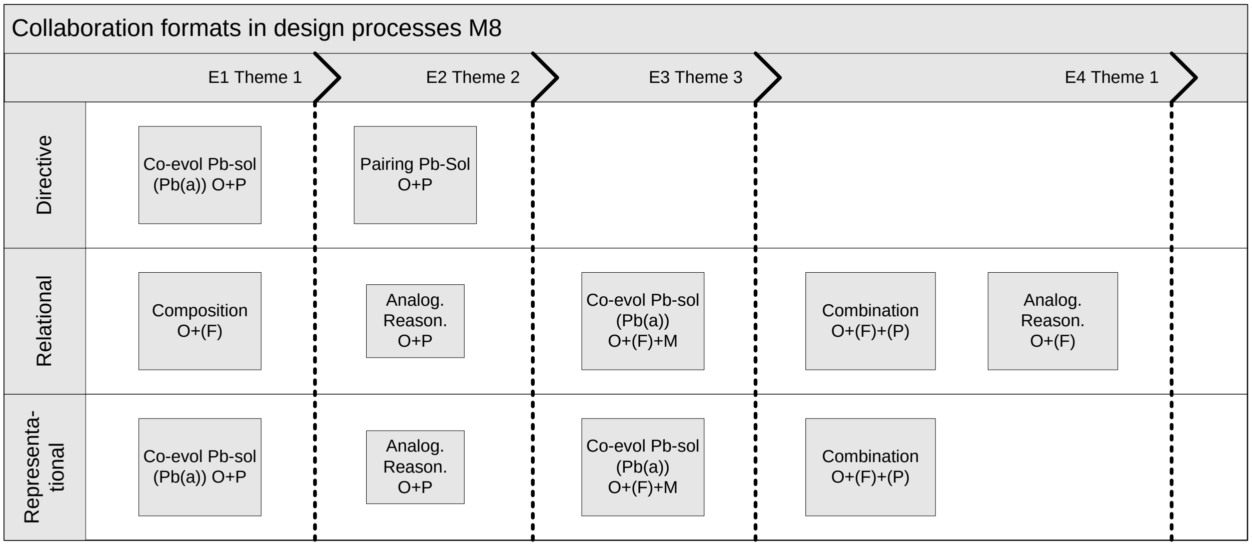

Figure 31. Formats de collaboration formats pour la séquence de réunions M8

2.3 Conclusion

Nos résultats ont souligné que tous les concepteurs et participants ont contribué à plusieurs étapes des processus sociocognitifs de conception. Par contre, certaines étapes clés ont été gérées par un seul concepteur, i.e. le chef de projet O. En effet, pour la délimitation du problème, nous avons observé seulement le concepteur O qui délimitait les problèmes. De plus, nous avons observé seulement le concepteur O qui rapportait des problèmes, solutions ou des expériences joueurs comme il est le responsable des ‘play-tests’. Ces résultats peuvent être expliqués par l’influence des rôles institutionnels et expertise soulignée dans les formats directifs et relationnels (chapitre Formes de collaboration : analyse interactionnelle) ; la délimitation des problèmes et les idées rapportées sont impliqués dans les formats directifs et relationnels respectivement.

3. Solutions créatives et leurs caractéristiques : analyses quantitative et thématique

Ce chapitre investie le point de vue première personne, i.e. le point de vue des concepteurs eux-mêmes sur le degré de créativité des solutions. Notre objectif dans ce chapitre consiste en l’identification et la caractérisation des solutions créatives.

D’un côté, pour l’identification, deux concepteurs présents tout au long du processus de conception ont complété un questionnaire qui avait pour but d’évaluer la créativité des solutions sur les dimensions de la créativité telles que la ‘nouveauté’ et la ‘faisabilité’ à l’aide d’échelles de Likert. Avec les scores des échelles de Likert, nous avons identifié au travers d’analyse quantitative le degré de créativité des solutions. De plus, les concepteurs ont jugé la créativité des solutions de manière ‘libre’, i.e. ils ont sélectionné librement les solutions qu’ils jugeaient les plus créatives.

D’un autre côté, pour caractériser les solutions créatives, nous avons procédé à une analyse thématique sur les verbatim (justifications des évaluations sur les échelles de Likert) des concepteurs pour les solutions créatives. Les verbatim des concepteurs ont été collectés durant un entretien semi-directif et un questionnaire.

3.1 Caractéristiques et processus cognitifs de conception des solutions créatives

Pour caractériser les solutions créatives, les deux concepteurs ont utilisé des caractéristiques de produits. Pour les caractéristiques de produits, plusieurs caractéristiques retrouvées dans la littérature ont été mentionnées par les concepteurs telles que ‘nouveauté’, ‘approprié’ et ‘surprise’. Une caractéristique originale a cependant émergé des verbatim qui est l’ « ownership ». Les caractéristiques des solutions créatives sont résumées dans le tableau suivant (tableau 6).

Caractéristiques	*Définitions*
Nouveauté	Idée de conception qui n’existe pas encore
Approprié	Une solution qui résout de manière pertinente le problème avec lequel elle est associée
Surprise	Un sentiment inattendu lors qu’il y a considération d’un produit/idée
« Ownership »	Une relation entre le/les concepteur/s et une idée de conception qui, cette relation, est vue comme une relation d’auteur

Tableau 6. Caractéristiques des solutions jugées créatives

3.2 Processus cognitifs de conception des solutions créatives

Pour les processus cognitifs de conception, nous avons relevé dans les verbatim des concepteurs plusieurs qui sont avancés dans la littérature tels que combinaison, addition et composition. Par ailleurs, un nouveau processus cognitif de conception a été souligné dans les verbatim des concepteurs qui est le « deepening ». Les processus cognitifs de conception utilisés par les concepteurs pour justifier leur évaluation des solutions qu’ils jugeaient créatives sont résumés dans le tableau suivant (tableau 7).

Processus cognitifs de conception	*Définitions*
Combinaison	Associer deux ou plusieurs idées ensemble pour former une nouvelle entité.
Addition	Ajouter un nouvel élément dans le processus de conception
Composition	Changer la localisation d’une idée de conception
« Deepening »	L’acte de prendre une idée existante avec la caractéristique spécifique de le pousser à un degré d’élaboration plus loin de ce qui a été fait.

Tableau 7. Processus cognitifs de conception des solutions jugées créatives

3.3 Conclusion

Nos résultats ont souligné plusieurs caractéristiques utilisées dans la littérature en tant que dimensions de la créativité telles que nouveauté, approprié et surprise. De plus, nos résultats ont également mis en lumière des processus cognitifs de conception pour décrire les solutions créatives, processus cognitifs de conception qui sont acceptés dans la littérature sur la créativité. Finalement, nous avons mis en exergue une caractéristique et un processus cognitif de conception originaux qui contribuent à l'enrichissement des dimensions/processus cognitifs de conception spécifiques aux solutions/produits créatifs

4. Croisement des formats de collaboration et processus cognitifs de conception avec les solutions créatives : analyse quantitative

Ce chapitre apporte une conclusion sur le croisement des deux points de vues, à savoir les processus et les produits. L'objectif poursuivi dans ce chapitre réside dans l'identification des formats de collaboration et les processus cognitifs de conception spécifiques à différents degrés de créativité. Pour atteindre cet objectif, nous avons croisé les résultats de points de vue à la troisième et à la première personne, c'est-à-dire les formats de collaboration et les processus de conception avec les solutions jugées à divers degrés de créativité par deux concepteurs.

4.1 Formats de collaboration et créativité

Nous avons constaté que le degré élevé de créativité tend à impliquer les formats de collaboration relationnels. Par ailleurs, nos résultats ont souligné que le degré élevé de créativité implique des relations à des idées de conception antérieures. Dans ce format relationnel, le degré élevé de créativité tend à être lié à des idées de conception antérieures qui ont été générés par les joueurs. De plus, lorsque les concepteurs rapportent les idées de d'autres participants, les concepteurs complètent dans certains cas l'idée rapportée avec le *personna* de l'énonciateur. Ces informations complémentaires tendent également à être associées avec un haut degré de créativité.

Le deuxième format relationnel, relations aux solutions réifiées, tend aussi à être associé avec un haut degré de créativité. Il englobe à la fois des solutions intra- et inter-domaine. Nous avons observé que des solutions réifiées intra-domaine ont tendance à être associées à un degré élevé de créativité.

4.2 Processus cognitifs de conception et créativité

En termes de processus de conception, nos résultats ont souligné une tendance pour le raisonnement analogique d'être impliqué dans un haut degré de créativité. Tout comme le format avec des relations à des solutions réifiées, nous avons constaté que les sources intra-domaine sont associées à un haut degré de créativité dans le processus de raisonnement analogique. Finalement, nous avons souligné que le processus de raisonnement analogique a tendance à être en association avec les formats relationnels.

4.3 Conclusion

A partir de nos résultats, nous avons pu répondre à notre question de recherche principale, quels sont les formats spécifiques de collaboration et les processus impliqués dans un degré élevé de créativité par rapport à des degrés moins élevés? Nos résultats soulignent à la fois un format collaboration, à savoir le relationnel, et un processus de conception, c'est à dire le raisonnement analogique, qui ont tendance à être spécifiques à un haut degré de créativité.

Nos résultats mettent l’accent sur l'importance du rôle de facilitateur, i.e. mettre en relation l'espace des utilisateurs avec l'espace de l'équipe de conception, au travers de l’association entre le format relations d’idées de conception antérieures et un degré élevé de créativité. Ils ont également souligné l'importance de rapporter les diverses idées générées par différents participants d'un groupe étendue de conception pour la génération de solutions créatives et plus précisément, celles générées par des joueurs. Dans le processus de conception, les membres du groupe étendu associés avec leur personna respectif semblent jouer un rôle important dans un degré élevé de créativité, ce qui peut être mis en relation avec l’importance de la diversité d’un groupe pour la créativité (Milliken, Barel et Kurstzberg, 2003 ; Nijstad, Diehl et Stroebe, 2003).

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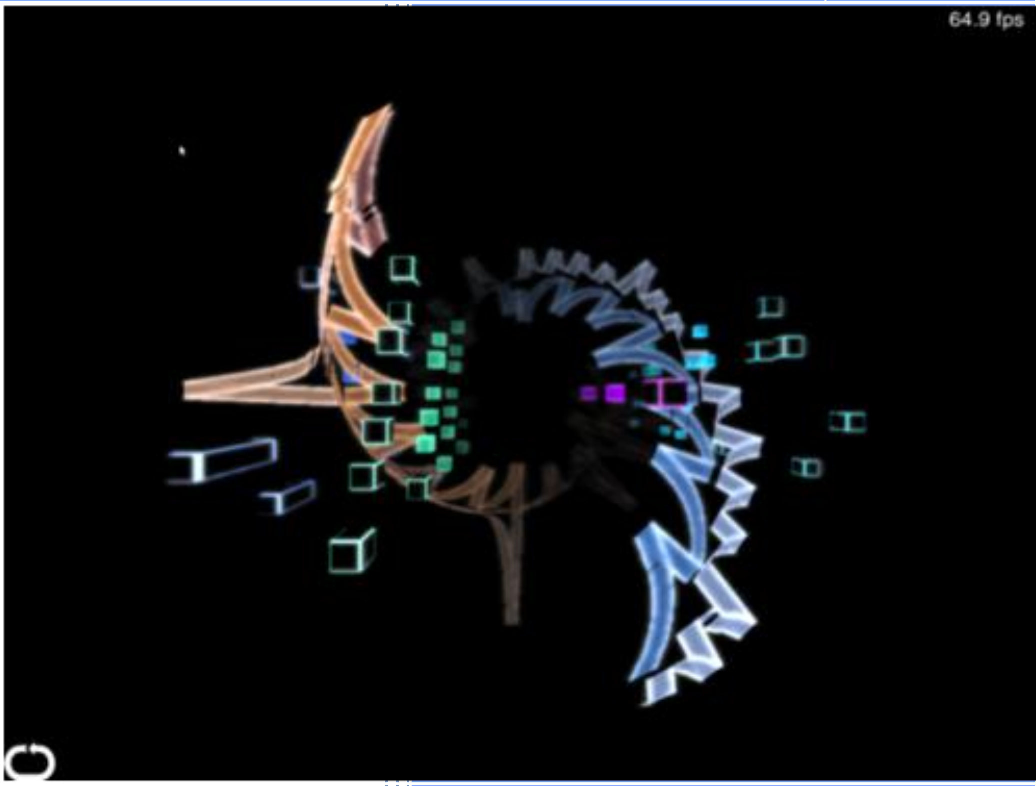
INTRODUCTION



1. Studying collaboration in group creativity

The last few years have seen a revival of interest in creative processes in the quest for profound innovations and novel entrepreneurial activities (EU Commission quoted in Wiltschnig et al., 2011) in a context where social capital, *i.e.* the composition and richness of participants, of group, organization or community has gained interests as well. Thus, it is relevant to look at how groups collaborate and more specifically collaborate in specific ways to promote and foster creativity.

Creativity has been studied extensively for several decades. Recently, a number of studies have shown that groups do not bring necessarily better outcomes in terms of creativity than the sum of non-interacting individuals. The inherent complexity of collaborative and design processes requires bringing to light how designers interact within socio-technical contexts and progress toward the object-to-be-designed and how collective design might be related to creativity.

In the creativity literature, we observed that a major focus has been on whether individual creativity is better than group creativity. This has led to a rich body of studies analyzing the consequences of collaboration on creativity. These studies are related to collaborative mechanisms that are detrimental to creativity in groups. A considerable number of research studies also aim to propose and assess socio-technical contexts that could alleviate the detrimental collaborative mechanisms and foster creativity in groups. However, the creativity community has not yet shed light on collaborative interactions of real professional designers (Gero, 2010). It would be safe to say that studies on interactions between professional designers in their ecological setting are even scarcer.

Another mainly regarded topic is cognitive design processes that have been largely investigated in experimental studies of individual creativity with few semiotic systems, *i.e.* mostly sketch, and in collaborative design. However, settings and variety of studies in individual creativity are more numerous than studies in group creativity on this topic.

Considering these limits in the state of the art, our focus is oriented toward professional designers collaborating in their ecological settings, and more specifically collaborating during the generation of the most creative solutions. With this focus, we seek to identify whether or not specific forms of collaboration and design processes are involved in the generation of the most creative solutions compared to the generation of the less creative ones. At a second level, we aim to characterize creative solutions.

The scientific stake is not to answer the question whether individual design is better than group design in terms of creativity, but to bring new light on how designers in their ecological settings collaborate and engage in design processes to generate the most creative solutions.

By taking this direction, we will aim to answer our main research question: ‘what are the specific collaboration formats, *i.e.* recurrent adjacent pairs of collaborative design activities, and socio-cognitive design processes, *i.e*. design processes distributed amongst the designers and participants, involved in the generation of the most creative solutions compared to the generation of less creative ones and how are they characterized?’ To reach this main aim, we will first invest the research question related to processes ‘what are the collaboration formats and socio-cognitive design processes in a collaborative design and how are they characterized?’ These collaboration and design processes will be further analyzed in order to bring light on ‘how different socio-technical contexts impact the way designers and participants collaborate and thus, the collaboration formats?’ Second, we will invest the research question related to products ‘which solutions are judged as creative by the designers themselves and how are they characterized?’

2. An original methodology that combines approaches on two focuses of creativity: processes and products

In order to answer our research questions, we will adopt an original methodology to study group creativity. The originality lies in the fact that we will consider creativity with focuses on processes as well as on products. In that vein, we will develop a third-person viewpoint, *i.e.* our analyses as analyst-observer, to shed light on the collaborative and design processes. In addition, we will introduce a first-person viewpoint, *i.e.* the designers’ viewpoint, to evaluate creativity of the solutions and thus, products will be taken into account. We will develop our methodology in three phases, *i.e*. analyses of processes, of products and the crossing of processes and products.

First, we will take into consideration processes with a third-person viewpoint. To analyze processes, we will adopt three analyses. We will proceed to a primary analysis with a content approach. This analysis will highlight basic activities and problems and solutions. Then, a secondary analysis will be conducted with sequence and interactional approaches. This will allow us to identify and characterize collaboration formats. After, we will conduct a tertiary analysis with a longitudinal approach to stress the temporality of collaborative problem solving and collaboration formats in meetings.

Second, we will consider products with a first-person viewpoint. This focus will be analyzed with the solutions identified in the third-person viewpoint, *i.e.* the primary level of analysis. For this focus, solutions will be evaluated by the designers on the basis of two creativity dimensions that are novelty and feasibility. Thus, the most creative solutions will be distinguished from the less creative ones. In addition, justifications of the evaluation given by the designers will be invested further to characterize creative solutions. This analysis of products also provided a means to confront our primary level of analysis, *i.e.* solutions identified in the content analysis, with the designers themselves.

Lastly, we will cross the processes and products and thus, the third-person and the first-person viewpoints respectively with quantitative analyses. This crossing aims to identify whether, if any, collaboration formats and socio-cognitive processes are involved in the generation of the most creative solutions compared to the generation of the less creative ones.

This methodology related to processes will be applied on corpora of various excerpts and conceptual meetings. Our corpora involve professional designers and external participants, *i.e.* participants outside the design team, collaborating in their ecological settings. The methodology related to products will be applied on interview and questionnaire conducted with two designers.

To reach our aim and answer our research questions, we studied the innovative domain of game design involving an extended design group with designers from different backgrounds and various end-users evolving in diverse socio-technical contexts.

3. Design of a musical video game with a pluri-disciplinary group

An ethnographic study was carried out in a small design studio in Paris called Mekensleep. The game studio was selected for four reasons. First, it aimed to create a new concept of musical video game. It presumed that the design process will encompass creative solutions. Second, the game studio was previously awarded for their last video game; the game won the best and the most creative awards. Third, the game studio has no direct economic interests, nor time constraint. These two characteristics of the design process make it a good candidate for studying creativity (Runco, 2004). At last, the design process is driven by different designers/participants that provide a diversity of backgrounds. We assume that this particular context will unleash creative potential.

An immersion as observer in the game studio Mekensleep aimed to cover the whole design of a video game, *i.e.* a fictional environment unfolding in a software. The design group was composed of a creative and project director with one coder. With this core team, one to two co-designers joined them depending on the needs. Other participants external to the design group, *e.g.* designers and/or players, contributed to the global design process.

The design group aimed to create a musical video game called *Hanabi* (photo 1). For that, the designers resorted to an iterative method combined with participatory design. With these methods, a significant emphasis on player's experience was considered by the core team. During the whole design process, designers developed several types of prototypes to progress toward their final goal. These prototypes were also evaluated and eventually developed further by other participants in brainstorming or play-testing sessions.

Photo 1. *Hanabi*

The fundamental concept of *Hanabi* was taken from an existing musical video game *Rez*. As a complement, the musical video game consisted in developing the concept of arrangement of different soundtracks rather than the concept of composition. These basic concepts were oriented toward a musical video game of improvisation without rewards and gains, *i.e.* a *païdian* game. This type of game is not common on the game market.

4. Our position on creativity in collaborative design

In this dissertation, we will consider a design task as "[consisting] *in specifying an artifact (the artifact product), given requirements that indicate –generally neither explicitly, nor completely– one or more functions to be fulfilled, and needs and goals to be satisfied by the artifact, under certain conditions (expressed by constraints). At a cognitive level, this specification activity consists of constructing (generating, transforming, and evaluating) representations of the artifact until they are so precise, concrete, and detailed that the resulting representations –the 'specifications'– specify explicitly and completely the implementation of the artifact product*" (Visser, 2006a, p 116).

In the design project studied, we consider that the co-designers faced a non-routine design task that aimed to create a new game concept that is not found on the market. Thus, as the design task is considered as a non-routine one, creativity is likely to occur (Bonnardel, 2006). We consider creativity as the capacity to produce ideas under an observable form or to realize a production that is both novel, *i.e.* original and unexpected, and adapted to the situation (Bonnardel, 2006; Bonnardel, 2009; Bonnardel and Zenasni, 2010; Sternberg and Lubart, 1996 quoted in Sternberg and Lubart, 1999).

The observed design activities are conducted in a collective setting. We are interested in the moments of collaborative design where co-designers, from different domains of design, elaborate or evaluate together one or more solution/s at a specific moment (Détienne, Baker and Visser, 2009; Visser, Darses and Détienne, 2004).

5. The structure of this dissertation

This PhD dissertation is organized in four parts. These four parts are detailed further below.

In the first part, chapters 1 to 4 introduce the concepts that are brought into play throughout this dissertation. These chapters form our state of the art and cover:

- Chapter 1 introduces the concepts of design and of creative design;
- Chapter 2 develops in more details individual creative design and uses of external representations;
- Chapter 3 exposes the collective aspects of creative design, thus it treats group creativity and external representations used by co-designers are also developed;
- Chapter 4 throws light on the video game domain with its concepts, model and methods of design.

In the second part, the chapters 5 and 6 expose the context of our research field as well as our research framework:

- Chapter 5 introduces the context of our field of research;
- Chapter 6 sheds light on our research questions and the methodology adopted to answer them.

In the third part, chapters 7 to 10 introduce our results:

- Chapter 7 develops our third-person viewpoint with the identification and characterization of three collaboration formats: directive, relational and representational formats. In addition, it highlights the impacts of the socio-technical contexts and design activities on these collaboration formats.
- Chapter 8 concludes our third-person viewpoint with the identification and description of socio-cognitive design processes involved in conceptual meetings and thus, focuses on collaborative problem solving. It highlights combination, analogical reasoning, composition, problem framing and co-evolution of problem-solution processes. Furthermore, it highlights how socio-cognitive design processes and collaboration formats evolve alongside in meetings.
- Chapter 9 introduces the first-person viewpoint with the identification and characterization of creative solutions from the designers' evaluation of creativity. Creative solutions are distinguished from non-creative ones and characteristics of creative solutions are underlined.
- Chapter 10 emphasizes the crossing of both third-person and first-person viewpoints with the identification of specific collaboration formats and socio-cognitive design processes involved in the generation of creative solutions, *i.e.* relational formats and analogical reasoning processes.

In the fourth part, chapter 11, the results will be discussed in a general perspective and a conclusion will be drawn.

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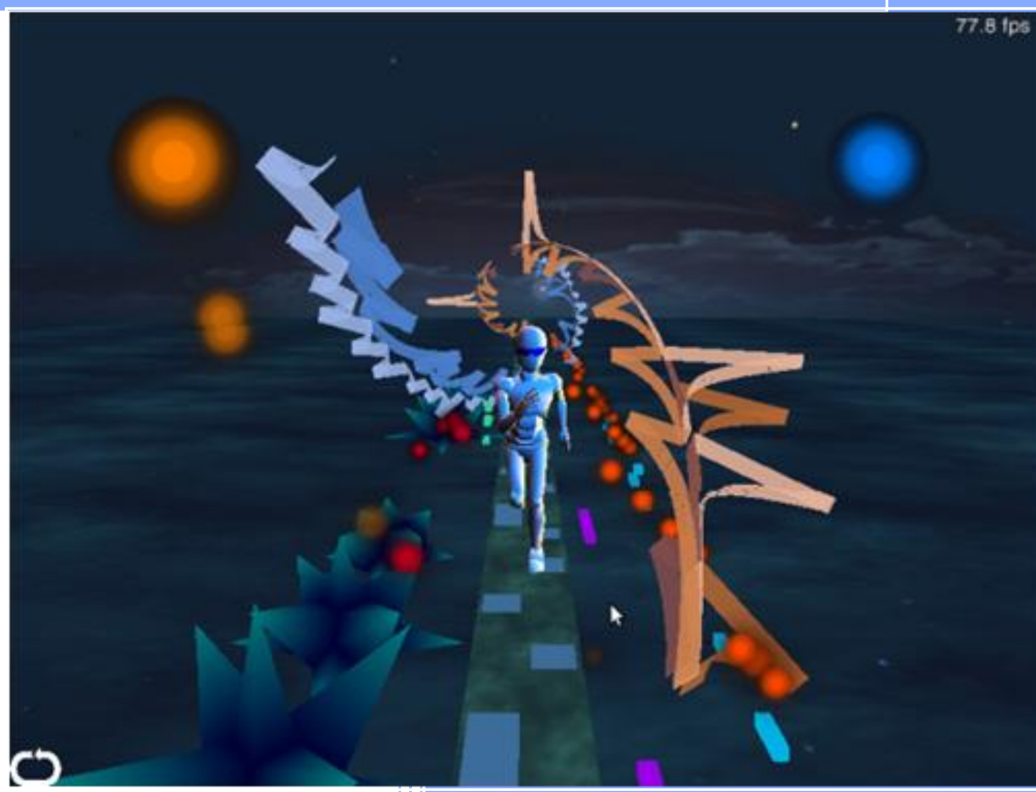
PART I – STATE OF THE ART



Chapter 1 From design to creativity

The situation we observed is an activity of design and more specifically of creative design. In this chapter, our aim is to provide a framework to our study and to the field in which this study is conducted.

We will first clarify the concept of design by looking at the evolution of the paradigms in which it has been analyzed. We will continue by describing the different design activities involved in individual and collaborative design tasks.

In some cases, these design tasks can lead to creative outcomes. Therefore, we will introduce the concept of creativity. For this particular concept, we will shed light on which cases and moments creativity is likely to occur. Then, we will describe the three focuses of creativity that are retrieved in the literature. Lastly, we will develop the main approaches that are used to study creativity.

1. The concept of design

The concept of design has been deepened further since the publication of *The sciences of the artificial* (Simon, 1969) that considered design as a cognitive activity rather than a professional status. This led to the development of a variety of design models in both practice and research domains and of the characteristics of this activity.

First, research embraced the elaboration of prescriptive models and then a shift brought an emphasis on descriptive models. On the one hand, the prescriptive models were developed to guide the design process (Visser, 2006a; Visser et al., 2004). These models proposed several linear and sequential steps that designers should carry on. In software design, many models have been proposed without any reference to the actual activity and are nevertheless used as a basis for managing software development, *e.g.* the waterfall model is probably the classic software model where software development is supposed to go through (Visser, 2006a).

On the other hand, descriptive models propose a structure of some components of the design activity. However, there is no descriptive model that proposes a structured architecture of all the components of the design activity (Visser, 2004 quoted in Visser et al., 2004). These models focus for example on evaluation (Bonnardel, 1999), reuse in design (Detienne, 1998), and organization of the design activity (Visser, 1994).

The shift from prescriptive to descriptive models has highlighted several limitations of the prescriptive models. Some empirical studies have shown that the linear and sequential steps are seldom applied in practice. By comparing the outcomes of these two models, researchers can underline the differences between what is prescribed and the effective activity.

In the ergonomics domain, the interest is focused on effective activity. Therefore, descriptive models, more focused on effective activities, are in line with it. This will constitute our position in this dissertation.

1.1 Design and evolution of the paradigms

In a cognitively oriented approach, symbolic information processing (SIP) is the framework in which Newell and Simon (1972 quoted in Visser, 2009b) define design as a problem solving task in which an 'initial state' of the problem will be evolving through 'operators' in order to reach a 'goal state'. These 'operators' will drive transformations from the 'initial state' to the 'goal state' through intermediary states. In this evolution, search is essential in the problem space that encompasses the different states, constraints and operators.

The characteristics of design advanced by Simon (1969) have been criticized in the design literature. Nevertheless these characteristics of design provided a basis on which improvement has been made. For example, the transition from the SIP paradigm to the situated activity (SIT) espoused especially by Schön and Bucciarelli (Visser, 2006a).

Visser (2009a) undertakes a transition from the characteristics of problem solving (SIP) from which she nevertheless builds on. She defines the general characteristics of design in cognitive design research as follows:

- In a design task, designers are often incapable to retrieve a predefined answer and thus, they need to define a new procedure in order to reach a solution;
- Problems are ill-defined; the 'goal state' is specified but ill-defined in the fact that specifications are mentioned in an abstract level by the function and/or some constraints, and the "initial state" and the "operators" are almost always under-specified and thus ill-defined;
- Design is structured with different activities, *i.e.* problem analysis, generation of solutions, that evolve in a parallel manner;
- Problem are complex and decomposition is a strategy to solve a problem although sub-problems are not completely independent;
- In design, designers seek acceptable and satisfying solutions instead of the optimal one as compromises are used when there is a lack of information;
- Design problems assume more than one acceptable solutions which can be related to the multiple design constraints of the problem that drives the search for compromises;
- For the evaluation of a design project, there are few pre-existing and objective evaluative referents, *i.e.* constraints and criteria, specified in the brief;
- Reuse of knowledge through analogical reasoning is a fundamental strategy in design;
- Design is opportunistic with hierarchical episodes - this characteristic is still under debate.

In this framework, design involves problem solving, but it is not only and not mainly problem solving as it involves also socio-cultural factors that interact with its cognitive aspects (Visser, 2006b). Design, according to Visser (2006a, p.116) "[consists] *in specifying an artifact (the artifact product), given requirements that indicate - generally neither explicitly, nor completely - one or more functions to be fulfilled, and needs and goals to be satisfied by the artifact, under certain conditions (expressed by constraints)*". This view of design focuses on the constructive aspects of design activity and on the importance of the different representational forms (Visser, 2009b). In this sense, designers establish the relationship between internal and external data through the use of her/his knowledge and representational activities in a problem-solving task (Visser, 2006b).

The role of constructive aspects of design in the SIT related to the fact that designers do not simply modify ideas based on new data, but also adopt new interpretations of old data, concurs with the view of design as a construction of representations (Visser, 2006a; Visser, 2006b).

1.2 Individual design activities

In this design framework, there are three classical design activities: problem (re)formulation, solution generation and solution evaluation (Visser, 2006). Problem (re)formulation and generation of solutions progress in parallel and are inter-dependent (Visser, 2009a; Visser et al., 2004). Moreover, Visser (1994) demonstrates through empirical findings that generation and evaluation are strongly intertwined.

In sum, it is considered that these three design activities are in continual interaction (Bonnardel, 2009; Visser, 2002; Visser, 2006a) and may evolve in an opportunistically organization (Visser, 1994).

1.2.1 Formulation and reformulation of the problem

The necessity for a designer to devote a great part of her/his activity on the definition of the problem more than on the resolution of the problem is underlined by numerous researchers (Bonnardel, 2006). This is due to the complexity of the design problem as well as the absence of predetermined and specified procedures for the development of a solution which force the designer to formulate the problem in terms of goal to reach (Darses and Falzon, 1996).

In problem formulation, a designer refines the design goals and specifications and thus, refines her/his mental representation of the problem (Bonnardel, 2000; Bonnardel and Sumner, 1996). This step refers to the collection of relevant information to formulate-reformulate the problem (Bonnardel, 2009).

With this collection of relevant information and mental representation of the problem, a designer can specify types of constraints. The prescribed constraints result from an analysis by a designer of the initial data given in the problem statement and the constructed constraints emerge from the knowledge acquired from her/his experience and stocked in her/his memory (Bonnardel, 1992 quoted in Bonnardel, 1993; Bonnardel, 1999; Bonnardel, 2006). The latter ones depend on the expertise of the designer (Bonnardel, 1999).

The representation of the problem will be constructed by the designer and will evolve throughout the resolution of the problem depending on diverse factors namely problem specificities, competence and level of expertise in a domain (Bonnardel, 2009). Until the final implementation level is reached, each solution developed and paired to a problem constitutes in itself a new problem to be solved which gives them a double status of solution or problem depending on whether it is an output or an input (Visser, 2006b). This double status is termed 'problem solution' (Visser, 1991 quoted in Visser, 2006b).

To formulate a new design problem that needs to be solved, the designer will need to frame a problematic design situation that is to say the designer will set its boundaries, will select particular things and relations to attend to and establish a coherence that will guide the subsequent moves (Schön, 1988 quoted in Cross, 2004). In that respect, the problem re-formulation will iteratively interact with the generation and evaluation of solution (Bonnardel, 2000). From that, additional constraints will be highlighted to specify the properties that the next solutions should have. Through this development, another set of constraints will emerge; the deducted constraints result from an inference activity that comes from a consequence analysis of the previously defined constraints and/or the analysis of the current state of the resolution of the problem (Bonnardel, 1993; Bonnardel,1999; Bonnardel,2006).

1.2.2 Generation of solutions

The proposition of solutions activity is referred to as generation or synthesis and is considered as the design strictly speaking (Bonnardel, 2006; Visser, 2002). The underlined types of constraints in the (re-)formulation of a problem will intervene in this activity (Bonnardel, 2000; Bonnardel, 2006). They define aspects or properties that a solution should have and thus, play a role of current goal during the research of a relevant solution (Bonnardel, 2000; Bonnardel, 2006). Constraints, *i.e.* evaluative referents relative to general characteristics of a solution that need to be further elaborated before being applied, play a role in restricting the search space of solutions and thus restrain the activity of a designer whereas criteria play a role of directive principles in the resolution of the design problem (Bonnardel, 1993; Bonnardel, 1999; Bonnardel, 2006). With these, designers will be able to generate different types of solutions; solutions can be generated with different levels of abstraction, *i.e.* functional, structural and physical solutions (Visser et al., 2004).

Two cases are seen in design. On the one hand, the representation that the designer made of the problem differs from previous problems solved by the designer. In this case, the designer does an elaboration of a solution from her/his generic knowledge - from scratch - which can be the case of some sub-problems (Visser, 2002).

On the other hand, a solution can be generated from a specific or analog problem solved formerly; this is the case of reuse. Reused-solution nevertheless are more or less adapted to the problem at hand (Visser, 2002). Reuse entails an analogical reasoning process (Détienne, 1998; Visser, 2002) in which schematic apparatus or episodic knowledge can be used as a source to transfer into the targeted problem (Détienne, 1998). This type of reasoning process used to solve a problem is considered to potentially lead to creative solutions (Visser, 2002).

1.2.3 Evaluation of solutions

The different constraints, evoked in the formulation and reformulation of the problem, are also used during the evaluation of solutions and they are considered as evaluative referents (Bonnardel, 2000; Bonnardel, 2006). Evaluative referents can be constraints if they are directly applicable and if not, they are criteria (Bonnardel, 1993).

The evaluation of a solution/product consists in assessing it *vis-à-vis* one or more referents (Visser, 2009a). Evaluation ensure, in many ways, the control over the design activity by determining the next step in the design process, by selecting one solution amongst many and by the definition of the focus of attention of a designer - specific constraints - (Bonnardel, 1999).

Solution evaluation can be achieved through two highly entangled processes which are the simulation of the artifact functioning - to test the artifact's specifications or to make choices -, and the definition and application of evaluation referents (Visser et al., 2004). Simulation through external representation/s can be used as a proof of the value of a criterion –or constraint– and thus strengthen the weighting of the evoked criterion - or constraint - (Darses, 2001). The evaluation and value of criteria or constraints themselves enables the designer to attribute different statuses to the evaluative referents and their relative importance toward the object under scrutiny (Bonnardel, 1999).

Depending on the use of the referents, three types of evaluation can be performed: (1) analytic, *i.e.* allows the identification of the pros and cons of solutions toward evaluative referents, (2) comparative, *i.e.* allows an evaluation on the same basis and evaluative referents of alternative solutions or the considered solutions against a reference solution, (3) or analogical, *i.e.* allows a transfer of a previous evaluation of a solution considered similar or analog to the solution at hand (Bonnardel, 1993; Bonnardel, 1999; Bonnardel, 2006; Détienne, Martin and Lavigne, 2005; Martin, Détienne and Lavigne, 2001). Bonnardel (1999) and Bonnardel (2006) underline another type of evaluation that consists in a global evaluation which allows a designer to appreciate globally the interest of a solution without attending to a detailed and precise analysis of its characteristics.

The points of view - or multiple perspectives - of a designer on the evaluative referents as well as the evaluative strategies that they adopt depend on their knowledge and representations (Visser, 2009a) and type and level of expertise (Bonnardel, 2006).

However, evaluation of solutions entails several difficulties related to the fact that designers often have incomplete evaluative knowledge, do not always recognize problematic solutions and that design needs to be evaluated through multiple perspectives (Bonnardel and Sumner, 1996).

1.3 From individual to collaborative design activities

Design is in general a collaborative and social process where few designers work entirely in isolation (Ward and O'Neill, 2005). In addition, it may involve a diversity of expertise (Visser et al., 2004). As a consequence, it is necessary to consider its collective aspects.

Collective design can be conducted in two forms: co-design, *i.e.* co-designers of different domains elaborate or evaluate together solution/s at a specific time, and distributed design, *i.e.* each designer representing a domain of design treat separately a specific problem related to his/her domain (Détienne et al., 2009; Visser et al., 2004). These two forms involve different characteristics and activities. We observed these two forms in the design process; however our focus remains on co-design. Thus, we will describe in further details co-design.

Co-design or collaborative design implies that a task focus is shared by the co-designers (Détienne, Baker and Burkhardt, 2012). Additionally, co-design involves a certain symmetry in interactional positions between co-designers, *e.g.* each co-designer contributes by generating solutions (Burkhardt, Détienne, Hébert and Perron, 2009). Furthermore, it involves elaboration and evaluation performed by several designers using complementary modalities, *e.g.* verbal, gestural, graphical, etc. (Détienne and Visser, 2006).

Individual design plays an important role in collaborative design, but the essential part is done through interaction between designers that brings specific activities and representational structures (Visser, 2009a). The individual design activities described above are also found in collaborative design activities and combined with other specific activities linked to collaborative processes (Détienne et al., 2005; Visser, 2002). These collaborative processes are communication, synchronization, coordination, points of view management and conflict resolution activities through argumentative activities (Visser, 2002). The collaborative design activities classically distinguished two types of activities namely content-related and process-related activities (Darses and Falzon, 1996; Détienne et al., 2009).

1.3.1 Content-related activities

Several authors agree about the content-related activities in various collaborative design settings as well as in different design domains (Détienne et al., 2009): (1) elaboration activities, *i.e.* elaboration, enhancements of solutions and of alternative solutions; (2) cognitive synchronization activities, *i.e.* construction of a common ground by the design team; (3) evaluation activities, *i.e.* evaluation of solutions and alternative solutions on the basis of criteria and constraints.

The elaboration and evaluation activities were described in detail in the previous chapter. However in a collaborative context, collaborative processes are involved as we stated earlier (Détienne et al., 2005; Visser, 2002).

In a conversation analysis study, McDonnell (2010a) analyzes how social actions are structured and completed in an architectural meeting. She suggests that vagueness, *i.e.* ‘sketchy talk’ characterized by openness and ambiguity, and hesitation, *i.e.* as explicit enumeration of possible design variations or proposals generated with linguistic modals, play positive roles in support of the collaboration’s purpose. Similarly to the low-fidelity sketches/prototypes that prompt user engagement to (re)-negotiate their characteristics and/or features, this author advances that vagueness and hesitation both serve the function of ‘encouragement-to-contribute’ alternative solutions. Ambiguous situations require people to participate in making meaning (Gaver, Beaver and Benford, 2003), which in turn can lead to the generation of alternative solutions.

In another study on software designers, McDonnell (2010b) suggests that tentativeness is supportive of constructive collaboration. Tentativeness signaled by hedging - hedge words *e.g.* for example, I think, perhaps - emphasizes the provisional nature of a solution which can lead to several types of moves in the design process that are important for progression (McDonnell, 2010b).

McDonnell (2010a) also argues that delay, *i.e.* delaying of decision, serves collaboration’s purpose as to postpone decision; delay can be used as a deliberate strategy to cope with uncertainty or lack of information. This author observes delay in the resolution of some critical differences of perspective between collaborators. She argues that the use of delay is motivated by an overriding need to keep designing productively.

These encouragements to contribute and strategy to postpone decision can leave more space for generation of alternative solutions.

It is suggested that the designers are required to cognitively synchronize in order to develop and evaluate jointly a solution (Darses and Falzon, 1996; Détienne et al., 2009). This cognitive synchronization is built through three cognitive activities: building of a common referential, integration of points of view and collective decision making (Darses, 2009).

Cognitive synchronization refers to the building of a common referential between participants (Détienne et al., 2009; Détienne, Boujut and Hohmann, 2004). The common referential refers to a common functional representation shared by co-designers that orient and control their collective activity (Darses, 2009).

Cognitive synchronization calls upon communication between co-designers to ensure that they all share the state of the situation encompassing problem data, state of solutions, selected hypotheses, etc. (Darses, 2009; Darses and Falzon, 1996; Falzon, 1994). It will also ensure that they share the same general knowledge linked to their domain, *i.e.* technical rules, domain-related objects and their properties, resolution procedure, etc. (Darses and Falzon, 1996; Falzon, 1994). It is worthwhile to note that co-designers might not share the same knowledge and representations, *i.e.* representations can be different, but compatible. The communication of general knowledge varies in function of the level of shared knowledge hold by co-designers (Darses and Falzon, 1996).

This collective activity is supported by an omnipresent argumentative process (Darses, 2001). The argumentation consists of formulating the constraints and the criteria mentioned during the formulation of the problem and to eventually match them with underlying justifications – arguments - (Darses and Falzon, 1994).

The argumentation process is at the core of progressive movements toward the convergence to a solution and it is through this argumentation that is processed the different points of view of the co-designers (Darses, 2001). Point of view, viewpoint or perspective refers to a particular representation for an individual of an object that is seen differently according to the constraints specific to her/his discipline (Détienne et al., 2005). Their consideration is essential for the success of a design process as they ease the construction of a shared representation of the problem and resources for solutions (Wolff, Burkhardt and De La Garza, 2005).

Thus, it results that solutions are progressively constructed in argumentative discussions in which ideas are confronted (Darses, 2001; Détienne, 2006) with a common referential, the integration of the different points of view described in order for the co-designers to reach a commonly agreed upon solution. The last activity of this cognitive synchronization is the collective establishment of a design decision (Darses, 2009). In this respect, the more affirmed convergence of views are, the more decisions become irreversible (Darses, 2009).

1.3.2 Process-related activities

The process-related activities focus on the collective organization of the design process. Two types of activities are involved namely project management activities and interaction management activities.

In project management activities, designers plan and allocate tasks (Détienne et al., 2009; Détienne et al., 2004). As the design activity does not provide *a priori* a predetermined procedure toward the solution, the designers need to reinvent the steps that separate specifications from production (Darses and Falzon, 1996). In that respect, the designers construct and/or retrieve mental representation in order to organize, anticipate and guide their design activity (Visser, 1994). In the case where designers face a new task, the discussion around the allocation of (sub) tasks will be all the more needed (Darses and Falzon, 1996; Falzon, 1994). These activities ensure management of tasks interdependencies, which is most important in a tightly coupled task such as design (Détienne et al., 2012; Détienne, Burkhardt, Hébert and Perron, 2008)

In interaction management activities, designers order and postpone design topics treated in a meeting (Détienne et al., 2009; Détienne et al., 2004). These refer to the generation and alignment on the defined goal or topic during meetings (Détienne, 2010).

These collaborative design activities can lead to design outcomes as well as to creative outcomes. This leads us to define the concept of creativity.

2. The concept of creativity

In a creative perspective, design consists to define the characteristics of an object that presents a certain novelty and that adapts to an evolutionary set of various constraints and to the context in which it occurs (Sternberg and Lubart 1999). In turn, creativity is the capacity to produce ideas under an observable form or to realize a production that is both novel, *i.e.* original and unexpected, and adapted to the situation in which it occurs (Bonnardel, 2006; Bonnardel, 2009; Bonnardel and Zenasni, 2010; Sternberg and Lubart, 1996 quoted in Sternberg and Lubart, 1999).

2.1 Potential occurrences of creativity

Two different types of creativity are distinguished. On the one hand, there is the H-creativity (historical creativity), *i.e.* no one has come up with the idea before as it has arisen for the first time in human history (Boden, 2004). On the other hand, the P-creativity (psychological creativity), *i.e.* an idea that is surprising, valuable and new to the person who generates it without taking into account if this idea has been generated previously by other individuals (Boden, 2004). We will concentrate on the P-creativity in the next sections and chapters as it is the one that we will focus on in this dissertation.

In design, P-creativity can appear in different contexts such as innovation, specific problem and conceptual phase.

2.1.1. Creativity in innovation

Creativity does not imply innovation automatically; there is also a need to consider the probability and ease of developing an idea into a final product (Kristensson, Gustafsson and Archer, 2004). The crafting of creative solutions into new products, processes or services is the process Shalley and Zhou (2011) refer to as innovation.

Ultimately, innovation is possible only if a creative solution has already been generated (Shalley and Zhou, 2011). The dimension of realization of a new product, service or process focuses on the application of creativity to innovation and represents the degree of innovativeness of a generated idea (Kristensson et al., 2004). Thus, creativity represents a necessary but not sufficient condition for innovation (Shalley and Zhou, 2011). Innovation encompasses three steps: (1) the convergence between a function to be fulfilled and a concept, (2) the development of the concept and (3) its diffusion (Asselineau and Piré-Lechalard, 2008).

Given the definitions of creativity and innovation, it should be clear that creativity and innovation are closely linked phenomena (Shalley and Zhou, 2011). However, we will consider the concept of creativity in this dissertation rather than innovation.

2.1.2. Creativity in function of the link between problem and design

Design activities can be conducted in different ways depending on the link between the problem and the design. Two types of design problem are reported: the problems considered as routine and the ones considered as non-routine (Bonnardel, 2006; Bonnardel, 2009; Visser, 1994; Visser, 2006a; Visser, 2006b). "*Routine problems are familiar problems that although not eliciting an automatic memorized answer, can be solved by applying a well-known procedure. Although the problem solver does not immediately know the answer to a routine problem, [they know] how to arrive at an answer. For example, the problem 888x888 is a routine problem for most adults. In contrast, nonroutine problems are unfamiliar problems for which the problem solver does not have a well-known solution procedure and must generate a novel procedure*" (Mayer, 1989 quoted in Visser, 1994, p. 4). It is worth noting that a problem will be considered as routine or non-routine in function of the knowledge needed to solve the problem at hand that a designer holds (Bonnardel, 2006).

In the case of routine problems, the designer will be required to adapt the predefined design process in order to solve the problem at hand (Visser, 1994). In the case of non-routine problems, designers must show some creativity (Bonnardel, 2009). These two types of design problem can be both retrieved in a single design task as different sub-problems (Visser, 2006b).

2.1.3. Creativity in design moments: conceptual phases

Some studies point to specific moments in a design process where creativity is likely to occur. It is advanced that creativity is mainly manifested in a conceptual phase (Bonnardel, 2006; Bonnardel, 2009). In this moment, a designer is concerned with understanding the problem and generating general rather than specific characteristics of the product to be conceived (Bonnardel, 2006; Bonnardel, 2009; Edmonds and Candy, 1993). In that sense, a conceptual phase starts with a high-level description of requirements and proceeds to a high-level description of a solution (Mc Neill, Gero and Warren, 1998). It is likely that major decisions will be observed in conceptual design phases (French, 1999).

The model A-GC, *i.e. Analogies et la Gestion de Constraints*/analogies and constraints management, summarizes processes involved in conceptual phases (Bonnardel, 2006; Bonnardel, 2009). On the one hand, analogical reasoning can open up the research space of ideas or inspirational sources and lead to creative outcome if the designer moves away from the first evoked source (Bonnardel, 2009). Otherwise, this authors suggests that the designer could restrict her/his research space of ideas. On the other hand, constraints management enables the orientation of analogies and the progressive circumscription of the research space (Bonnardel, 2009). The notion of constraints in creative design also guides the construction of mental representations and orients the course of the resolution of the design problem that allows a designer to reach solutions that are novel and adapted to the situation (Bonnardel, 2006). In complement to the prescribed constraints, designers can add their own constraints; it is argued that creativity is manifested within a constrained cognitive environment (Bonnardel, 2006; Stokes, 2006). Accordingly, without constraints, designers can tend to be wholly uncreative as they can focus on what has been working best in the past (Stokes, 2006). On the contrary, people who strategically use constraints can bolster creativity; reliable responses can be prevented and novel surprising ones are promoted (Stokes, 2006).

Christiaans (1992, p. 136) suggested that "*the more time a subject spent in defining and understanding the problem, and consequently using their own frame of reference in forming conceptual structures, the better able s/he was to achieve creative result*". During this (re)-formulation of the problem activity, Dorst and Cross (2001) found that experienced designers all found a 'surprise'. These authors suggest that surprising parts discovered by designers during the (re)-formulation of a problem drive the originality streak in a design process. Similarly, Edmonds and Candy (1993) and Runco (2004) suggest that creativity might be associated with a (re)-formulation of the problem space.

From these studies, we can consider design moments such as conceptual phases as good candidates to study creativity.

2.2 How creativity is studied

Studies on creativity investigate different focuses namely persons, products and processes. These can be retrieved in both individual design creativity and group creativity. With these focuses, several approaches were developed in order to understand how creativity is brought to bear.

First, we will further detail the three focuses of creativity. Then, we will describe main approaches used to study creativity.

2.2.1. The four focuses of creativity: persons, places, products and processes

In the literature, creativity can be defined by its creators, its places, its products or its processes. These four focuses will be presented. In this dissertation, products and processes will be developed. Therefore, we will detail further these two focuses of creativity.

Persons**.** Some researchers tend to refer to creativity as a set of a person's attributes (Sternberg, 2005). The person focus encompasses research on individual differences in people's creativity or on the distinctive characteristics of creative people (Mayer, 1999). These two orientations that study creativity as property of people have covered issues such as personality (*e.g.* Feist, 2010), motivation (*e.g.* Collins and Amabile, 1999), intelligence (*e.g.* Policastro and Gardner, 1999) and so on.

It is the uniqueness of the an individual's perspective that is at stake in this component; it is the result of the life experience, culture, education and background knowledge that the individual has as well as the personal meaningfulness found in the current situation (Fischer, Giaccardi, Eden, Sugimoto and Ye, 2005).

Places. Some research studies focus on the places in which creativity is unleashed. This can refer to the local environment of creativity, *i.e.* work environment of a designer, but also the field in which creativity can occur. It is suggested that when a person does a task which is controlled, it results a reduced autonomy and in turn creativity can be impeded (Collins and Amabile, 1999). In a work environment, teamwork, network between employees, open discussion and supportive external environment are suggested to enhance creativity (Williams and Yang, 1999). Furthermore, non-experimental research has reported that creative performance is higher when competition occurs between groups rather than within groups (Amabile, 1988 quoted in Collins and Amabile, 1999).

At a higher level, the field where creativity can occur has to be considered. It is argued that changes are not adopted unless they are sanctioned by some group entitled to make decisions as to what should or should not be included in the domain. Csikszentmihalyi (1999) suggests that the field has to provide some economic resources or access as a way to lay down the conditions that make innovation possible and provide a certain degree of autonomy.

Products. Some other studies are related to products - or solutions -. Creative products are usually defined by dimensions. Dimensions are facets, aspects that together provide an important perspective on the quality of a creative product (Kristensson et al., 2004).

Most definitions of creative products include the dimension of novelty, *i.e.* original and unexpected (Maher, 2010). A considerable number of studies on creativity stress another dimension, which is appropriateness, *i.e.* useful and adapted. Novelty alone is not sufficient; the product needs to satisfy constraints of the considered situation (Boden, 2004; Bonnardel, 2006; Gero, 2010; Goldschmidt, 2010; Kristensson et al., 2004; Sternberg and Lubart, 1996 quoted in Sternberg and Lubart, 1999; Warr and O'Neill, 2005).

On the one hand, a novel product is original, not predicted and distinct from previous work (Sternberg and Lubart, 1999). Novelty is considered to be based on a comparison of a potentially creative product to other products in the same conceptual space (Maher, 2010). On the other hand, a product is considered appropriate if it conforms to the characteristics of the defined/redefined problem; it satisfies the problem constraints, it is useful or fulfills a need (Sternberg and Lubart, 1999; Warr and O'Neill, 2005). Usefulness and functionality may be quite widely interpreted, but this component is nevertheless indispensable (Goldschmidt, 2010).

However, for some products, *e.g.* a new artistic movement, the criteria are a matter of a more subjective sphere and thus utility is contestable (Bonnardel, 2006). This latter dimension could be replaced by another one, the feasibility or realizable dimension in the design of an artistic product. Kristensson et al. (2004) argue that there is also a need to consider the probability and ease of developing an idea into a final product, which would be represented by the feasibility dimension of creativity/innovation. An argument that would support this dimension over the appropriateness/usefulness is that the definition of creativity itself implies the feasibility character 'creativity is the capacity to <u>produce,</u> express ideas under an observable form or to <u>realize a production</u> that is…' (*cf.* page 14). As the object of design in our research field is considered as a work of art, we will consider that a creative solution is both novel and feasible.

Other dimensions are used to define creative products such as surprise (Boden, 2004; Gero, 2010; Maher, 2010; Wiggins, 2006) and value (Boden, 2004; Bonnardel, 2006; Bonnardel, 2009; Maher, 2010; Wiggins, 2006). Furthermore, Boden (2004) considers two levels of dimensions, *e.g.* surprise is a feature of the novelty dimension. As for the other dimensions proposed in the literature, Wiggins (2006, p. 451) argued that some are a property of the receiver or the assessor of the potentially creative product; they lie outside the characteristics of the artifact "*it is an emotion generated by either the novelty of the output, or (cynically) by the unexpected ability of the creative system to produce something of value*".

These dimensions - and features - are used to evaluate the creative potential of design products. Creative potential in design is typically determined by asking designers to evaluate their own productions or by asking experts or independent judges for their evaluation of the design product (Bonnardel, 2006; Maher, 2010). However, in these approaches, creativity lies in the interpretations of the assessors and not in the inherent property of the design itself (Gero, 2010) and is thus subjective (Ward and O'Neill, 2005). It is suggested that individuals or experts should be asked "*Just how creative is it and in which way(s)?*" which should highlight the subtleties of the idea itself and the process/es that could have brought it to mind (Boden, 2004, p. 2). This would have at least the advantage of clarifying interpretations and eliciting relations between interpretation and the product's properties.

Processes. A large number of studies focus on processes that are entailed in the generation of creative solutions. A commonly held view is to consider designing as special process/es that can be readily studied and that sometimes leads to creative outcomes (Gero, 2010). In these processes, divergent and convergent thinking are mainly used to describe creative processes. In addition, several other cognitive design processes are investigated. This focus will be detailed further in the two next chapters (chapters 2 and 3).

2.2.2. Several approaches to study creativity: psychometric, cognitive, systemic and interactional

The developed approaches here can investigate different focuses of creativity. We will detail further some approaches, *i.e.* psychometric, cognitive, systemic and interactional.

Psychometric. The psychometric approach is used to study measures of creativity such as person's mental traits (Mayer, 1999). In the past 20 to 25 years, researchers have used psychometric methods to measure creativity of the products, environmental characteristics associated with creativity, to refine the measure of idea generation and evaluation, and to develop new measures of personality characteristics associated with creativity and inventive behavior (Plucker and Renzulli, 1999). A major critic to this approach is emphasized by Wallach (1976 quoted in Plucker and Renzulli, 1999, p.60) "*subjects vary widely and systematically in their attainments –yet little if any of that systematic variation is captured by individual differences on ideational* [*i.e.* quantity of responses (Plucker and Makel, 2010)] *fluency tests*".

Cognitive. Another approach largely developed in the creativity literature is the cognitive approach in which understanding mental representations, knowledge and performed processes in creativity are investigated (Bonnardel, 2006; Bonnardel and Marmèche, 2005a; Bonnardel and Marmèche, 2005b; Ward, 2007; Ward, Smith and Finke, 1999). Interestingly, this approach takes into account the cognition of individual/s that is situated in a specific context, *e.g.* availability of external representations, level of expertise, etc. In this approach, the focus of creativity is the processes. This approach will be developed further in the next chapter (Chapter 2).

These two approaches study individual creativity. In the following paragraphs, we develop two main approaches that are brought into play in group settings.

Systemic. Other approaches widen their scope by taking into account groups of people involved in the generation of creative outcomes. This is the case of the systemic approach in which the object is analyzed in its whole complexity, *e.g.* relations between several individuals. This social aspect can be analyzed through the implementation of different inputs, *e.g.* different compositions of groups, that can result in different outputs, *e.g.* variation of creativity in function of the level of the groups' diversity.

In this approach, creativity is a phenomenon that is constructed through interaction between producer and audience and thus not a product of single individuals, but a social system making judgments about individual's products (Csikszentmihalyi, 1999). Here, creativity is the result of a cycle that associates three systems: (1) the individual that brings transformations in the domain's knowledge, (2) the domain that consists of cultural knowledge encompassing ideas and productions selected by a field and (3) the field including a group of persons or social institutions that control a domain by assessing and selecting ideas and productions that should be retained (Bonnardel, 2006). The point in this approach is that the extent of creativity at any given time is not determined just by how many original individuals are trying to change a domain, but how receptive the field is to innovation (Csikszentmihalyi, 1999) and thus, places where creativity can arise.

Interactional. Another approach that focuses on interactions between individuals is the interactional approach. This approach comes from the psychology of interaction research field. It grants a central focus on dialogue as the object of study (Détienne et al., 2009). In cognitive ergonomic studies, dialogue can be a means to approach cognitive and collaborative mechanisms that intervene in a collective activity, such as design (Darses, Détienne, Falzon and Visser, 2001; Détienne et al., 2009). In this framework, collaborative design is a situated, collective and a multi-modal practice (Bruxelles, Greco, Mondada and Traverso, 2009). This interactional approach can be carried out with either conversation analysis (for example see McDonnell, 2009) or coding schemes (for example see Détienne et al., 2009).

This approach has been carried out in collaborative design. It has been adopted to study socio-cognitive design processes that are considered creative in the creativity literature, *e.g.* co-evolution of problem-solution (Reymen, Dorst and Smulders, 2009). Yet few if any studies from the group creativity research field adopted this approach.

3. *Toward an interactional approach to study creative design*

Design has been studied extensively. A considerable body of literature analyzed its specificities and characteristics as a cognitive activity rather than a professional status. Thus, several design activities have been enlightened. Collaborative design has been also considerably studied and collaborative processes have been scrutinized. These individual and collaborative design studies were conducted within prescriptive as well as descriptive models. The latter has provided numerous studies underlining effective activities entailed in individual design as well as collaborative design. The position taken in this dissertation is focused on the description of effective activities.

In regard to creativity, a large number of studies concentrate mainly on one of the four focuses, namely persons, places, products or processes. Few studies, if any, have undertaken the challenge to shed light on and develop in detail at least two of the four focuses. Thus, this challenge remains to be undertaken. This is the direction in which this dissertation will be carried on that is to say develop both processes and products.

Furthermore, a considerable number of studies in collaboration design focused on interactional and systemic approaches. Yet, the former one is not that well represented in studies on collaborative creativity. In this dissertation, we will undertake this new avenue to throw new light on the long-established research field of creativity.

In the two next chapters, we will introduce studies in creative design that are mainly positioned in the cognitive approach (chapter 2). Then, we will shed light on collaborative creative design studies that are mainly positioned in the systemic approach and a few in the interactional approach (chapter 3).

Summary

In this chapter, we defined the concept of design as "[specification of] an artifact (the artifact product), given requirements that indicate –generally neither explicitly, nor completely– one or more functions to be fulfilled, and needs and goals to be satisfied by the artifact, under certain conditions (expressed by constraints)" (Visser, 2006a). This definition is situated in the design paradigm of problem solving entangled with socio-cultural factors as well as cognitive aspects. In a design task, a designer will proceed to the design activities of (re)-formulation of the problem, generation and evaluation of solution.

In regard to a collective setting, collaborative design implies that a task focus is shared by the co-designers. Furthermore, it involves symmetry in interactional positions between co-designers, i.e. each co-designer contributes by generating solutions, for example (Burkhardt et al. 2009). Additionally, co-designers elaborate and evaluate solutions using complementarily modalities (Détienne and Visser, 2006). In this collaborative context, designers will carry on supplementary –to individual design activities– design activities such as communication, synchronization, coordination, points of view management and conflict resolution activities through argumentative activities (Visser, 2002).

Design activities can lead to creative outcomes. Creativity is the capacity to produce ideas under an observable form or to realize a production that is both novel and adapted to the situation in which it occurs (Bonnardel, 2006, 2009; Bonnardel and Zenasni, 2010; Sternberg and Lubart, 1996 quoted by Sternberg and Lubart, 1999).

Creativity can be H-creativity or P-creativity. The latter can be retrieved in innovation, in conceptual design phases and in function of the link between problem and design. This type of creativity can be studied through four focuses, namely persons, places, products and processes. However, few studies, if any, have developed in detail more than one focus. This challenge will be undertaken in this dissertation that is to say to take into consideration and examine both processes and products.

Chapter 2 Individual creativity

Individual creativity has been largely studied. The four focuses on creativity mentioned above, *i.e*. persons, places, products and processes, were all emphasized in these studies. This chapter will concentrate on the processes involved in creative work with the cognitive approach.

A thoroughly studied question in individual creativity is whether the use of external representations favors the accomplishment of cognitive design processes that can lead to creative outcomes. Moreover, the level of expertise of participants is another variable that is often analyzed in experimental studies from this field of research.

In this chapter, we will describe in detail the individual cognitive processes involved in creative design. Then, we will end this chapter by shedding light on external representations that hold a central role in design as well as in creative design.

1. Individual creative processes

Several cognitive processes are often brought up in the literature on creative design. However, these processes are not all at the same level. On the one hand, some are involved in the evolution of a problem solving task - and thus involve both design problem/s and solution/s - such as divergent and convergent thinking, co-evolution of problem and solution and problem framing. On the other hand, some are more focused on the evolution of a solution such as combination, analogical reasoning and composition.

In order to evaluate the creative potential of these design processes, some of the studies use metrics that were developed in the psychometric approach, *e.g.* the Torrance test which includes criteria of fluency, flexibility and originality. Other studies use metrics such as creativity dimensions, *e.g.* novelty, appropriateness, to evaluate the creativity of the outcomes. These metrics can be assessed by external judges or by designers/subjects themselves.

In this section, we will define some design processes and underline their creative potential. In addition, we will describe in greater detail the impacts of external representations and levels of expertise on some of the design processes.

1.1 Divergent and convergent thinking

Divergent thinking is a cognitive process that sometimes leads to creative ideas (Runco, 2010). This cognitive process leads a designer in various directions (Runco, 1999) and allows her/him to generate and ideas (Runco, 2010). It refers to the ability to produce unique and original solutions (Cropley, 1999a; Fasko, 1999; Runco, 1999). In order to engage in divergent thinking, critical judgment and logical considerations must be suspended, to allow directional ideation shifts at all times, and the production of a large number of ideas (Routhier, 1998). As a result, ideas ranging from conventional to unconventional can be generated.

Associative processes seem to be involved in divergent thinking at least when the problem at hand is open-ended (Fasko, 1999; Runco, 1999; Runco, 2004). In order for people to make new connections and associations, it is required to search for and to receive new information in order to create new knowledge; the larger the set of skills, information and knowledge is at hand, the more numerous are the potential alternatives for producing something novel (Kristensson et al., 2004). Consequently, unconventional idea might be discovered using divergent thinking (Runco, 2010) and more precisely through associative processes.

The Torrance test of creative thinking is the commonly used measurement of divergent thinking (Plucker and Renzulli, 1999; Runco, 2010). These measures encompass (1) fluency, *i.e.* total number of relevant solutions, (2) flexibility, *i.e.* number of different categories of answers, (3) originality, *i.e.* rarity of an individual's answer compared to the ones given by a group and (4) elaboration, *i.e*. amount of details in answers (Plucker and Renzulli, 1999; Runco, 1999; Runco, 2010; Sternberg and Lubart, 1999).

Conversely, convergent thinking refers to searching for an acceptable solution from a pool of ideas according to the constraints and characteristics of the situation (Routhier, 1998). It refers to the ability of an individual to find a correct and/or conventional idea to a problem (Runco, 1999). For that, individuals apply conventional logic to the information related in order find the one and only best answer regarding the available information (Cropley, 1999b).

In this cognitive process, knowledge is of a particular importance (Cropley, 2006). This author claims that knowledge suggests pathways to generate solutions and provides criteria to assess the effectiveness and novelty of an idea (Cropley, 2006).

With the amount of ideas pooled during a divergent process, a designer is able to perform numerous cognitive design processes - complementing associative processes - on them in order to reach creative outcomes.

1.2 Problem framing

A designer may designate some features of the problem space to which s/he choose to attend, *i.e.* defining the problem, and then s/he proceeds to identify areas of the solution space in which s/he chooses to explore in greater detail, *i.e.* framing the problem (Cross, 2004). This allows a designer to refine her/his mental representation of the problem (Bonnardel, 2000; Bonnardel and Sumner, 1996). As we mentioned, the problem framing process, involved in the (re)formulation of a problem, is considered as a moment where creativity is likely to occur (Christiaans, 1992; Dorst and Cross, 2001; Edmonds and Candy, 1993; Runco, 2004).

The design process is an exploratory activity that first tends to define the problem instead of solving it (Lanzara, 1986 quoted in Bonnardel, 2006). Framing refers to the activity of setting the boundaries of the design situation, selecting particular things and relations to attend to and imposing on the design situation a coherence that guides the following moves (Schön, 1988 quoted in Cross, 2004). Then, problem framing is associated with the generation and evaluation of solutions - referred to as problem-solving - (Simon, 1995 quoted in Bonnardel, 2006).

1.3 Co-evolution of problem-solution

Maher, Poon and Boulanger (1996) have defined the model of co-evolution of problem-solution - referred to as the design exploration model - in two distinct exploration spaces: (1) the problem space as the functional requirements and design goals, and (2) the solution space as the current search space for design solutions. These authors point out that these two spaces interact over a time spectrum with horizontal movement considered as an evolutionary process, *i.e.* P(t) evolves to P(t+1) and so on, and diagonal movement considered as a search process where goals lead to solutions (figure 1).

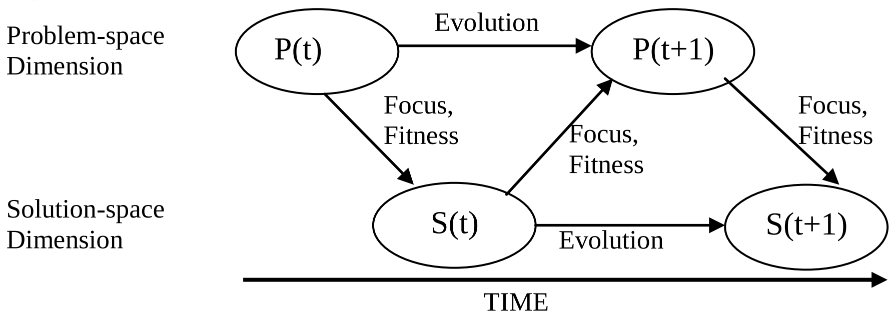


Figure 2. The co-evolution of problem-solution (Maher et al., 1996)

The design community acknowledges that problem solving activity results in a co-evolution of problem-solution which is a matter of developing and refining together both the formulation of a problem and the ideas for a solution, with constant iteration of analysis, synthesis and evaluation processes between the two design spaces (Cross, 2004; Dorst and Cross, 2001). These authors suggest that a designer begins by exploring the problem space in order to find a partial structure. This partial structure is then used to create a partial structure in the solution space. After a shift from problem to solution spaces, the designer takes the extended partial structure from the solution space and transfers it to the problem space to see the implications of the extended partial structure in the problem space (Cross, 2004; Dorst and Cross, 2001).

The main goal of co-evolution of problem-solution is to create a matching problem-solution pair that remains at a certain point unstable and unfixed (Cross, 2004). Therefore, the problem and solution co-evolve (Kolodner and Wills, 1996 quoted in Cross 2004; Maher et al., 1996). It is argued that the co-evolution of problem-solution is a creativity process (Dorst and Cross, 2001).

1.4 Cognitive design processes performed on solutions

Some cognitive design processes performed on solutions have been largely studied such as combination, analogical reasoning and to a lesser extent composition. These cognitive design processes were mainly studied in a cognitive approach within experimental settings.

Some studies aim to seek the role of external representations in these cognitive processes. These studies encompass conditions with and without external representation/s - mainly sketch/es -. The underlying hypothesis is that external representation/s could support cognitive design processes. In addition, other studies focus on another variable that is the level of expertise. In that line, researchers seek whether designer’s expertise has an impact on the performance of cognitive design processes. Globally, these studies also aimed to specify if cognitive design processes lead to creative outcomes.

In this section, the cognitive design processes of combination, analogical reasoning and composition will be described. Furthermore, results on the support of external representation/s and the impact of expertise will be underlined.

1.4.1 Combination

Combination refers to blocks of information that can be associated in various ways (Verstijnen, Heylighen, Wagemans and Neuckermans, 2001). The example below (figure 2) illustrates a combination process based on perceptual association of separate components; the letters "D" and "J" are combined to form an umbrella (Finke and Slaton, 1988 quoted in Verstijnen et al., 2001).

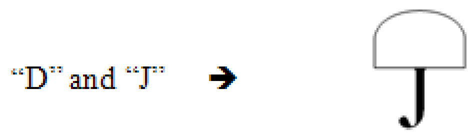


Figure 3. Combination process

This process has been studied with or without the support of sketches. Several studies concur to the fact that combination is possible without the support of an external representation such as a sketch (Kokotovich and Purcell, 2000; Verstijnen, Hennessey, van Leeuwen, Hamel and Goldschmidt, 1998; Verstijnen et al., 2001; Verstijnen, van Leeuwen, Goldschmidt, Hamel and Hennessey, 1998).

Regarding the effect of expertise on this design process, Verstijnen, Hennessey, van Leeuwen, Hamel and Goldschmidt (1998) and Verstijnen, van Leeuwen, Goldschmidt, Hamel and Hennessey (1998) found no difference between novices, *i.e.* undergrade psychology students, and experts, *i.e.* industrial design engineering students with at least two years of drawing education, in both with-sketch and without-sketch conditions. Contrastingly, discrepant conclusions are noticed in the literature. Indeed, Kokotovich and Purcell (2000) argue that experts, *i.e.* design students/graphic designers, compared to novices, *i.e.* law students, do produce more creative forms in mental combination. The discrepancy could be attributed to the different score measurements used in these studies; the first ones used a combining score based on spatial configurations and the latter one used a score of creativity given by judges' ratings.

As this process is considered to be feasible without the support of external representation, Ward et al. (1999) suggest conceptual combination as a synthesis or a merging of previously separate concepts. These authors report studies on the nature of the combined concepts in the combination process. They suggest that dissimilar concepts result in more creative outcomes than compatible concepts as "*dissimilar pairs are less readily aligned and foster a search beyond the parent concepts to resolve the conflicts in their structures*" (p. 203) and thus, could bolster creative potential.

In terms of available elements to be combined, Heylighen, Deisz and Verstijnen (2007) demonstrate that the more designers generate alternative solutions, the more unique combinations are likely to emerge. Moreover, Jaarsveld and van Leeuwen (2005) report that new combinations were mostly generated using a mixture of old and new objects. These authors interprete this as a means of bringing new elements into the design process and thus, bringing more divergence to the design outcome.

A considerable number of studies seem to agree on the character of combination as a creative process (Jaarsveld and van Leeuwen, 2005; Verstijnen, Hennessey, van Leeuwen, Hamel and Goldschmidt, 1998; Verstijnen et al., 2001; Ward et al., 1999). Results of these studies were partly reached by the evaluations of creativity by independent judges, *e.g.* design teachers, associates of design engineering department. As for the ratings, metrics such as ‘fluency’, ‘originality’, etc. were used. Some other ratings performed in these studies were based on classification system, *i.e.* operationalized spatial configurations. However, others did not report the operationalization of their metrics, *i.e.* ‘creativity’.

1.4.2 Analogical reasoning

In a design perspective, Ball, Ormerod and Morley (2004) refer to analogical reasoning as a kind of reasoning that entails the use of ‘source’ information retrieved from a previous problem-solving activity as a means to ease attempts at solving a current ‘target’ problem. However, the source-object might not always be concretely retrieved or perceived in externalized representations of the target, *i.e.* the design product (Bonnardel, 2006).

Analogical reasoning can be looked at from a viewpoint of distance between the source and the target. The source can be in the same domain of the target, *i.e.* intra-domain, or located in a different domain from the target, *i.e.* inter-domain. Depending on the nature of the analogy, designers could expand or reduce the solution space and achieve more or less creative solutions (Ball et al., 2004; Bonnardel, 2006). The semantic distance between the source and the target seems to be beneficial to design outcomes. In other words, a source from a different domain of the target might enable the designer to produce more creative ideas (Bonnardel, 2000; Bonnardel, 2006; Bonnardel, 2009).

As this reasoning process can play a major role throughout the design process (Bonnardel, 2006), some studies pinpoint various purposes for analogical reasoning. Studies concur that its purposes include identifying new constraints/criteria and generating and evaluating solutions (Bonnardel, 1993; Bonnardel, 1999; Bonnardel, 2006; Casakin and Goldschmidt, 1999; Martin et al., 2001). Bonnardel (2000, 2006, 2009), Bonnardel and Marmèche (2005a) and Bonnardel and Marmèche (2005b) suggest that that intra- as well as inter-domain analogies are found in generation of solutions and that the evaluation of solutions performed through an analogical mode is conducted with intra- and inter-domain solutions.

Lastly, another variable was studied in relation to the purposes and the nature of the source. Some differences between expert designers and novice designers in analogical reasoning have been reported: expert designers (1) can escape from the suggested sources of inspiration to open up their search space, (2) are able to generate more aspects to transfer from sources to target than novices regardless of the domain of the sources, (3) exhibit more schema-driven analogizing rather than case-driven conversely to novices, and (4) are able to focus on both functions and structures in inter-domain sources compared to novices (Ball et al., 2004; Bonnardel, 2000; Bonnardel, 2006; Bonnardel and Marmèche, 2005a; Bonnardel and Marmèche, 2005b; Casakin and Goldschmidt, 1999).

1.4.3 Composition

The composition process refers to a change of an object's location in a sketch (Jaarsveld and van Leeuwen, 2005). In other words, at a certain time an object in an artifact has a specific location and the process of composition refers to the action of a designer when s/he takes the object's specific location and shifts it to a new one. For example (Jaarsveld and van Leeuwen, 2005), with a frame subdivided in 3x3 cells numbered 1 to 9 from left to right and top to bottom, the composition process consists in switching the object from cell 5 - the dotted circle - to cell 3 - the plain circle - (figure 3).

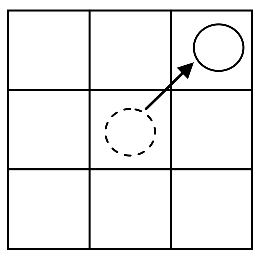


Figure 4. The composition process

This process was addressed in a study where individual psychology students interacted with sketches. Participants explained and evaluated the evolution of their problem solving activity. This self-assessment was complemented by an 'art critics' scores' for the final design. This latter was determined by four professionals: an independent painter, an illustrator, artist representative and an artist counselor. For high art critics' scores, Jaarsveld and van Leeuwen (2005) found that participants introduced objects in their sketches at an early stage and changed their location at a latter stage. These authors consider these two phases as divergent and convergent productions. The divergence and convergence are considered creative by these authors.

2. External representations used in individual design and creative design

One specific aspect of the design process is the intensive use of different types of external representations associated with different steps of the process (Visser et al., 2004). In both design activities and creative design, designers use various external representations that allow her/him to engage in design activities. These activities encompass those described above, *i.e.* the (re)-formulation of problem, the generation and the evaluation of solutions.

In this section, we will describe in greater detail various types of external representations. Then, we will introduce three functions performed by external representations.

2.1 Types of external representations

External representations, viewed as material representations are concrete, physical objects with which abstract, non-physical qualities, *i.e.* meanings, ideas, etc., are always associated, and their materiality affects the ways the designers relate to them, use and experience them (Schmidt and Wagner, 2002). Dix and Gongora (2011) consider that externalizations suggest both embodied interactions with artifacts and the process of making external representations of our own thoughts, feelings and interior life.

External representations can differ in their nature. They can be required resources for the development of solutions or representations of an intermediary state of the artifact (Visser et al., 2004). They can be: (1) physical, with at least some aspects of the product being designed, (2) schematic or representative, providing aspects of the final product possibly in other media or (3) symbolic, dealing with abstract concepts, ideas, criteria or properties, all of which can differ in their modality of expression (Dix and Gongora, 2011).

Designers also recognize sensory components as materials that engage and activate our senses (Jacucci and Wagner, 2007). Consequently, each modality can convey information in its own sphere, with its own specificities. In that respect, external representations offering different modalities of interaction are fundamentally different from the sequential order of speech and action (Bucciarelli, 2002).

It is worth noting that software design can be considered as essentially different from other domains of design, *e.g.* architecture; some domains of design focus on the structure. For example, architecture uses sketches to draw or sketch the structure of buildings (Visser, 2009b). Conversely, this author argues that software design deals not only with structural issues, *i.e.* code, but also with processes that systematically exhibit temporal characteristics. She relates this difference to the different external representations used in software design.

2.2 Functions

External representations are cognitive artifacts - in Norman's (1991, 1993) sense - that are in an intermediary and mediating position between the designer and the artifact and that amplify a designer's information processing abilities (Visser et al., 2004). Accessing non-physical qualities - meanings, ideas, etc. - through external representations can have various purposes in design. We will develop three functions, namely: the storage of design information, 'conversations with materials' and their experiential role.

2.2.1 Storage of design information

A less active role of external representations is the storage of information, *i.e.* the representation acts as an external memory. External representations enable designer to preserve and store information (Visser et al., 2004). In a number of studies using sketches, the function of storage is largely accepted. In that respect, sketching is argued to enable the designer to archive and retrieve design information (van der Lugt, 2002). Consequently, external representations result in visual tokens reducing memory load (Suwa, Gero and Purcell, 1998). These authors also suggest that external representations such as sketches serve as external memory where designer can leave ideas that can be revisited at any time.

Similarly, external representations can serve as external memory for the decisions made during the whole design process (Vyas, 2009; Vyas, van der Veer, Heylen and Nijholt, 2009) as another type of information.

2.2.2 Back and forth communication

A considerable number of studies on design and creativity focus on the roles of external representations. It is suggested that external representations such as "*sketches serve as a physical setting in which design thoughts are constructed on the fly in a situated way*" (Suwa, Gero and Purcell, 1998a quoted in Gero, 1999, p. 98). A designer acts in response to visuo-spatial features of the physical setting s/he is immersed in (Suwa et al., 1998). Wiggins (1992 quoted in Suwa et al., 1998) suggests that representations of ideas in sketches are the essence of the early design process. From these external representations, a designer can extract various abstract representations such as typological schema, organizational principles, morphological principles, functional relationships, etc. (Oxman, 1997).

External representations can give opportunities to proceed to two types of reasoning: (1) the designer can 'see-as', *i.e.* meaning is extracted from the external representation and (2) the designer can 'see-that' *i.e.* s/he deals with the consequences of newly acquired meaning which are retrieved in any kind of designing and semiotic systems (Goldschmidt, 1991). In that sense, Goldschmidt's work shows the double facet of these representations; sketches are a revelation of a set of ideas as well as a stimulus for generating new ones (Goldschmidt, 1994 quoted in Suwa and Tversky, 2003) and thus, for divergent thinking. This process is referred to as a 'conversation with materials' (Schön, 1992), and it can support cognitive design processes.

In a ‘conversation with materials’, a designer not only visually registers information, but s/he also constructs its meaning (Schön, 1992). External representations in this case allow a designer to explore designed objects. Subsequently, unexpected discoveries can be found which consist in the action of noticing consequences that were not intended by the sketcher when s/he drew it (Schön, 1992). It refers to a new perceptual action that has a dependency on earlier physical action/s such as overdrawing or tracing a previously drawn element, or paying attention to the existence of a previously drawn element (Suwa, Gero and Purcell, 2000). As a result, the ‘conversation with materials’ can trigger a co-evolution of problem-solution.

Reinterpreting sketches and generating new ideas constitutes a productive cycle that is to say when a designer makes a new perceptual discovery in her/his own sketch/es, s/he is more likely to come up with new ideas (Suwa and Tversky, 2003). Reinterpretation can be stimulated in different ways. To produce new interpretations, Suwa and Tversky (2003) suggest that it is helpful, although not necessary, to ‘see the sketch differently’ −that is to reorganize parts of the sketch or to view it from a different perspective, from a different perceptual reference frame, *e.g.* in the ambiguous figure of the duck-rabbit, this refers to switching from the duck to the rabbit.

On the one hand, attending to parts by combining them or focusing on different parts is associated with the enhanced generation of interpretations and is used as a strategy by expert and novice architects (Suwa, Tversky, Gero and Purcell, 2001). These authors conclude that the reorganization of sketches should have payoffs in the form of designs that are more creative and more functional, as well. On the other hand, it is considered that changing the reference frame, *e.g.* switching from duck to rabbit, may stimulate the generation of new interpretations (Suwa and Tversky, 2003). Sketching supports the reinterpretative cycle (van der Lugt, 2002) where the emergence of new ways of seeing the representation of a potential design solution (Purcell and Gero, 1998) can open up new directions for further exploration (van der Lugt, 2002).

With external representations, a designer sets and solves a problem that informs her/him further designing, illustrating again the process of ‘conversation with materials’ (Schön, 1992). In this way, the externalization of ideas and the inspections of these ideas provide a means for the designer to see new features and relations that propose ways to refine and revise their ideas (Suwa et al. 2001). Following this, designers are driven to draw again (Suwa et al., 1998). As a result, external representations take over part of the design activities by providing knowledge elements regarding the solution being elaborated that will enable the designer to make a decision (Visser et al., 2004).

2.2.3. Experiential role

The 'conversation with materials' can be carried on through multiple dimensions. In that sense, with the experiential role of external representations, it is not only the cognitive dimension and its processes that are at stake, but also subjective emotions. Thus, more dimensions are encountered in this particular function.

As software design encompasses structure and processes (Visser, 2009b), *i.e.* design of space and of temporality, the experience of interacting with a software artifact might be considered different from the interaction with a simple sketch, which is a static and non interactive external representation. In that respect, a second way of having a 'conversation with materials' is by interacting with external representations and accessing a meaningful experience. Experience is by nature subjective and the best way to understand the experiential qualities of an interaction with an external representation is to experience it subjectively (Buchenau and Fulton Suri, 2000).

'Experiential' means possessing qualities that go beyond satisfying basic functionalities and bring value to the activities of an individual (Hallnäs and Redström, 2002 quoted in Vyas, Heylen, Nijholt and van der Veer, 2009). Related to external representations, it supports the richness of an interaction by adding meaningfulness (Vyas, Heylen, Nijholt and van der Veer, 2009). The key idea is that a designer makes discoveries her/himself, when going through a vivid experience. This, in turn, creates subjective and lasting memories (Buchenau and Fulton Suri, 2000). These authors suggest that these subjective and lasting memories will guide the designers' choices and decisions throughout all the stages of the design process.

The richness comes partly from the materiality of some of the external representations, and more precisely from their multimodality; it is this multimodality that turns the materiality of an external representation into a source of rich experience, and provides occasions for multiple actions (Jacucci and Wagner, 2007). In that respect, Vyas, Heylen, Nijholt, and van der Veer (2009) claim that a physical model allows a designer to extend their mental conceptualization of their product to a sensory conceptualization, and to 'play' with it. Thus, this activity, achieved through external representations, can in turn, lead to exploring and evaluating design ideas (Buchenau and Fulton Suri, 2000). Exploration may not necessarily be about the products themselves, but about interactions and expressions that a designer wants to communicate through the products (Vyas, Heylen, Nijholt, and van der Veer, 2009).

The experiential role of external representations can be valuable in the design process for different kinds of activities such as understanding existing user experience and contexts of use (Buchenau and Fulton Suri, 2000), and for supporting creativity (Vyas, Heylen, Nijholt and van der Veer, 2009). The experiential role of external representations in the early stages of design may enable a designer to understand the problems and situations that s/he is designing for, since external representations represent and embody users' expressions, performance, and reasoning in everyday life (Vyas, Heylen, Nijholt, and van der Veer, 2009). In this case, experiences, through external representations and interactive behavior, provide a basis to evaluate a variety of ideas and, through successive iterations, to mould the user experience (Buchenau and Fulton Suri, 2000). The experience provided by external representations aims, in this case, to facilitate the exploration of possible solutions and to direct the designer towards a more informed development of the user experience and of the tangible elements that compose it (Buchenau and Fulton Suri, 2000).

3. Toward empirical studies with semiotic systems and explicit evaluation of product to study creative design

Research on the cognitive design processes carried out on the solution are, in most cases, experimental studies. Variables taken into account include the presence or absence of external representations, the level of expertise, and the components, *e.g.* intra- or inter-domain sources. Conversely, the cognitive processes involved in design process such as divergent and convergent thinking, problem framing and co-evolution of problem-solution use the experimental method to a much lesser extent.

Furthermore, a considerable number of these studies restrict the nature of the semiotic systems taken into account. External representations are often limited to sketches. This can be viewed as a lack of consideration for other semiotic systems such as prototypes. In addition, this restriction on the semiotic systems taken into account limits the ability of researchers to take into account the potential experiential role of external representations.

We mentioned that a large number of studies in creativity focus mainly on one of the four focuses of creativity mentioned in chapter 1, *i.e*. persons, places, products and processes. Even if the some studies reported in this chapter evaluate the creativity of products - to link specific processes in the generation of creative products -, the evaluation of these products can be criticized. We will highlight two critics.

First, evaluation of creativity is not always made explicit or is not operationalized. For example, some studies made no use of known creativity dimensions such as novelty and appropriateness for example. Consequently, this lack of common ground in performance measurement jeopardizes generalization of results and comparisons across studies (Gero, 2010). In that respect, we will consider in this dissertation a creative product as a novel and feasible product/solution.

Second, relying solely on a scoring system does not emphasize the creative characteristics of a solution. It seems necessary to take into account some qualitative components. In that vein, it is argued that evaluations of creativity should involve metrics and explanations: the questions should be for example "*Just how novel is it, and in which ways?*" (Boden, 2004, p.2). The evaluations of creativity mainly involve metrics, but do not consider in which ways the work is, for example, novel or not. Moreover, the use of experts or independent judges does not underline the subtle appreciation of the specificities of each solution. Thus, creativity is left for interpretation by the judges themselves, who only score the creative production without any further justifications. In this dissertation, we will base our creativity's evaluation on Likert scale complemented by explanation of designers on each product/solution.

In short, the work reported here suggests that few studies, if any, take into account equally both creative processes and creative products. These studies tend to emphasize processes. To study the processes, researchers evaluate products in order to determine which processes led to creative products/solutions. However, these studies do not analyze in any depth the details about the evaluation of products/solutions' creativity. Indeed, creative products' evaluation received much less attention (Plucker and Makel, 2010). This challenge of taking equal consideration for processes and products is the originality of this dissertation.

These limitations are also apparent in some studies on group creativity. This will be the focus of our next chapter.

Summary

Individual creativity has been the subject of a considerable number of studies focused on cognitive design processes. Indeed, divergent and convergent thinking, problem framing and co-evolution of problem-solution involved in the evolution of the design process are largely developed in the creativity literature. Additionally, combination, analogical reasoning and composition involved in the evolution of solutions are also well represented in this literature.

Most of these studies rely on experimental setting. They use variables such as the use of external representation/s – mainly sketches –, the level of participants' expertise and the components involved in the processes, *e.g.* intra/inter-domain analogical sources. Yet, the majority of studies agree that these cognitive design processes are involved in the generation of creative solutions. In this dissertation, we will extend the focus as we will take into account several semiotic systems.

In both the design and creative design literature, external representations serve several functions that include supporting a 'conversation with the material', constructing and discussing an experience, and storing design information. Additionally, these representations serve as a support to the cognitive design processes reported in this chapter. In this dissertation, we will extend the range of the semiotic systems taken into account; we will not only consider sketches, but also other diverse semiotic systems, *e.g.* prototypes.

From the research studies we introduced in this chapter, we could underline some critics related to the evaluations of creativity. First, the lack of common ground on dimensions used to evaluate creativity can challenge the generalization of results and comparisons across studies. In that regard, we will adopt in this dissertation an evaluation of creativity based on known and accepted creativity dimensions namely novelty and feasibility. Second, relying only on scoring system can prove to be unefficient to emphasize creative characteristics of products. In that vein, we will base our creativity's evaluation on a scoring system, *i.e.* Likert scale, complemented by explanations and justifications on each product evaluated.

Chapter 3 Collaborative creativity

Collaborative creativity has recently attracted the interest of the research community on creativity. Design problems require more knowledge than any single person can possess and the knowledge required for solving a design problem is often distributed amongst different stakeholders who have different perspectives and background knowledge (Fischer, 2000 quoted in Fischer, Scharff and Ye, 2002). As a result, bringing together stakeholders with different points of view and the work on sharing understanding amongst all stakeholders can then lead to new insights, ideas and artifacts (Fischer et al., 2002). Much human creativity arises from activities that occur in a social context, *e.g.* group, community, in which interactions with other people and external representations that embody group knowledge are important contributors to the creative design process (Fischer, 2005; Fischer et al., 2005).

In this chapter, we will throw light on the collective context of design and more precisely on group creativity. In order to do so, we will first underline some socio-cognitive design processes. Furthermore, we will shed light on the collaborative processes that are advanced to neutralize creativity. This will lead us to introduce specific socio-technical environments that are considered to alleviate these collaborative processes drawbacks. As collaborative design and group creativity can be supported by the use of external representations, we will conclude this chapter by specifying the position of the external representations in a collaborative and creative context of design.

1. Socio-cognitive design processes in group creativity

The cognitive design processes emphasized in the previous chapter are scarcely analyzed and studied in a collaborative context. The exception might be collaborative divergent and convergent thinking. Furthermore, it is worth noting that some studies are not taken from the group creativity research field, but from collaborative design research.

In this section, we will introduce some studies on design processes such as divergent and convergent thinking, problem framing, co-evolution of problem-solution, combination and analogical reasoning conducted in a collaborative context.

1.1 Divergent and convergent thinking

The need to take different perspectives and to generate alternative solutions when faced with a problem solving or decision-making task is considered as a divergent thinking process (Milliken, Bartel and Krutzberg, 2003). Divergent thinking in a group is manifested in several ways that include the number of perspectives and alternative solutions proposed and the degree to which members share uniquely held information (Milliken et al., 2003). ‘Encouragements to contribute’ (McDonnell, 2010a; McDonnell, 2010b) could be used in this divergent thinking process as to pool a greater number of alternative solutions.

In a collaborative context, a wider range of perspectives is more likely to emerge when several members approach a problem from different angles or backgrounds (Milliken et al., 2003). Similarly, high levels of cognitive diversity increase the potential range of perspectives taken and of opinions members bring to the task (Stasser, 1992 quoted in Milliken et al., 2003). Potential disagreements in opinions or perspectives can serve to encourage each participant to give more careful attention to her/his point of view (Gruenfeld, 1995 quoted in Milliken et al., 2003). Although diversity can bring about positive effects to groups, it can also lead to misunderstandings and other problems of communication amongst group members (Nijstad, Diehl and Stroebe, 2003).

With these solutions pooled in the group, the designers will have to process them; the designers need to evaluate alternatives and choose one to use or to recommend (Milliken et al., 2003). This need refers to convergent thinking. Convergent thinking can be inappropriate if the group does not fully consider all alternatives before converging onto a solution (Nemeth and Nemeth-Brown, 2003). In that case, premature consensus may limit group creativity (Nijstad and Paulus, 2003).

1.2 Problem framing

Only recently studies have considered problem framing - amongst others - in a team design context (Stumpf and McDonnell, 2002). It is considered that the team should work within a common frame and have the same appreciation of the design problem and how to solve it (Stumpf and McDonnell, 2002). In turn, the process of alignment on a problem frame - both identification a frame and modifying or rejecting it again - seems important as it supports the building of a mutual understanding on the design task and its solution (Cross and Clayburn Cross, 1995; Valkenburg and Dorst, 1998).

Valkenburg and Dorst (1998) distinguish between framing the problem and framing the solution as exploring the design task for the former and developing solutions for the latter. A recent model of iterative framing cycle depicts, in team design, the evolution of four iterative steps that go from (1) pseudo-frame setting, (2) individual frames made explicit, (3) conflicts made salient and (4) common frame negotiated (Hey, Joyce and Beckman, 2007). These authors provide a evolutionary view of problem framing in a collective context.

Finally, it is considered that the quality of frames can impact the quality of the artifacts (Stumpf and McDonnell, 2002; Valkenburg and Dorst, 1998). In that line, Cross (2004) reports a study of Atman et al. (1999). These authors underline that attention to frames - referred to problem scoping as adequately setting up the problem which includes gathering a large amount and a wide range of problem-related information - result in better design.

1.3 Co-evolution of problem-solution

Co-evolution of problem-solution is a design process that has been studied mostly in individual design. Only recently, co-evolution of problem-solution has started to be analyzed in collective design meetings. In that context, co-evolution of problem-solution refers to discussions concerning a problem or solution in which actors provide insights to produce problem-solution pairs (Reymen et al., 2009).

Reymen et al. (2009) analyze co-evolution of problem-solution episodes in an empirical study on architect-client collaboration using protocol analysis. These authors encounter limitations when only referring to utterances as to code 'problem' and 'solution'. They propose to study co-evolution of problem-solution through the notion of 'use'. They suggest that 'use' lies between problem and solution; 'use' is more closely related to solutions for an architect whereas 'use' is more closely related to problems for the client.

1.4 Socio-cognitive design processes centered on solutions in group creativity

As in individual design, some socio-cognitive design processes are centered on solutions. Studies analyzing them are found to a lesser extent in the literature on team design. We will develop the processes of analogical reasoning and combination.

1.4.1 Combination

Combination is considered as a process by which creative outcomes can occur in a group design context (Cross, 1997). In this collective context, Cross (1997) refers to this socio-cognitive process as the combination of features from existing designs into a new configuration.

Maiden, Gizikis, and Robertson (2004) organized a workshop with successive sessions where the participants, in one session, were guided to proceed to combinations once many ideas had been generated thus, following a divergent thinking process. These authors found that proceeding to an exclusive session dedicated to combination resulted in leaving some ideas left unexplored. In turn, they suggest that sessions should be focused on all generated ideas and their elaborations instead of on design processes.

1.4.2 Analogical reasoning

Christensen and Schunn (2007) have shown that analogical reasoning is used as spontaneous analogies without salient superficial similarity between source and target in a study with teams of expert engineering designers. This socio-cognitive design process is considered as a basis leading to creative outcomes in collaborative design (Cross, 1997).

Several functions of analogical reasoning were proposed. Christensen and Schunn (2007) and Ball and Christensen (2009) found that analogies had functions related to the identification of problem and problem solving. They also underline a function of explanation for analogy that they assume to be related to the need to reach a communicative alignment when a novel concept is proposed as the novel concept exists only in the mind of the other team members. Another function was pointed out by Ball and Christensen (2009) as the identification of a product's function.

The need to study the relationship between different functions and the nature of the sources was also studied by Ball and Christensen (2009) and Christensen and Schunn (2007). These authors claim that problem identification is mainly achieved through intra-domain analogies. Differently, explanation and identification of a product's function are mainly achieved though inter-domain analogies (Ball and Christensen, 2009; Christensen and Schunn, 2007). Finally, both intra- and inter-domain analogies are found in problem solving (Ball and Christensen, 2009; Christensen and Schunn, 2007).

We introduced some socio-cognitive design processes that are involved in creative design. In the next section, we will focus on collaboration processes that are suggested to neutralize creativity.

2. Collaborative processes neutralizing creativity: production loss

A whole body of literature aims to ascertain whether or not individual design gives better outcomes than group design in terms of creativity. To this end, a number of studies have carried out comparisons of nominal groups, *i.e.* a set of non-interacting individuals, *versus* real groups, *i.e.* interacting individuals, in different settings without reaching unequivocal conclusions. However, the disparity - and disagreements - in the research has an interest because it covers a wide range of variables involved in group creativity. The remaining question of whether individuals or groups provides the most creative outcomes is not ours to answer, but crucial variables pinpointed by this kind of research can be translated to a collaborative design perspective and thus provide valuable insights when considering creativity in collaborative design.

The dampening effect of social factors on creativity - groups do not necessarily have superior performance in terms of creativity compared to non interacting individuals - is primarily the result of four interacting social influences: production blocking, evaluation apprehension, free riding and interference (Nijstad et al., 2003; Smith, 2003; Ward and O'Neill, 2005). These social influences have been termed 'process loss' or 'production loss[1]' (Nijstad et al., 2003). It has been largely studied in order to identify the causal factors that are responsible for the lower creative performance in groups.

Being creative in a group can be considered inherently more difficult as collaboration processes are added to the design task; designing as alone individual relieves the communication costs where one must ensure a sustained mutual understanding amongst participants, coordination as for a fluent collaboration without chaotic overlaps of turn-taking, etc. These additional cognitive and monitoring costs can impact the course of the design activity in terms of creativity.

In this section, we will develop further the production loss, such as production blocking, evaluation apprehension, free riding, interference and conformity bias.

[1] This process loss or production loss has been consistently found in groups with three or more participants (Nijstad, Diehl and Stroebe, 2003)

2.1 Production blocking

Production blocking is reported to provoke production loss (Ward and O'Neill, 2005). Production blocking can be related to the collaborative process of fluent turn-taking in verbal interactions. In other words, as one person can talk at a time - rule of fluid collaboration or coordination of turn-taking -, the deferred verbalization of one's idea can cause forgetting or suppression of idea, prevent new generation of ideas or interference with a participant's thought process (Dennis and William, 2003; Nijstad et al., 2003). As a consequence, if participants rehearse their ideas internally, which prevents them from concentrating on what other members are saying, it makes the sharing of categories of ideas ineffective, whereas this feature could make real groups potentially more creative than nominal groups (Ward and O'Neill, 2005).

After series of experiments to demystify production blocking, Dennis and William (2003) and Nijstad et al. (2003) conclude that group members have to face multiple tasks at the same time that span from listening to others, monitoring the discussion, *i.e.* turn-taking, to generating ideas which can be considered as an overload for the cognitive system.

2.2 Cognitive interference

Another production loss is cognitive interference. It occurs when the ideas generated by other participantsd interfere with a member's own activity of idea generation; retrieving memories can be biased or blocked by involuntary retrieval of the other member's memories and creative ideas can be constrained by implicit retrieval of examples given by other brainstormers (Nijstad et al., 2003; Smith, 2003). In this production loss, the cost is the breadth and flexibility of ideas generation (Nijstad et al., 2003; Smith, 2003).

In one case, cognitive interference as cognitive stimulation is beneficial as the solutions generated by the other brainstormers of the group can stimulate ideas generation of an individual and in another case, it can limit the flexibility of ideas generation (Nijstad et al., 2003). These authors suggest that a generated idea from a semantic domain that is at odd with an individual's idea belonging to another semantic domain or successive ideas belonging to dissimilar semantic domains will prevent the individual to continue the exploration and generation of solutions within the odd semantic domain. They claim that it can result in the loss of potential ideas and the switch between semantic domains and thus, it reduces the depth of ideas generation within a particular semantic domain.

2.3 Evaluation apprehension

It has been shown that non-common options or solutions are less likely to be expressed in a group and thus, may not provide a basis for consideration of alternative or new ideas (Nemeth and Nemeth-Brown, 2003). This is related to the fact that people may be concerned with and fear negative evaluation by the other group members (Nemeth and Nemeth-Brown, 2003; Nijstad et al., 2003). This is termed *evaluation apprehension*.

One reason proposed to explain why groups can have lower performance than individuals in terms of creativity is the fear of evaluation; members worry that others will judge them negatively (Nemeth and Nemeth-Brown, 2003). These authors suggest that a social or cognitive inhibition is the result of these worries, which lead to low creativity in groups as more common solutions are more likely to be shared. Dennis and William (2003) underline that ‘deindividuating’ - *i.e.* enforcing the anonymity of individuals - behaviors lead the participants to share ideas that otherwise would have been withheld due to evaluation apprehension in some organizational situations. However, this option can lead to another detrimental aspect of group creativity that is *social loafing* (Bartis, Szymanski and Harkins, 1998; Karau and Williams, 1993 quoted in Dennis and William, 2003; Ward and O’Neill, 2005).

2.4 Social loafing

Social loafing or free riding concerns members of a group that free-ride on the efforts and accomplishments of the most productive group participants by letting them achieve most of the work (Paulus and Brown, 2003). It is the result of individuals of the group being lazy, relying on the other participants and not contributing as many ideas as they could (Ward and O’Neill, 2005).

Differences between group and individual assessment are underlined to have an influence on this production loss (Diehl and Stroebe, 1987 quoted in Ward and O’Neill, 2005). These authors found that groups with group assessment, *i.e*. where all members’ ideas are assessed as a result of group work, produced fewer ideas, which was linked to social loafing whereas groups with individual assessment, *i.e*. where individual’s effort can be monitored, resulted in the production of more ideas.

Notwitstanding, there is a tradeoff between free riding and evaluation apprehension; increasing individual and group performance by reducing free riding cause a negative effect on creativity by enhancing evaluation apprehension (Ward and O’Neill, 2005).

2.5 Conformity bias

Other sources of production loss have been investigated. In phases of convergence, the mechanism of conformity bias is reported. The strive to consensus - groupthink or pressure for conformity - can lead to premature closure which is one of the reasons for poor decision making in groups, to agreement with the majority views whether these are wrong or right, and to extreme views on issues where there is fundamental agreement (Nemeth and Nemeth-Brown, 2003).

When participants are ‘similar’ - as opposed to having a diversity of backgrounds, knowledge, etc. -, close-knit, isolated from contrary views and/or have a strong leader who expresses a clear preference, groups strive to find a consensus toward the preferred solution of the leader or of the majority and that even if it is erroneous (Nemeth and Nemeth-Brown, 2003). As a result, the pressure to conformity often provokes reluctance to voice dissent, which is a stimulus for divergent thinking and creative thought (Nemeth and Nemeth-Brown, 2003).

Group performance in terms of creativity can be enhanced if production loss can be outweighed by positive and constructive mechanisms. We now turn to some socio-technical environments that counteract production loss.

3. Socio-technical environments to enhance creativity

By acknowledging the detrimental costs of a design task coupled with collaborative processes, design methods, socio-technical devices and group compositions have been studied. They involve proposals to alleviate the impediments of collaboration processes in order to increase the creative potential of the group, with the idea that a group is more than the sum of the individuals (Nijstad et al., 2003).

3.1. Design organization and methods

Design-oriented organizations and methods are brought up to prevent the decrease of creativity in group settings. We will develop the introduction of breaks in the design process and then the brainstorming method that is highly documented in creativity literature.

3.1.1 Introducing breaks and allowing sufficient time in the design process

With respect to the design methods and techniques that we intend to develop, introducing short breaks is likely to help designers suspend the activation of old ideas and to open up possibilities for generating new ideas (Nijstad et al., 2003). Paulus (2010) claims that if participants have sufficient time to reflect or let ideas incubate, it is likely that additional creative insights may occurs.

Moreover, allowing groups sufficient time to complete their tasks also enhances the likelihood that information held by an individual will be brought to the group’s attention (Nemeth and Nemeth-Brown, 2003). This sharing of uncommon information is considered to be beneficial for creativity, *e.g.* in divergent thinking tasks (Milliken et al., 2003).

3.1.2 Switches between individual and collective brainstorming

In a collaborative context, one popular technique to generate creative ideas is brainstorming. Brainstorming was proposed by Osborn (1963 quoted in Paulus and Brown, 2003) in order to increase creativity in groups. Brainstorming is a technique designed specifically for groups, which involves attempts to evoke as many ideas as possible by establishing a social context that gives free rein to imagination and reinforces the use of it (Nickerson, 1999). Thus, divergent thinking is strengthened. The ‘encouragements to contribute’ (McDonnell, 2010a; McDonnell, 2010b) can be beneficial in this context.

Its basic ideas rely on suspending critical judgments during the session, leaving the floor to only one speaker at a time, encouraging 'wild' ideas, and building on and combining ideas of other brainstormers (Matthews, 2009; Maiden et al., 2004; Nijstad et al., 2003). These constitute the brainstorming rules. Theoretical bases for the effectiveness of group brainstorming are also provided and concern social facilitation of activity levels, social reinforcement of idea generation, social reward with approval, agreement and retake, and mutual cognitive stimulation of an idea (Paulus and Brown, 2003).

Brainstorming can be considered as a search process that aims to generate innovative and useful ideas (Bonnardel and Marmèche, 2005a). The aim is that more good ideas will be generated and stimulated from other members of the group by this process than by one in which people express only ideas that have already been evaluated critically (Nickerson, 1999). The emphasis of brainstorming is on the quantity of solutions generated by the exploration of all ideas that come to an individual's mind and to combine and improve on the presented ideas; the intention is to promote novel combinations of divergent ideas (Paulus and Brown, 2003).

It has been proposed that individual brainstorming intertwined with group brainstorming is a solution to allow participants to benefit from exposure to different knowledge sources and perspectives brought by other team members (Paulus, 2010; Smith, 2003). It could provide another benefit related to the fact that in an individual brainstorming session, individuals generate a broader range of solutions as brainstormers' ideas might suffer less cognitive interference from the expressed ideas of the other brainstormers (Smith, 2003). The group can then explore them from multiple perspectives (Smith, 2003).

In a design process, each stage can involve a session of brainstorming or an activity similar to brainstorming to identify the various possibilities to take into consideration (Nickerson, 1999). Regarding the organization, Matthews (2009) suggests that designers are not condemned to accept a specific format of meeting or any other social encounter if it does not offer them the flexibility or structure that they need.

The brainstorming method can be conducted within different socio-technical contexts. We will now elaborate further upon two socio-technical devices supporting brainstorming.

3.2. Socio-technical support in brainstorming: brainwriting and electronic brainstorming

Socio-technical environments can be offered by brainwriting, *i.e.* brainstormers write down their ideas on a piece of paper and then exchange their notes, and electronic brainstorming (EBS), *i.e.* brainstormers enter their ideas in a computer system and have access to ideas from other brainstormers (Nijstad et al., 2003; Paulus, 2010). These authors claim that brainwriting and EBS provide environments where some of production losses are removed by writing on paper or entering ideas in a computer system which allows access to other members' ideas in order to be stimulated.

On the one hand, brainwriting and EBS prevent production blocking in the sense that brainstormers may express their solutions without any delay related to turn-taking and thus are able to generate as many solutions as they could from a specific train of thought, *i.e.* ideas from a specific semantic domain (Nijstad et al., 2003). Dennis and William (2003) provide experimental evidence that production blocking is prevented because all participants can generate ideas simultaneously. Furthermore, the unpredictability of having the floor interferes with the activation of a new semantic domain, *i.e.* trains of thoughts, (Nijstad et al., 2003). These two socio-technical devices prevent this, notably because it is not required to monitor unpredictable turn-taking (Nijstad et al., 2003).

On the other hand, as stimulus ideas increase the accessibility of semantically related knowledge and increase performance (Nijstad et al., 2003), the availability of other participants' solutions provided by brainwriting and EBS might offer another benefit to group brainstorming as ideas are stored in the system (Dennis and Williams, 2003). However, individuals will be influenced by the other brainstormers to the extent that they pay attention to each other's solutions (Paulus and Brown, 2003).

However, issues related to evaluation apprehension and social loafing require further research as they seem to play a part in the explanation of production loss (Rickards, 2010). Even though we have highlighted several advantages of brainwriting and EBS, these socio-technical devices are not without drawbacks. Dennis and William (2003) reported a production loss related to brainwriting and EBS that is linked to communication speed, the inherent cost of writing and typing versus speaking.

Furthermore, access to other brainstormers' solutions was viewed as restricting the range of ideas and thus decreasing the number of semantic domains in the case of homogeneous group (Nijstad et al., 2003). This leads us now to consider the composition of groups.

3.3. Composition of groups: enhancing diversity

In order to increase the performance of a group, careful selection of participants can maximize mutual cognitive stimulation in order for the group to come up with divergent ideas (Nijstad et al., 2003). Diversity can be of different levels: cognitive, *e.g.* with members' knowledge and perspectives resulting from their work experience, education and training, etc., or detectable diversity, *e.g.* belonging to specific social categories, gender, ethnic groups, etc. (Milliken et al., 2003). We will only develop the cognitive diversity, as it is the one that is beneficial for creativity (Milliken et al., 2003), and the one that is taken into account in this dissertation.

The argument that diverse groups seem to outperform homogeneous groups or non-interacting individuals is based on the assumption that these diverse groups have a greater range of skills and resources from which to work with (Milliken et al., 2003). As a result, performance on most tasks can be enhanced and improved by considering alternatives or multiple perspectives (Nemeth and Nemeth-Brown, 2003).

A new perspective brought up by one member of a diverse group may trigger new ideas from others that they would otherwise not have thought of, and bring the level of performance of the group at the same level of performance of a nominal group (Nijstad et al., 2003). It may also provide greater opportunities for creative combination of ideas (Paulus and Brown, 2003), increase the number of alternative solutions considered and the probability that individual participants will have unique information to share (Milliken et al., 2003). All are key manifestations of the divergent thinking required for creativity. Nijstad et al., (2003) suggest that the diversity of the group and their points of view causes a productivity gain related to cognitive stimulation by the other members that counteracts production loss.

At another level, for people working together with different backgrounds, training, skills, etc., bringing different perspectives to the group can lead to disagreement and conflict which, if processed in the interest of the project, will generate improved performance (West, 2003), and if not, may be counter-productive. Notwithstanding this, conflict - viewed as the expression of different perspectives maintained over time - amongst competing positions is suggested to be essential for increasing creative solutions and quality of decision making (Nemeth and Nemeth-Brown, 2003).

3.4. Socio-relational aspects: favoring anonymity?

In relation to other benefits of brainwriting and EBS is the anonymity that can be implemented in these socio-technical systems to prevent evaluative apprehension (Dennis and William, 2003). However, these authors argue that in these cases, social loafing is made stronger. As we mentioned earlier, there is a tradeoff between these two sources of production loss (Ward and O'Neill, 2005). Furthermore, it is argued that anonymity counteracts the openness that is required for creative team work (Rickards, 2010). This author and other research underline that more studies are required to shed light on this production loss.

4. External representations: boundary objects and multiple modalities

At the collective level, the functions depicted in external representations used by individual designers are also retrieved in the context of collaborative design. However, some external representations will provide support for interactions and communication between designers, *e.g.* brainwriting and EBS.

External representations constitute a design world that will be interpreted differently by different designers (Bucciarelli, 2002) and will constitute a basis which designers will work on and with. The physicality and multi-modality of external representations is crucial for collaborative design (Vyas, van der Veer, Heylen and Nijholt, 2009). Not only for collaborative design, but it is suggested that external representations also support creativity (Fischer et al., 2002). Bruner (1996 quoted in Fischer et al., 2002) underlined some functions of external representations linked to creativity:

- They cause the designers to move from vague mental conceptualization of an idea to a more concrete representation of it;
- They create a common language of understanding;
- They provide a means for the other designers to interact with, react to, negotiate around, and build upon an idea;
- They allow more voices from other stakeholders to be brought in.

4.1 External representations as a mediator of information for the group

Design crosses or lives on the boundaries of diverse communities that have different practices, power and interests (Bodker, 1998). External representations, gestures conveying meaning (Visser, 2009c), and material external representations can act as mediators of information (Vyas, Heylen, Nijholt and van der Veer, 2009) between potentially diverse participants involved in a joint design activity.

Jacucci and Wagner (2007) suggest that material external representations engage designers with all their senses and that the interaction with them is not just physical, but that they also spur thinking, and help communication of ideas that would be otherwise difficult to communicate through words. This multi-modality and ability to support and convey information through multiple channels or senses facilitate rich communication between designers (Vyas, van der Veer, Heylen and Hijholt, 2009).

In this sense, external representations contribute to explanation and communication activities (Visser, 2009a) and to spur points of view related to different domains which help the designers reach a mutual understanding (Visser et al., 2004; Vyas, Heylen and Hijholt (2009). These communication activities concern both face-to-face communication, and also ‘deferred’ asynchronous communication such as the sharing of ideas through sheets of paper in brainwriting or through data entered in an EBS session.

Creative activities grow out of the relationship between an individual and the outcomes of her/his work as well as out of the ties between an individual and other/s (Fischer, Nakakoji, Ostwald, Stahl and Sumner, 1998 and Gardner, 1995 quoted in Fischer et al., 2005). They arise from activities that take place in a context where interaction with other people and the external representations that embody group knowledge are important contributors to the design process (Fischer, 2004). They enable co-creation and allow participants to build on the work of others (Fischer et al., 2005).

To expand on this consideration, the environment of individuals can also be taken into account. Indeed, the space inhabited by designers supports visualization, exploration and inspiration through access to external representations (Moultrie et al., 2007; Vyas, van der Veer, Heylen and Nijholt, 2009). Moultrie et al. (2007) suggest that the physical environment can potentially support co-evolution of problem-solution - which they refer to as problem finding and problem solving - and implementation activities through the availability of suitable tools and resources.

The transformation of external representations features and translation of features in different media are core strategies of collaborative expression and experience (Jacucci and Wagner, 2007). The study by Visser (2009c) concludes that gestures are used not only to specify the characteristics of the design product, but also to specify the experience of users. The role of experience through multi-modal external representations is to let different co-designers or stakeholders communicate with each other and understand the subjective properties of a design idea by directly experiencing it (Buchenau and Fulton Suri, 2000).

The openness of external representations allows them to (1) facilitate and accommodate the contributions of others and thus to stimulate desginers' imagination and eventually to perceive novel elements within familiar elements, (2) to discover a relationship between seemingly incongruent objects and/or notions to relate the 'unrelatable' and (3) to jointly take a step forward in the design process (Wagner and Lainer, 2001 quoted in Bucciarelli, 2002). As a result, external representations shared in a group are sources "*where the unexpected can be expected, where innovative and unorthodox solutions are found, where serendipity is likely and where old ideas find new life*" (Fischer et al., 2005, p. 9).

4.2 External representations as a vector for cooperation and coordination

External representations are a vector for cooperation and coordination between designers (Visser et al., 2004). CSCW researchers have increasingly found that external representations of different kinds play crucial roles in coordinating and aligning cooperative work (Bucciarelli, 2002).

Vyas, Heylen and Hijholt (2009) proposed that the use of physical space, which refers to the ecological set-up in a design studio that can be filled by different types of design materials and external representations, helped designers organize, coordinate and manage their design activities. Some external representations aim to enable designers to maintain a kind of order in the large collection of distributed representations required to objectify the work in progress of the designers; they are normative constructs governing distributed activities in a design project (Bucciarelli, 2002). Moreover, having different materials around the studio improves visibility and provides an overview of the work being carried out, supports awareness of co-workers' activities and hence, contributes to the coordination of work (Vyas, Heylen and Nijholt, 2009).

At another level, external representations can be used as a reminder of design principles and of the overall work to be done, and thus serve as a template for project meeting, as marks of the contributions of different designers or participants, as a mark of the design decisions that have been worked out (Schmidt and Wagner, 2002). They cross organizational and professional boundaries many times (Bucciarelli, 2002) and act as a source of information about the division of labor (Vyas, Heylen, Nijholt and van der Veer, 2009). During an interaction, external representations can also insure the joint attention toward an object under discussion, *e.g.* through deictic gestures (Visser, 2009c).

5. Toward creativity processes through design dialogues in ecological settings

Some of the mentioned studies in this chapter were carried out with experimental protocols. From there, we can deduce that the ecological character of design situations is not emphasized. Furthermore, some studies are conducted with subjects that are not designers. As a result, there is a need to shed light on creative collaboration carried on by professional designers in their natural work settings encompassing potentially diverse semiotic systems.

Different socio-cognitive design processes and collaborative processes involved in creativity were documented and that with different approaches, *e.g.* socio-cognitive, systemic, and to a lesser extent, interactional. However, we mentioned that the interaction between designers themselves in the context of group creativity is still in need of being developed.

Taken together, the research field of group creativity has not yet shed light on interactions between real professional designers occurring in ecological settings. In this dissertation, the focus will be devoted to professional designers collaborating in their ecological settings. This focus will be approached with an interactional analysis of video game designers. The video game domain will be developed in the next chapter.

Summary

In this chapter, we developed the notion of collaborative creativity. We started by defining some socio-cognitive design processes that can lead a group to generate creative outcomes. We elaborated a little on divergent and convergent thinking, problem framing, co-evolution of problem-solution, combination and analogical reasoning.

In some contexts, several studies suggest that group creativity is not necessarily more efficient in terms of creativity than the sum of non-interacting individuals. These lead to a considerable body of literature investing the collaborative processes that neutralize creativity, which is termed ‘production loss’. We have defined different types of production loss namely production blocking, evaluation apprehension, social loafing and conformity bias.

To counteract these production losses, one popular design technique to achieve creative outcome in collaborative design is proposed: alternation of individual and collective brainstorming. In another strand of research, some socio-technical devices are reported as being beneficial to creativity such as brainwriting and electronic brainstorming. At a more organizational level, the composition of groups was investigated. Several studies concur to the benefits of a group of great diversity, also in terms of creative performance.

Collaborative design and creativity can involve external representations with the functions found in individual design. Complementary to these functions, other functions are more oriented toward the purpose of communication. In that respect, external representations can fulfill the function of supporting communication of designers with each other, between designers and users, and facilitating and accommodating the contributions of other designers. Other functions are related to external representations as a vector for coordination and cooperation.

A considerable body of research reported in this chapter was carried out with experimental protocols. As a result, the ecological settings were not preserved. Furthermore, in some studies, subjects were not always designers *per se*. In this dissertation, we will shed light on interactions between real professional designers in their ecological settings. This will be undertaken with an interactional approach.

Chapter 4 Designing video games

In this chapter, we will introduce video games as an object of design. Our goal in this chapter is to frame the object of design studied in this dissertation. For this, we will define different concepts connected with video games that are *play* and *games*. This will point out the concepts taken into consideration in the design of video games. This will lead us to shed light on models encompassing the main components of video game design and some prescriptive methods used in software design. We will then introduce the concept of *user experience* that has an important place in video games. We will end this chapter by highlighting empirical studies investing creativity in this specific domain.

1. Concepts in video game design

The purpose in this study is not to find 'the' definition of a video game, but to shed light onto its concepts so that we could unravel important principles for its design. Henceforth, we will look at different definitions of 'play' and 'game' from the fields of the social sciences and game design. We will conclude this section by pointing out the connections between these two concepts.

1.1 The 'play' concept from a social science perspective

In social sciences, we can underline the work of the anthropologist Huizuiga (1950) that was expanded by the work of the sociologist Caillois (1958). These researchers focused on the definition of 'play'. In this case, the definitions are more related to the interaction of an individual with a (video) game:

- Play is defined by Huizinga as a "*free activity standing quite consciously outside "ordinary" life as being not serious, but at the same time absorbing the player intensely and utterly. It is an activity connected with no material interest, and no profit can be gained by it. It proceeds within its own proper boundaries of time and space according to fixed rules and in an orderly manner. It promotes the formation of social groupings which tend to surround themselves with secrecy and to stress their difference from the common world by disguise or other means*" (Huizinga, 1950, p. 13).
- Caillois (1958) followed with his definition of play as "*an activity which is essentially (1) free i.e. in which playing is not obligatory; if it were, it would at once lose its attractive and joyous quality as diversion, (2) separate i.e. circumscribed within limits of space and time, defined and fixed in advance, (3) uncertain i.e. the course of which cannot be determined, nor the result attained beforehand, and some latitude for innovations being left to the player's initiative, (4) unproductive i.e. creating neither goods, nor wealth, nor new elements of any kind and except for the exchange of property among the players, ending in a situation identical to that prevailing at the beginning of the game, (5) governed by rules i.e. under conventions that suspend ordinary laws and for the moment establish new legislation, which alone counts, and (6) make-believe i.e. accompanied by a special awareness of a second reality of a free unreality, as against real life*" (pp. 9 and 10).

Caillois (1958) went further and defined ways of playing. He describes a continuum going from *païdia* to *ludus*. *Paidian* games cover the spontaneous manifestations of the play instinct. It refers to a "*common diversion, turbulence, free improvisation, and carefree gaiety is dominant. It manifests a kind of uncontrolled fantasy*" (Caillois, 1958, p. 13). Whereas *ludus* a "*frolicsome and impulsive exuberance is almost entirely absorbed or disciplined by a complementary, and in respect inverse, tendency to its anarchic and capricious nature: there is a growing tendency to bind it with arbitrary, imperative, and purposely tedious conventions, to oppose it still more by ceaselessly practicising the most embarrassing chicanery upon it, in order to make it more uncertain of attaining its desired effect*" (Caillois, 1958, p. 13). *Ludus* is complementary to and a refinement of *païdia*, as *ludus* disciplines and enriches *païdia* (Caillois, 1958).

1.2 The 'game' concept from the game designers perspective

Game designers - practitioners and academics - tend to define the concept of 'game' instead of focusing on the concept of 'play'. A majority of practioners and academics tend to define games as goal-oriented and outcome-oriented (Juul, 2003; Koster, 2004; Salen and Zimmerman, 2004; Schell, 2008). The goal is mainly described as problem solving (Koster, 2004; Schell, 2008). Furthermore, outcomes are considered to be resources (Costikyan, 1994 quoted in Salen and Zimmerman, 2004) that are quantified with assigned values (Juul, 2003; Salen and Zimmerman, 2004).

The resources are managed through decisions making (Costikyan, 1994 quoted in Salen and Zimmerman, 2004). These decisions are oriented by the game's structure determined by rules that delimit the possibilities of the players (Juul, 2003; Salen and Zimmerman, 2004).

The game requires the active participation of players (Costikyan, 1994 quoted in Salen and Zimmerman, 2004; Juul, 2003; Schell, 2008) which in turn lead to a subjective experience (Schell, 2008). Obviously, this experience is safe and not threatening to the ordinary life (Juul, 2003; Koster, 2004; Salen and Zimmerman, 2004).

Most interestingly, Costikyan (1994 quoted in Salen and Zimmerman, 2004) defines games as art and as a form of culture.

1.3 Articulation between the concepts of 'play' and 'game'

We have defined the concepts of 'play' and 'game'. Some elements of the provided definitions are nevertheless shared by these two concepts. These elements are depicted in the following table (table 1):

Elements of definition	*Social scientists*		*Game designers*				
	Huizinga	*Caillois*	*Salen and Zimmernam*	*Koster*	*Schell*	*Costikyan*	*Juul*
Proceeds according to rules that limits players	✓	✓	✓				✓
Not serious and absorbing	✓						
Never associated with material gain	✓	✓					
Artificial, safe, outside ordinary life	✓	✓	✓	✓			✓
Create special social groups	✓						
Voluntary		✓					
Uncertain		✓					
Make-believe, representational		✓					
Goal-oriented, outcome-oriented			✓	✓	✓	✓	✓
Involves decision-making, learning				✓	✓	✓	
Experience					✓		
Form of art						✓	
Interaction of players					✓	✓	✓

Table 1. The elements covered in the definitions of ‘play’ and ‘game’

Overall, we could say that there is a distinct separation between the definitions proposed by social scientists and by game designers. Some elements of the provided definitions are nevertheless shared by these two concepts, *i.e.* (1) rules and (2) the character of being artificial, safe and outside of ordinary life.

All the quoted game designers grant a considerable attention to the experience of the user/player. Nevertheless, most of them have failed to integrate it into their definition: only Schell (2008) integrated experience to his definition. This might be related to the fact that the game is a means to the end; on their own, games are artifacts unless users/players play and interact with them (Schell, 2008). Therefore, the definitions are oriented toward the design of means, *i.e.* the video game itself, for the game designers and toward the end, *i.e.* the act of play, for the social scientists.

It is worth noting that all the game designers define a video game as *ludus* type games; they all underline the goal-oriented and outcome-oriented characters of games. These two elements are typical of *ludus* games.

2. Model and general design methods in video games

With the definitions of play and games and the description of their elements, it seems logical to turn to the model of this design domain. This model will be introduced with its main components. This will lead us to shed light on general prescriptive methods that are retrieved in this domain.

2.1 Model of video game design with three main components: game design, level design and gameplay

The model of video game design encompasses three main components. In this section, we describe these three components namely game design, level design and gameplay.

2.1.1 Game design

Game design did not appear with video games, it was used to design other games; board games for example need to have a game system with rules, and possibly a ludo-narrative structure and player experience (Guardiola and Natkin, 2005). In the video game domain, game design can be related to the design of an entertaining experience as well as issues related to interaction design (Ermi and Mäyrä, 2005).

Game designers are mainly responsible for designing three (not mutually exclusive) schemas: (1) *rules*, which consist of the formal game design schema, that focus on the essential logical and mathematical structure of the game, (2) *play*, which consists in experiential, social and representational game design schema that serve as a foreground to the player's participation in the game, possibly with other players and (3) *culture*, which consists in contextual game design schema that investigate the larger cultural contexts in which games are designed and played (Salen and Zimmerman, 2004).

At the core of the design of video games, game design refers to the set of processes that will prompt the user to be immersed in the fictional environment of the game unfolding in a software in order to make her/him become a player (Benoist et al., 2007). These processes refer to a set of sub-components to be designed such as the context of the game, the global scenario, the features of the game, the principles of gameplay, image and sound charts, and ergonomic principles (Gal, Le Prado, Natkin and Vega, 2002).

From this definition and these subcomponents, game design has to deal with the structure of the video game and its evolution to provide users with a fictional environment to build experience. This structure and evolution, in part, require the contribution of another type of design, which focuses on the levels of the game.

2.1.2 Level design

A game level encompasses a virtual space, a set of puzzles to be solved in this space, and typical actions that the players will perform in order to reach the goal of the video game (Gal et al., 2002). In this respect, level designers bring into the game specific arrangements of the architecture and challenges, in ways that are fun and interesting; in other words s/he will make sure that there is the right level of challenges, rewards, meaningful choices, and all the other things that make a good game (Schell, 2008).

Level design focuses mainly on problem solving, an element encompassed in the definitions of games. Following this, levels in video games are designed in such a way as to progressively increase the complexity of the problems to solve (Gal et al., 2002). These problem/s should be difficult enough so players do not get bored (Koster, 2004). They should also be accessible enough and not too hard, so players do not give up the game because it is not within their reach or ability to solve the problem (Koster, 2004). This specific component of video games is mainly based on human cognition and more specifically on learning curves.

2.1.3 Gameplay

In complement, the system in the fictional environment with its rules and progression - provided by game design and level design - will involve a transverse type of design that is gameplay, *i.e.* the experience that will be provided by the interaction of a player with the system in the fictional environment. There are many discrepancies related to definitions of gameplay in the literature. These discrepancies could be related to the points of view with which this component is defined. On the one hand, some researchers and members of the game community define gameplay by placing players at the core of this component. This results in definitions of gameplay based on the experiential perspective of the players. The gameplay, then, is the actualization of playability (Benoist et al., 2007) and the core of gameplay may be about the emotion of 'fun' (Koster, 2004).

On the other hand, gameplay can be defined by taking the point of view of the designer. In this case, the gameplay consists mainly in rules and goals. In this case, gameplay can be defined as the hierarchy of goals given to the players (Gal et al., 2002). These goals can be achieved by a "*dance that occurs somewhere between the dice, pieces, board, and the rules themselves, in and among the more rigid formal structures of the game*" (Salen and Zimmerman, 2004, p. 304)

These points of view on gameplay are discrepant and subject to a great debate, but we could see them as complementary; the point of view of the designer provides the tools that allows the point of view of players: 'the game is a means to an end'. It is worth noting that not all designers take the designer's point of view; it seems more dependent on the approach of design. In other words, designers with a user-centered approach of design will probably take the players point of view of gameplay and designers with a process-centered approach will probably take the designer's point of view of gameplay.

In short, these definitions with different points of view cover the range of user experience, which involves cognition, *e.g.* the rules and goals to solve a problem, emotion, *e.g*. fun, and behavior, *e.g*. the actions to access the playability (user experience will be covered in a following section).

2.2 Prescriptive methods of design

Prescriptive methods of design are not specific to video game design, but general methods for software design and/or other domains of design. Furthermore, they are prescriptive methods that both individual and collaborative design can follow. We will introduce three design methods namely waterfall, iterative and participatory design.

2.2.1 Waterfall method

Royce (1970) first introduced this design method. The waterfall model, developed for software design, is a sequential process composed of five steps: requirements, design, coding, test and maintenance. Each of these steps needs to be fully completed in order to proceed to the following step.

Many criticisms were formed against this design method. Software projects can be considered complex and this linear method was not quite able to reflect the complexity of this type of design. Thus, the waterfall model is not considered appropriate (de Hoog, de Jong and de Vries, 1994; Laplante and Neill, 2004; Schell, 2008). The reality of software development is that change is unavoidable and must therefore be explicitly accommodated in the development cycle (Laplante and Neill, 2004). As pointed out in a critique of the Waterfall method by Visser, (2006a), requirements fixed in the front-end of the design generally evolve during the design project and are sometimes found to be inconsistent throughout the designing and coding steps. Complications and technical glitches are not discovered until system performance is tested, when the system is almost entirely coded. Thus, the player experience is tested only at the end of the design process. It is thought that designers need more flexibility in software design methods (de Hoog, de Jong and de Vries, 1994).

However, the waterfall model had the benefit of encouraging developers to spend more time planning and designing before just investing the code (Schell, 2008).

2.2.2 Iterative method

In response to the limitations of the waterfall model, other design methods have been proposed. One of them is the iterative design method. Iterative design is a process-based design methodology proposing a cyclical process of prototyping, testing, analyzing and refining a work in progress (Salen and Zimmerman, 2004).

Prototyping and testing are at the core of the iterative model as designers create systems and test them; designers/participants critique the system, bend it, break it and re-fashion it into something new (Zimmerman, 2003). Prototype testing is used as a form of research for informing and developing further the artifact (Zimmerman, 2003) as it is not possible to fully anticipate play in advance. It is not possible to completely predict the experience of a game (Salen and Zimmerman, 2004). It is widely accepted that rapid prototyping is crucial for quality game development (Schell, 2008; Zimmerman, 2003) and it is considered as a valuable tool (Salen and Zimmerman, 2004). These designed prototypes constitute external representations used to communicate information between designers and between designers and users.

First, the decision to enter into the prototyping step is critical; moving too early without a clear concept wastes a lot of time, as it is simpler to change elements, functions, etc. in one’s mind than in the physical prototype. Moving too late may not reveal design weaknesses early enough and may require a complete redesign. (Knizia in Salen and Zimmerman, 2004)

Game prototype representations emphasize game rules, which are manifested as the internal logic of the game that is tied to the player's interaction (Zimmerman, 2003). Therefore, the initial concept of the game should be defined beforehand. When the concept reaches a sufficient level of maturity, the designers can start prototyping. The first playable prototype needs to be the simplest possible iteration of the core interactive idea (Salen and Zimmerman, 2004; Zimmerman, 2003).

Prototypes need to follow some rules that are meant for both designers and players. On the one hand, designers need to clarify "*exactly what* [they] *want to test and how*" in order for testing to be successful (Zimmerman, 2003, p. 4). Pinpointing the right question and designing the prototype accordingly will provide answers that designers are seeking without costing the designers the time and effort of irrelevant and inadequate iterative cycle/s. This seems essential as the amount of time and money to test and adjust the system is greater for a video game than for traditional games (Schell, 2008). On the other hand, early prototypes can and should be developed through the 'quick and dirty' method (Schell, 2008). In this way, the users might be more inclined to renegotiate features than if it is a more realistic and high-tech prototype (McDonnell, 2010a).

When a game prototype is designed according to the goal targeted by designers, play-testers come into the design process in a particular context. Designers should not get involved in what play-testers do; they should look at what they actually do, rather than telling how the prototype is supposed to work (Salen and Zimmerman, 2004; Zimmerman, 2003). As iteration starts as users test the game prototype, designers could try out different parameters and immediately see how they have affected the experience, adjusting the rules to arrive at a different kind of play (Zimmerman, 2003).

In the iterative design process, the most detailed thinking designers need at any moment is the one that will get them to their next prototype (Zimmerman, 2003). To inform and develop design prototypes, designers will pass through analyzing and refining steps. The results from the testing step will be at the core of these two steps. Hence precision and clarity in what the designers want to test is important. In that regard, Schell (2008) suggests that every prototype should be designed to answer a specific question, and sometimes more than one.

With iteration, the design process develops through an ongoing dialogue between designers, external representations and the testing audience (Zimmerman, 2003). With the results of the testing step, the designers will be able to state the problems in more detail; they will look for problems and figure out how to fix them (Schell, 2008). The refining step is the phase where designers will search the solution space to select one solution that will satisfy the identified problem.

In this design method, game designers can become players and the act of play can become an act of design (Salen and Zimmerman, 2004). This can be seen as a double role. It can also apply to other actors; testers can be players and the act of play can become potentially an act of design.

It is worth underlining that the iterative design method can be complemented by participatory design, which we describe next.

2.2.3 Participatory design

Participatory design seeks to involve users as co-designers more deeply in the design process by empowering them to generate design alternatives within many approaches and techniques (Fischer, 2003). Furthermore, it provides opportunities to users to share emotions, experience and representations (Fischer et al., 2005). However, its benefits and success can be thwarted if conducted in the late stages of design (Fischer, 2011).

Different levels of participations can be described. On the one hand, participants can test a product and thus participate in a user-centered approach (Ermi and Mäyrä, 2005). Regardless of the method used to evaluate user experience, this evaluation refers to a level of contribution that can be retrieved in the waterfall, iterative and participatory design methods. On the other hand, participants can assume roles such as users, testers, informants and co-designers (Druin, 2002; Ermi and Mäyrä, 2005) and thus, provide a wider range of contributions. These levels of contributions are retrieved in the participatory method.

As users, participants will use the technology to try to understand the impact that existing technologies have on users, so future technologies can be changed (Druin, 2002). In that sense, they become aware of the possibilities offered by the technology (Fischer, 2011). As testers, the participants will test the technology to change the way future iterations of the designed technology are developed (Druin, 2002). As informants, the participants will play a part in the design process at various stages to offer input and feedback (Druin, 2002). Finally, as co-designers, participants will, as equal stakeholders in the design of technology throughout the entire experience, contribute to the process in ways that are appropriate to the final users and to the process (Druin, 2002).

The participatory design approaches give three sets of advantages related to the participation of users: (1) providing a set of user data and feedback; (2) producing, testing prototypes; and (3) collaborating in the development of the design process (Humphreys, Leung and Weakley, 2008). However, one cannot just ‘add users and stir’ (Muller and Druin, 2002); participatory design is not without difficulties; it provides rich and diverse data that needs to be properly processed.

Accessing information related to user experience is of great value as it can provide inspiration (Visser, van der Lugt and Stappers, 2007). This information however is not regarded as the definitive and unquestionable truth, but should be analyzed and interpreted by the designers (Ermi and Mäyrä, 2005). The challenge of participatory design arises from the problems of interpreting the data from various project actors and from the application of the results in the design (Ermi and Mäyrä, 2005). User experience will be further developed in the next section.

With a high level of user involvement, users work with information from the company instead of the opposite. Consequently, users can gain remote information that they can combine in a creative way; “*the user who generated an idea for a new product on the basis of personal and sticky information in combination with newly acquired company information will suggest a product idea that is likely to be perceived as original, valuable, and realizable (i.e. creative)*” (Kristensson et al., 2004, p. 7).

2.3 External representations in video game design

Design methods are supported by various external representations that fulfill a wide range of functions. In that respect, external representations in video game design can be of many forms. Schell (2008) posits that external representations can be oriented toward:

- Design encompassing (1) game overview, *i.e.* what the game is, such as documents which serve as support for archiving ideas and for communication supports to inform the design team, and (2) story overview which encompasses the dialog and narration in the game;
- Engineering encompassing (1) technical design documents which are documentations of the system architecture, (2) pipeline overview which specify the 'do's' and 'don'ts' the artists must adhere to, (3) system limitations, (4) art bible which provide guidelines to the look and feel and can provide examples of environment, of color usages, of the interface, or anything that defines the look of any element in the game and (5) finally the art overview document which presents how the game is going to look like, based on a set of images;
- Management encompassing (1) the game budget, (2) the project schedule, (3) the story bible, *i.e.* change of the story throughout the design process, (4) the scripts, *i.e.* the dialog to be implemented, and (5) the game tutorial and manual.

These cover a wide range of external representations, whether these are or not specific to video game design. As game design *is* design, the external representations presented in the two previous chapters are as much relevant in this particular kind of design. Notwithstanding, testing in waterfall and iterative design and users' involvement in participatory design are at the core - at least for the last two - of these design methods. Therefore, prototypes can be viewed as having a central role amongst external representations.

3. Video game as an interactive display providing player experience

The definitions of concepts and components of video game model point out what designers can take into consideration in order to design a video game. These elements to be taken into account can be developed in participatory design with different participants.

In game design, Schell (2008) points out that a core team should be established on the basis of who is both *interested* and *productive* in different kinds of design sessions with the responsibility of informing the rest of the team about the decisions made. This practitioner has also drawn up a typical design process with the various participants involved (restricted to the design team) as follows:

- Initial brainstorming should involve as many members of the team as possible;
- Independent design should be carried out independently by the core team;
- Design discussions should be conducted between the members of the core team to pool their ideas, discuss them and try to reach a consensus;
- Design presentation should be presented to the whole team by the core team in order to share the progress, allowing time for comments and criticism from the whole team. This often turns into brainstorming, kicking off the next round of the iterative cycle.

This depiction characterizes the limited scope of the design team. Gradually, the design team is surrounded by the development team, by other people in the office, and/or organized groups of testers that match the targeted audience throughout the entire design process (Zimmerman, 2003). In that respect, the design team can determine who should participate and at which level to gather feedback (Schell, 2008):

- Developers are available and can give considerable and meaningful feedback. However, as they can be considered too close to the game, this might distort their opinion.
- Family and friends can also be available. However, they might be biased and be predisposed to like the game.
- Expert gamers such as ‘hardcore gamers’ have an expertise of many games that are similar to the one being designed and can give detailed accounts of how the designed game distinguishes itself from games of the same gender. However, these experts in one game gender often require more complex and difficult gameplay challenges than an average gamer. Thus, they represent a small proportion of potential end-users.
- ‘Tissue testers’ are the ones that have never seen the designed game before. Thus, they bring fresh eyes that could notice things that the designers may be accustomed to seeing. They would be interesting for questions related to usability, communication and the initial appeal of the game. However, as games are played and re-played, testing the designed game with tissue testers does not provide designers with feedback on their experience over time.

These different stakeholders can be introduced within rich ecologies of participation that propose different levels of participation based on different levels of expertise, interests and motivations (Fischer, 2011). They will potentially provide valuable information for game design.

The valuable information can be related to the specficities of video game that is to say player experience. In the next sections, we will develop the player experience. For that, we will emphasize its specificities in video games, definition and methods of evaluation.

3.1 Video games: a strong focus on player experience

It is obvious that video games are encompassed in the domain of human-computer interaction (HCI) as they are software programs ran on computers that are used by people via an interface (Barr, Noble and Biddle, 2007). However, academic and practitioners communities agree that video games are distinctive to the traditional focus of HCI. Numerous accounts underline differences in the specificities of the experience provided by HCI and video games. This experience is related to the gameplay component of video games and more precisely to the ludic character of the software.

Barr et al., (2007) summarized contrasts between video games and HCI by their interaction-centric points:

- Games focus on the process of use (gameplay) rather than on the results of that process;
- The goals of games are usually defined and motivated within the game world, while the goals of productivity applications are generally defined outside the application that is by the task;
- Games actively encourage a variety of experiences while productivity applications strive for consistency;
- Games impose constraints on the user while productivity applications seek to remove them;
- The use of sounds and graphics in games is to convey moods and environments rather than functionalities;
- The degree of innovation in games tends to exceed that of productivity applications in both content and control systems.

Except for the last point, these distinctions between productive applications that fall into HCI and video games are mainly linked to the notion of experience encompassing a designer's point of view, *e.g.* goal and rules, and a user point of view, *e.g.* gameplay and moods. We could add a point related to the notion of experience that is considered by Schell (2008) as an additional constraint that productivity applications do not have; video games need to be designed in order to be fun for the players.

Despite the fact that HCI and video games are quite different in their experiential nature, they nonetheless share one main structural characteristic: the plasticity of software (Burkhardt and Sperandio, 2004). Tschang and Szczypula (2006) consider the plasticity of software as a common feature, which allows video games to be re-shaped or re-organized to fulfill different needs.

We will shed further light on the experiential component of video games that distinguish them from other HCI.

3.2 Definition of player/user experience in game design

Player or user experience is related to several concepts still debated in user studies and game design. Nonetheless, the proposed concepts share a common characteristic; they all encompass the emotional, sensorial, cognitive and behavioral spheres. Furthermore, some of these proposed concepts are highly related to the notion of pleasure: entertainment, fun and enjoyment.

One concept to define player experience is *entertainment* (Koster, 2004; Schell, 2008; Tychsen, 2008). This concept has been defined as an affective response to entertainment products (Tychsen, 2008) and is related to intensity (Koster, 2004) of that affective response. This concept of entertainment has been described to encompass the notion of surprise as a crucial part; "*it is at the root of humor, strategy and problem solving*" (Schell, 2008, p. 27).

A second concept that has been investigated is *fun*, which can happen via physical stimuli, aesthetic appreciation and arises out of mastery and comprehension (Koster, 2004). Fun consists in different motivations and reception factors that can vary as a function of the game, the players and the play context amongst others (Tychsen, 2008). It results in multi-modal (Tychsen, 2008) feedback as an individual absorbs patterns for learning purposes; it is about learning in a context where there is no pressure (Koster, 2004). It is related to pleasure with surprise (Schell, 2008).

However, these concepts have not been operationalized in further detail. This makes their use difficult and questionable in academic research.

The third concept of *enjoyment* has been brought up to characterize the game experience by adapting the flow theory (see Csikszentmihalyi, 1996) to create a model for measuring flow in gameplay (Salen and Zimmerman, 2004; Sweeter and Wyeth, 2005) or as one measure of player experience (Nacke et al. 2009). Flow is an experience "*so gratifying that people are willing to do it for its own sake, with little concern for what they will get out of it, even when it is difficult or dangerous*" (Csikszentmihalyi, 1990 quoted in Sweeter and Wyeth, 2005, p. 3).

Flow is considered to be relevant to game design as the heightened enjoyment and the engagement of the flow state is exactly what game designers seek to provide to players (Salen and Zimmerman, 2004). Moreover, the heuristics in the video game literature were found to overlap closely with the core elements of flow (Sweeter and Wyeth, 2005). These researchers compared elements from usability and user experience in the video game literature to the notion of flow in order to operationalize the *Gameflow* model, which consists of eight core elements (table 2).

Game literature	*Flow*
The game	A task that can be completed
Concentration	Ability to concentrate on the task
Challenge player skills	Perceived skills should match challenges and must exceed a certain threshold
Control	Allowed to exercise a sense of control over actions
Clear goals	The task has clear goals
Feedback	The task provides immediate feedback
Immersion	Deep but effortless involvement, reduced concern for self and sense of time
Social interaction	N/A

Table 2. Core elements of game and flow in Gameflow model (Sweeter and Wyeth, 2005)

Each core element is rated on a Likert scale and then summed up to give a score which provides insight on what makes a particular game enjoyable and how. The Gameflow model is designed mainly to understand enjoyment in games. The concept of enjoyment is operationalized here through flow, and covers quite well the range of user experience spheres: emotional, *e.g.* involvement and immersion; sensory, *e.g.* feedbacks; cognitive, *e.g.* concentration; behavioral, *e.g.* completing a task.

This model can be attractive for academic research because of its usability and its operational character. However, it proposes several entangled levels of core elements; the characteristics of the game/activity, *e.g.* goals and feedbacks, are intertwined with the effects of the game/activity on player, *e.g.* immersion and concentration. It has nonetheless the potential of combining the designer's and player's perspectives on gameplay.

3.3 Methods to evaluate player experience

There are several methods to evaluate the player experience that can be used in the design methods mentioned above, *i.e.* waterfall, iterative and participatory design. Evaluations of player experience range from biometric measurements to game metrics *via* heuristic evaluation. Like the definition of player or user experience, consensus toward *the* method to assess player experience is still lacking both in the research and game development communities. This could be due to the fact that no consensus on the user experience concept has been reached and these different methods bring different types of feedback. However, the complementarity of some methods is largely accepted in these communities.

Heuristics and usability guidelines are proposed as a method to assess efficiency, efficaciousness and satisfaction criteria in an interface (Benoist et al., 2007). It has been pointed out that HCI professionals could offer fresh view to both the design and the evaluation of the software product, and if they also have gaming experience, they could apply their knowledge and expertise successfully to the ludic software (Federoff, 2002). The main criticism that can be addressed to this method is that it is not specific to video game but to software in general and that it covers only in part the spheres of user experience, *e.g.* emotion, sensation, etc. Nevertheless, it seems important to use this method in order to ensure a good basis in the video game.

In another line of research and practice, biometric measurements method have been proposed as an indirect mean to access emotions and vigilance (Benoist et al., 2007) as well as playability (Nacke et al., 2009). These methods can rely on physiological, *e.g.* skin temperature, heart rates; behavioral; and neurological, *e.g.* electroencephalograms and functional magnetic resonance imaging, measures (Nacke et al., 2009; Tychsen, 2008). However, the restricted feedbacks from these measurements make this method unable to stand alone, and in need of being complemented by more qualitative methods (Benoist et al., 2007; Tychsen, 2008).

With regard to qualitative methods, interviews with players are commonly used. With this method, the designers can figure out the *why*, *e.g.* 'why do players find specific game design elements or situations in the game particularly arousing, frightening or fun?' which provide an access to the underlying causes of player's reaction (Tychsen, 2008). This method can be carried out either in open interviews, semi-directive interviews or questionnaires (Benoist et al., 2007).

A more interactive method is the open play-test, or user testing. It is a test of user experience with a prototype (Schell, 2008) that aims to analyze the reactions of the players in terms of gameplay (Benoist et al., 2007; Nacke et al., 2009). In these play-tests, the playability, fun and ergonomics of the game are tested (Benoist et al., 2007). The results of the play-tests are relevant and worth gathering for designers; the players are experiencing a near-real situation (Benoist et al., 2007), unpredictable behavior of players can be detected (Desurvire, Caplan and Toth, 2004) and can provide a means to access concepts that are not evaluated through other methods (Sweetser and Wyeth, 2005).

These methods allow to some extent the designers to carry on user-centered evaluations by accessing and assessing the player experience. Nevertheless, a number of studies highlight the fact that specific methods, *e.g.* biometric measurement, game metrics, etc., could not assess all the parameters of player experience and thus, would need to be combined with user testing (Desurvire et al., 2004; Nacke et al., 2009; Sweetser and Wyeth, 2005; Tychsen, 2008) or would need to combine several methods as they are complementary (Benoist et al., 2007).

In addition, the genre of the game, *e.g.* musical games, first-person shooter, but also its remoteness from classical features in video games, *e.g. païdian* versus *ludus* games, and the expectations regarding each type of player, *i.e.* persona as a representation of a group of users with their goals, behaviors and limitations, can differ widely. The methods and the criteria used should be suited to each type of game and player as their activity can be influenced by these variables while testing a video game. For example, "*people are likely to select problems that they think they have a chance at solving… different people bring different experience to the table that leave them with differing levels of ability in solving given types of problems*" (Koster, 2004, pp. 100, 104). If a game is oriented toward spatial navigation or logic, the activity will differ greatly. Additionally, the activity will also vary depending on the level of ability of the players facing a specific type of problem. These variables could be involved in the difficulty of stabilizing an evaluation protocol accepted by the diverse communities related to video games.

It is worth noting that the ultimate goal of assessing player experience is that designers need to think about what the players really care about and why, and from that, gain insights about how their game can be improved (Schell, 2008). Thus, an adequate and appropriate approach to gain these insights seems important for the designers and their designed product.

4. Toward empirical studies on creativity in video game design

Design methods have been well documented in both theoretical and empirical approaches. The video game domain has also a considerable body of literature focused on its design activities. However, creativity in game design has not been studied as much as in other design domains, *e.g.* architecture, engineering, etc. Nevertheless, a few studies have appeared recently in the fields of innovation management and art.

Based on an analysis of ten design studios, Parmentier and Mangemating (2007) advance that creativity can emerge from two axes of activities in game design: (1) exploratory activities are focused on the search of new game concepts, game engine and refer to the experimentation of several alternatives to test new solutions or new universes and (2) exploitation activities that consist on the enhancement of existing concepts and refer to a refinement and extension of competences, technologies and existing paradigms.

Tschang and Szczypula (2006) identified several creative design processes potentially present in these two activities, and involved in video game design from both interviews with designers and ethnographic observation. These authors highlight cognitive design processes such as analogical reasoning, combination and at another level, shifts of perspectives - referred to as *taking the opposite viewpoint* -.

Following another perspective, Jeffries (2011) identified several skills required to spur creativity from interviews with academics and practitioners. This author underlines skills (1) agreed on by both academics and practitioners, such as the ability to analyze a game and (2) highly rated only by practitioners as (a) working within gameplay rules, (b) being a creative facilitator, *i.e.* bringing other people’s ideas into the game, (c) having an overall vision of the game and (d) skills in design/level design. The ability to analyze a game could be related to what Salen and Zimmerman (2004) mention as being required in order to create new games, *i.e.* the understanding of systems, interactivity, player choices, actions and outcomes.

Although some of these studies are based on empirical data, there is still a need to analyze the real-world activities of designers in the video game industry, and more specifically in creative game design.

User studies, as studies on user experience, have also recently encountered a tremendous growth. Indeed, this field of study expands its view to a holistic one to encompass elements from various spheres, *e.g.* emotional. Furthermore, user experience has attracted increasing interest from companies aiming to develop innovative user-centered products (Visser et al., 2007). This could explain the current growth in this field of research.

We mentioned that restricted semiotic systems taken into account in research on creative processes limit the ability of researchers to study the potential experiential role of external representations. The video game domain allows us to shed light on the experiential role of external representations; the use of video game prototypes by players makes the access possible to user experience covering several spheres that are retrieved in the experiential role of external representations.

In the next part, we will introduce the context and the research framework of this dissertation. This will start with the description of the design of the video game we followed.

Summary

In this chapter, we defined video games with two key concepts that are *play* and *games*. These two concepts have been defined by social scientists and game design communities respectively.

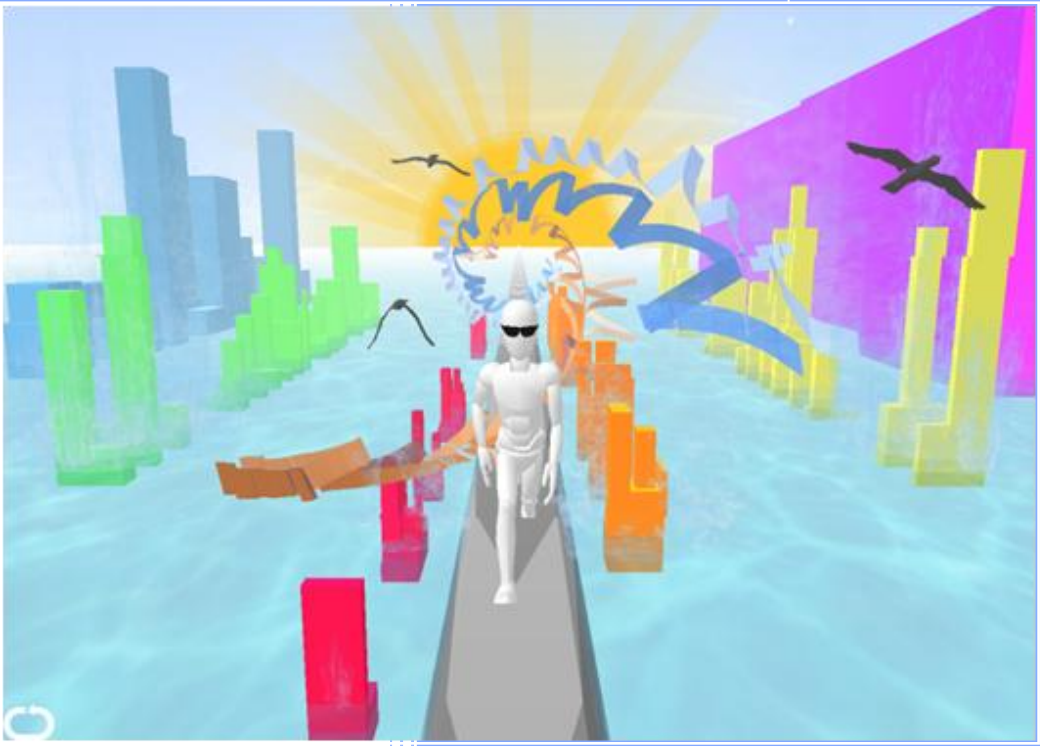
The model we use to describe the main components of a video game was then introduced. We defined game design, level design and gameplay. These three components can be developed through prescriptive design methods such as the waterfall, iterative and participatory design methods that are used in Human-computer interaction (HCI) amongst others. However, there is a distinction between productive applications from HCI and video games that lies in the emphasis on user experience.

We further developed this concept of user experience through several notions, *i.e.* entertainment, fun and enjoyment, spanning over the emotional, sensational, cognitive and behavioral spheres.

Following this, we described some evaluation methods used to assess user experience: usability guidelines, biometric measurements, interviews and open play-tests. The latter can be carried out with various types of users/players and lead to various levels of contribution from users/players. Moreover, in these play-tests, prototypes, viewed as core external representations, allow communication of designers with each other, as well as between designers and users/players.

This chapter ends with a brief description of a few studies focusing on creativity in the domain of video games. Creativity has been scarcely studied in video game design. In this dissertation, we intend to study creativity in the design process of a video game.

PART II – CONTEXT AND RESEARCH FRAMEWORK



Chapter 5 Context of the research field

This chapter aims to introduce our research field. In that respect, we will first describe its global context. Then, we will develop in further details the whole design process. This will lead us to introduce the design group that contributed throughout the video game project. This will provide an overview of the context in which our research unraveled.

1. Research field: a design process with high potential of creativity

In this section, we will develop our research field by giving a global description of the design of the musical video game we studied. We will start by giving information that oriented the choice of our research field. Then, we will provide an overview of the design process and the team involved in the design process. We will end this section by describing the video game that we studied.

There are several reasons that oriented our choice toward our research field. It was selected as the game studio, Mekensleep, aimed to create a new concept of musical video game. It presumes that the design process could encompass creative solutions. Moreover, the game studio was previously awarded for their last video game; it won the award of the best video game as well as the most creative one. Differently, Mekensleep has flexibility to carry on the design process; it has no direct economical issues, nor temporal constraint. These two characteristics of the design project make it a good candidate for studying creativity (Runco, 2004). At last, the design process driven by different designers/participants provides a diversity of backgrounds and knowledge. We presumed that this particular context could unleash creative potential.

We started an immersion in the game studio in Febuary 2009 and stayed until March 2010. During this period, we follow the design process of the musical video game called Hanabi. The design process unfolded with the development of different prototypes with an iterative method of design. These different prototypes were developed by different design groups that brought different knowledge and backgrounds into the design project. Yet, a core team, *i.e.* a project director and a coder, was transversal to all the design process and prototypes developed.

For each prototype designed, iterative cycles were carried out by designers. In these iterative cycles, contributions were made by designers of the design group, external individuals, *i.e.* other designers in the design studio or external to the design studio, and players. The contributions were also provided during structured events, *e.g.* video game conference or play days[2]. With this characteristic, the design process lies within a participatory design context.

[2] Play days were organized by the project director. Different individuals with different knowledge and background but with a shared interest toward games were attending. The aim of these play days was to play different types of games ranging from social game to video games. During these play days, the project director took opportunities to invite some individuals to use, test and potentially contribute to the design of the music video game.

The described context led to the description of the design artifact, the musical video game *Hanabi*. The idea of the video game was oriented toward a ‘way of playing’ that is specific of *paidian* games, *i.e*. improvisation and lack of pre-specified goals (Caillois, 1958). This ‘way of playing’ is not so well represented in the available musical video games on the market according to the project director. Consequently, it could afford creative potential at least for a *paidian* video game as it can be considered as a nonroutine design activity.

Notwithstanding, the idea of the video game was inspired by the musical video game *Rez* from which the fundamental concept of the game was taken: the principle of interaction-sound-image. This source of inspiration could be qualified as a *ludus* musical video game, *i.e*. the opposite of *paidian* games as they offer specific goals to be reached and rewarded.

The musical game can be described as a single player game in which the player uses a joystick to arrange - rather than compose - musical tracks of different instruments available. The player can make use of long and short tracks for each instrument. The long ones encompass several notes of an instrument. They can either be manually activated or be locked so that the player can focus on other instruments to include in her/his arrangement. The short ones encompass only a note or a chord of an instrument.

The soundtracks - longs and shorts - have an impact in the environment; the visual environment of the game changes in function of which soundtracks have been activated. Futhermore, it provides feedbacks for the players on which soundtracks are activated. The visual environment is composed of a character evolving in a mix water-city surrounding.

The video game began with abstract visual representations and ended up with figurative representations (photos 2). In addition, it started with the absence of reward and ended up with two reward systems linked to the character.

Photos 2. Evolution of Hanabi

It is worth to note that the Hanabi project was aborted in March 2010 and was supposed to be reinvested later. This is why creativity rather than innovation will remain the main focus in this dissertation; the crafting or realization to diffuse the creative solutions considered as innovation could not be observed (Asselineau and Piré-Lechalard, 2008; Kristensson et al., 2004; Shalley and Zhou, 2011).

2. A design process encompassing several prototypes developed with iterative cycles

In this section, we will detail further the global design process. We will develop further the prototypes involved in the design process. Then, we will introduce the iterative cycles that were retrieved in each prototype.

The global design process can be described by its types of prototype (table 3):

- The first type of prototype[3] was the 'abstract *païdian* interaction-sound prototype'. It corresponds to a prototype in which the interaction of a player gave auditory feedbacks, *i.e.* the musical soundtracks.
- After, designers integrated the third fundamental component which is 'image' into the former prototype. This led to the design of the 'abstract *païdian* interaction-sound-image prototype'.
- Then, the designers added a new experience; they introduced a *ludus* experience which resulted in an 'abstract half *païdian* half *ludus* interaction-sound-image prototype'.
- Not long after this and evolving in parallel, the designers transformed the abstract visual representations into figurative ones. Thus, they designed the 'figurative half *païdian* half *ludus* interaction-sound-image prototype'.
- Finally, the 'figurative half *païdian* half *ludus* prototype' turn into the 'figurative half *païdian* half *ludus* prototype with new music composition' when designers introduced new soundtracks. For this prototype, the visual environement had to be changed and reinvested to match the new music composition. It evolved partly in parallel with the 'figurative half *païdian* half *ludus* interaction-sound-image prototype'.

ID	Prototypes	Start	End	2009										2010	
				mars	avr.	mai	juin	juil.	août	sept.	oct.	nov.	déc.	janv.	févr.
1	Abstract païdian interaction-sound	02/02/2009	04/06/2009												
2	Abstract païdian interaction-sound-image	05/06/2009	28/08/2009												
3	Abstract half païdian half ludus interaction-sound-image	31/08/2009	22/12/2009												
4	Figurative half païdian half ludus interaction-sound-image	07/10/2009	22/12/2009												
5	Figurative half païdian half ludus interaction-sound-image with new music composition	20/11/2009	22/03/2010												

Table 3. Prototypes in the design process

The shift from one type of prototype to another can be described as an 'incremental' evolution. The designers proceed to a refinement of the musical game by making the prototypes progress. For example, the shift from the 'abstract *païdian* interaction-sound prototype' to the 'abstract *païdian* interaction-sound-image prototype' was an incremental evolution; the third component 'image' of the fundamental concept was added.

[3] During this prototype, no observation was made as the designer responsible for it was working outside the game studio.

Alternatively, the shift from one to another type of prototype can also consist in an evolution 'of rupture' with conceptual shift; the shift from one prototype to another was not anticipated and was triggered by a new orientation, a new solution. This was osbserved in two cases: the shift to the third prototype 'abstract half *païdian* half *ludus* interaction-sound-image' and the shift to the forth prototype 'figurative half *païdian* half *ludus* interaction-sound-image '.

In the first case, the shift to the third prototype was triggered by the implementation of a solution, a reward scale, initiated by a designer. This implemented solution led the designers to consider the introduction of a *ludus* experience, *i.e.* introducing rewards and specific goals, in the prototype. From this point, the design process was devoted to this new orientation.

In the second case of the shift to the forth protype, a designer proposed to transform the visual representations into clouds after a photo shooting session - personal activity performed outside the design process -. This proposed solution led the designers to invest the new orientation consisting in the introduction of figurative visual representations.

These two conceptual shifts occurred approximately at the same moment of the design process. The designers had to go over conceptual phases after these two shifts; the designers had to re-define the problem and the broad characteristics that would be implemented in the new prototypes.

Thus, the global design process encompasses five prototypes. Three of them were 'incremental' evolutions and two of them were evolutions 'of rupture' with conceptual shift. For each of these new prototypes, the designers started a new iterative cycle.

Iterative cycle consists in steps of refining, prototyping, testing and analyzing (Salen and Zimmerman, 2003). The designers started by refining a concept and then, they steped in the phase of prototyping to implement the defined concept. The implemented concept was tested and results of the test/s were then analyzed to start back another cycle. We observed that the designers went throught all these steps within each iterative cycle. Furthermore, in each of the prototype, designers performed several iterative cycles.

The iterative cycles were characterized by uses of external representations, *e.g.* video games, books, white board, etc. (see annex 1 the spatial representation of the game studio and localization of external representations) specific to each step (figure 4). These external representations supported the designers to answer questions specific to each step, *e.g.* 'how to refine a concept with the musical video game Rez?', 'how to code this function according to a code librairy?', etc.

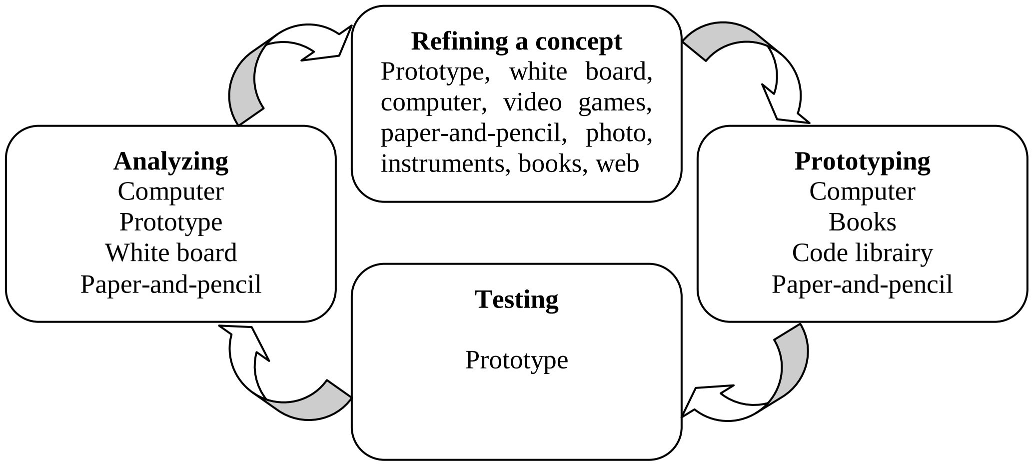


Figure 5. Iterative cycle and external representations

These steps of the iterative cycle were also carried out with the contributions of a diversity of designers and participants (figure 5). The steps refining a concept and analyzing were ran by designers of the design team but also by external participants. Differently, the prototyping step was driven by coder/s. Finaly, the step of testing was performed by play-testers.

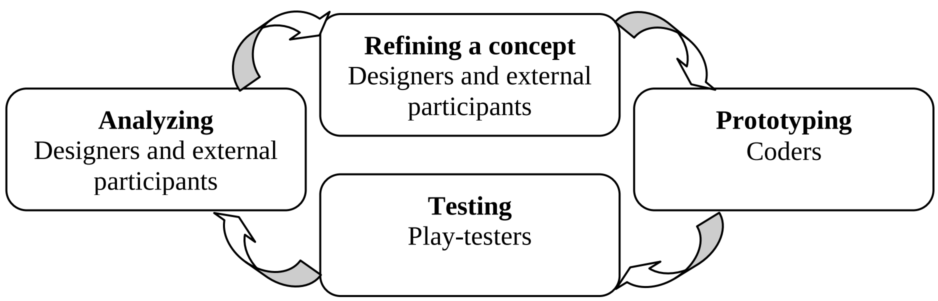


Figure 6. Iterative cycle and actors

We will turn next to a description of designers and participants in the global design process.

3. Diversity of designers and participants

The global design process was conducted with designers and participants from different domains of knowledge. These designers and participants were from:

- Video game domain, *i.e.* game designers, level designers, coders, developer, editor, but also different personas of players, *e.g.* hardcore gamers, casual gamers, hardcore gamers of musical video games, etc.;
- Art domain, *i.e.* art director, graphic designers, graphic artist, infographist;
- Music domain *i.e.* music designer, musicians;
- Other domains, *i.e.* historian and participant in public relations.

These designers and participants contributed to the design process by request or in an opportunistic manner, *i.e.* without being asked for.

The collective evolved throughout the design process. As the prototypes were more complex and conceptual shifts occurred, the design group integrated new designers with specific expertise, *e.g.* a graphic artist for the 'figurative half *païdian* half *ludus* interaction-sound-image prototype'. In addition, we mentioned that the steps 'refining' a concept, 'analyzing' and 'testing' - although this latter has restricted collaboration - of iterative cycles could involve the contributions of external participants. For these prototypes and steps of iterative cycles, contributions came from diverse designers and participants summarized in the following table (table 4). These are from video game, art, music and other domains such as history and public relations, and play-testers.

Prototypes	*Video game*	*Art*	*Music*	*Others*	*Play-testers*
Abstract *païdian* interaction-sound prototype (Feb. to May)	x				x
Abstract *païdian* interaction-sound-image prototype (May to Aug.)	x	x	x	x	x
Abstract half *païdian* half *ludus* interaction-sound-image prototype (Aug. to Dec.)	x	x			x
Figurative half *païdian* half *ludus* interaction-sound-image prototype (Oct. to Dec.)	x	x			x
Figurative half *païdian* half *ludus* interaction-sound-image prototype with new music (Oct. to Mar.)	x	x	x		x

Table 4. Knowledge domains of designers and participants involved in prototypes

The different domains represented brought a considerable level of diversity; the diverse domains brought different knowledge and backgrounds in the design process. As we underlined earlier, diversity of the group is important for the construction of the design team in order for them to be creative (Milliken et al., 2003; Nijstad et al., 2003; Paulus, 2010; West, 2003).

Regardless of their domain of knowledge, participants involved in the global design process can be categorized according to their affiliation to the design team. The categories are core team, contractual designers, surrounding workers and external participants.

The **core team** has worked for the *Hanabi* project from the start until the end and was based in the design studio. This group had access to all the external representations related to the musical video game and had the right to modify them. In addition, they were the ones who provided access to specific design documents to the other designers/participants. Finally, it was one or two members of the core team that conducted meetings with other designers/participants. The core team is composed of two designers, *i.e.* the project director and the coder.

The **contractual designers** worked for few months with the core team as apprentice or free lance designers. They were generally based outside the studio and they came to the studio for meetings. These designers had access to external representations related to their field of expertise or to their responsibility, *e.g.* graphic design, code. Moreover, their rights of modification were restricted to their field of expertise and were under the supervision of the core team. There was an apprentice coder, a graphic designer and a musician.

The **surrounding workers** are designers working in the design studio. They had opportunities to have a vision on all the projects developed in the design studio. At some points, they engaged in opportunistic collaboration and thus contribute to the *Hanabi* project from their own will. In other cases, they contributed when requested. These surrounding workers had access to document and prototype that were presented to them by the core team, but had no right to modify them.

The **external participants** are individuals, *i.e.* participants of various domain or players, outside the design project and the game studio that interacted mainly with the project director or the entire core team. These participants were at some point invited to come to the design studio or they did so in a more opportunistic way. Thus, they could be asked to play-test and/or discuss about the prototype. These participants only had access to the prototype they interacted with and had no right to modify document or prototype.

These designers and participants could contribute to the design project in an opportunistic manner, in an ephemeral collaboration, in medium-term or in long-term collaborations. The designers and participants contributed to the development and evaluation of the video game in different ways throughout the design process.

In the next chapter, we will intoduce our research framework. In that respect, we will introduce our problematic and develop the methodology that was adopted in this dissertation.

Chapter 6 Theoretical and methodological framework

This chapter aims to develop our research framework. In that respect, we will first introduce our theoretical framework and research questions. Then, we will describe the methodology we adopted to answer our research questions.

1. An approach focused on creative processes and products

Hitherto, few studies in creative design have analyzed interactions between professional designers. Indeed, "*few studies of designers collaborating have focused on creativity although team behaviors have been studied from a creativity viewpoint where team members were not designers in the traditional sense*" (Gero, 2010, p. 17). This might explain the absence of the interactional approach in creative design compared to collaborative design research. This latter has a considerable body of studies adopting this approach. Furthermore, interactions between professional designers in their ecological setting are even less stressed as an object of research in group creativity. This object of research is the focus of this dissertation. In that respect, we will adopt the position in which dialogue is a means to approach cognitive and collaborative mechanisms intervening in a collective design activity (Darses et al., 2001; Détienne et al., 2009).

Additionally, creativity studies usually analyze one the four focuses of creativity, *i.e.* persons, places, products and processes. In the creativity literature, processes have been widely studied. However, this is not the case for products; products have been studied to a much lesser extent (Plucker and Makel, 2010). If these focuses of creativity have been studied separately, emphasis on products combined with processes is a research goal that remains to be achieved. In that vein, we will take, in this dissertation, account of both products and processes.

In regards to the video game domain, these limits are also retrieved. Indeed, there are few if any empirical studies focusing on interactions between designers. Moreover, few empirical studies have focused on collaborative activities and creativity. Thus, the need to shed light on collaborative creativity processes and their outcomes is still a current issue in this domain.

Consequently, our goal is to shed new light to the long-established research field of creativity. In order to reach this goal, our research questions aim to identify the specificities of creative solutions by seeking to characterize and understand forms of collaboration and socio-cognitive design processes involved in their generation.

For that, we undertook an original approach that takes into account both processes and products through different viewpoints. The processes are studied through content, interactional and longitudinal analyses. They are invested through a third-person viewpoint that is our analyses as observer. We will also consider products, *i.e.* solutions, through an evaluation of solutions' creativity by the designers themselves. This represents the first-person viewpoint. These two viewpoints are then crossed.

2. Research questions

The processes and products are analyzed through third-person and first-person viewpoints in order to answer several research questions. We will introduce our research questions in this section. First, we will develop the ones related to processes and then, the ones related to products. Finally, we will end this section by introducing the ones related to the crossing of processes and products.

Processes. We mentioned that the design process of the video game *Hanabi* involved a wide range of designers and participants. These co-designers can participate differently in collaboration. Furthermore, some of the co-designers participate to the design process for specific purposes, *e.g.* bringing their expertise to the design process, evaluate prototype, etc. These characteristics of the design context can trigger the emergence of particular collaborative and design processes. Our analyses of these processes invested through a third-person viewpoint aim to identify and understand:

- Forms of collaboration, *i.e.* collaboration formats as recurrent adjacent pairs of collaborative design activities;
- Socio-cognitive design processes, *i.e.* design processes distributed amongst the designers and participants.

In order to appreciate the variety of collaborative and design processes, we will seek recurrent collaboration formats and socio-cognitive design processes. Furthermore, we will seek to depict how these collaboration formats and socio-cognitive design processes unfold in a temporality. Thus, we will aim to identify and characterize these collaborative and design processes. This will allow us to answer the following research question:

- What are the collaboration formats and socio-cognitive design processes in a collaborative design and how are they characterized?

The designers and participants had different affiliations. Moreover, they had different institutional roles and expertise. We consider that they formed an open and diverse group. The members of this group contributed within a rich ecology composed of a great variety of external representations. Thus, we will seek to identify and understand:

- Institutional roles and expertise involved in the collaboration formats;
- External representations involved in the collaboration formats.

Considering that diverse members participate to the collaborative design, we will seek to describe how this diversity is manifested in collaboration and if there is any asymmetry amongst the designers and participants. Additionally, the ecological settings might have an impact on collaboration as well. Thus, we aim to highlight impacts of socio-technical contexts on collaboration formats. From that, we will be able to answer the following research question:

- How different socio-technical contexts impact the way designers collaborate and thus, the collaboration formats?

Products. The design of the video game *Hanabi* encompasses a considerable pool of solutions. The two designers of the core team could have had knowledge of these solutions as they followed the whole development of the design project from the start. In that way, they could have knowledge of the solutions' subtleties. Thus, we could consider the core team as designers that can evaluate and describe the subtleties of solutions and the processes that brought them. For the products studied through the first-person viewpoint, we seek to identify and characterize:

- Creative solutions, *i.e*. products, through judgements and justifications made by the designers of the core team.

In order to recognize the creativity of solutions, we will aim to access the designers' evaluations of the solutions and how they characterize creative solutions. This viewpoint will allow us to answer the following research question:

- Which solutions are judged as creative by the designers and how are they characterized?

Processes and Products. We mentioned that the design process of *Hanabi* have a considerable creative potential, *i.e.* the design group aim to develop a new video game concept, is open and diverse, and have a previous experience designing a creative video game. We could assume that specific collaborative and design processes will be involved in the generation of the most creative solutions. The processes and products will be crossed as we will seek to answer our main research question:

- What are the specific collaboration formats and socio-cognitive design processes involved in the generation of the most creative solutions compared to the generation of less creative ones and how are they characterized?

To reach our research goal, we invested the innovant domain of video games through an ethnographic study. An immersion as an observer in a game studio allowed us to analyze interactions between professional designers and participants in their ecological settings.

The following section will describe in details the research strategy that we will adopt to reach our research goal. Thus, the methodology we will adopt will be described.

3. An original methodology that crosses processes and products

The processes and products through the third-person and first-person viewpoints respectively are invested in this dissertation and will be crossed in order to answer our research questions. Globally, an overview of the steps carried out can be depicted as:

1. Data collection and selection of our corpora;
2. A primary analysis of processes, *i.e.* content approach to underline basic activities, *e.g.* generate, argue, etc., and problems and solutions;
3. A secondary analysis of processes, *i.e.* sequence and interactional approaches to highlight collaboration formats;
4. A tertiary analysis of processes, *i.e.* a longitudinal approach to stress the temporality of collaborative problem solving and collaboration formats in meetings;
5. Analyses of products (solutions) with quantitative and thematic approaches to identify and characterize creative solutions;
6. Identification ofprocesses related to creative products based on a quantitative approach.

In this section, we will detail how we proceeded to gather, select and analyze our data. Then, we will present the structure of the next part that is to say the results.

3.1 Procedure: immersion in the game studio Mekensleep

An ethnographic study was conducted by an immersion in the game studio Mekensleep; we, as observer settled in the game studio, followed the activities of the designers. The immersion started with the international event *Global Game Jam*[4] in which we participated as observer and designer. This event took place in the game studio Mekensleep with some designers from the *Hanabi* project and other designers from all over the France. This immersion lasted four months, from February to May 2009. The aim was to get use to and gain knowledge of the video game domain.

Then, our immersion as observer continued to cover the design of the musical video game *Hanabi*. It took place from May 2009 to March 2010. During this period, several means of data collection were used alternatively to collect video-recorded sessions of collaborative meetings:

- We used the webcam system of a computer from the 5th of May to the 24th of June.
- We used a four audio-video channels multiplexer[5] that covered three computers of the working place of the *Hanabi* project (see annex 1 for a depiction of the disposition of computers for the project *Hanabi*), and one camera was move around if needed. During this period, we also used the webcam system of a computer to video-record the meetings that took place in the meeting room in the basement. We used this setting from the 25th of June to the 20th of July.

[4] The Global Game Jam is an annual event where designers from different backgrounds and expertise have to design a video game in 48 hours.
[5] A four audio-video channels multiplexer is a video recording system that captures synchronously and display a mosaic of the four synchronous video-recordings. The system also stores the video-recordings.

- We used the webcam system of a computer with a frontal view that captured the designers associated with a video camera that captured the actions of the designers, *e.g.* use of external representations. These were used from the 21st of July 2009 to the 22nd of March 2010. It is worth to note that is was not always possible to capture these two views as the designers moved around at several occasions.

We only used the video-recorded sessions from the webcam system of a computer and the video camera for our analyses. The data collected with the four audio-video channels multiplexer were impossible to extract from the device.

During this period, the designers were available to answer any questions that were in need of clarification.

Nine months after, *i.e.* January 2011, semi-structured interviews associated with a questionnaire were conducted with the designers of the core team that is to say the designers O and M. These interviews were audio-recorded.

We conducted individual semi-structured interviews (annex 3) with O and M. These interviews focused on the global design process, *e.g.* description of the design process, moments 'of rupture', novel solutions generated during the design process, etc. In complement, we asked, also individually, the designers to fill a questionnaire (annex 4) presenting problems and solutions identified by an analysis we performed previously to the interviews, *i.e.* content analysis.

For the questionnaire, we presented the components first and defined them if needed. Then for nineteen problems identified, the designers had to rate each solution on a 5 points Likert scale for two creativity dimensions, *i.e.* novelty and feasibility. They were also asked to write down the source of inspiration of each solution, if applicable. After all solutions were rated, we asked the designers to select the ones that they considered the most creative based on both dimensions together, *i.e.* the 'free' condition. Thus, the solutions could be rated and selected as creative by the designers. These steps were performed in the same order for both designers.

During the interviews, the designers had the possibility to ask clarifications on solutions that they found unclear. In this case, the interviewer would show to the designer a video sequence that was related to the unclear solution and if needed review the transcription of the verbatim encompassing the unclear solution. For that, a video sequence for each solution was prepared in advance and transcriptions of all the excerpts were available. At the same time, the designers could validate and rectify, if needed, the problems and solutions that were presented to them.

3.2 Data collection: observations and interviews

From May 2009 to March 2010 during our immersion in the design studio, we collected video-recorded sessions of meetings between different designers/participants and a variety of data, *i.e.* produced external representations, logs of IRC channels, printed screens, data from project-management tool (wiki) and informal discussions. The immersion allowed us to capture even collaborative meetings that occurred in an opportunistic manner.

In total, we collected video-recorded sessions of forty-three collaborative meetings (annex 2) that lasted between approximately fifteen minutes to four hours. Sixty-eight hours of meetings were collected.

This immersion and the collected data enabled us to follow, reconstruct and understand the global design process. We were then able to understand and structure the design process with steps of different iterative cycles and some of its design periods, *i.e.* pairing of solution/s to a problem, treated within the last four types of prototype.

Additionally, verbatim from the semi-structured interviews associated with the ratings and justifications of the questionnaire were collected. They brought complementary information on the global design process, *e.g.* key moments of the design process, inspirations. These verbatim and ratings of the questionaire enabled us to identify and characterize the creative solutions generated during the design process and validate the solutions we identified.

3.3 Data selection for analysis: excerpt and meeting corpora

We gathered a considerable pool of video-recorded sessions of collaborative meetings. From these, we selected an excerpt corpus and a meeting corpus that were both transcribed. In this section, we will introduce our corpora and their transcription.

3.3.1. Selection of our corpora

We selected an excerpt corpus and a meeting corpus. On the one hand, the excerpt corpus was meant to gather a great diversity of excerpts. This corpus was used to conduct the sequence and interational approach to highlight a wide range of collaboration formats. On the other hand, the meeting corpus was meant to perform the longitudinal approach. It was used to underline the socio-cognitive design processes as well as the collaboration formats in the temporality of two conceptual meetings.

We selected excerpts for our **excerpt corpus** (annex 5) with the following criteria: (1) the designers/participants generated solution/s, (2) the presence of different affiliated designers/participants, (3) the use of different external representations and (4) different moments in the global design process, *i.e.* conceptual phase or not, and in the two steps of the iterative cycle (a) refining a concept and (b) analyzing results of tests. According to these criteria, we selected eighteen excerpts to analyze.

We proceed to a second selection to compose a **meeting corpus** (annex 6); excerpts coming from the two meetings following a conceptual shift. The first meeting refers to the ‘introduction of figurative visual representations’. It lasted three hours and forty-five minutes. In the excerpt corpus, two excerpts were selected from this meeting. The second meeting refers to the ‘introduction of rewards for a *ludus* experience’. This one lasted forty-five minutes. Four excerpts were selected from this meeting in the excerpt corpus.

The second selection for our meeting corpus aims to increase the excerpts' number of the first meeting that has only two excerpts for a three hours and forty-five minutes meeting. For that, we used three criteria: (1) the designers/participants generate solution/s, (2) the use of different external representations and (3) different moments within the meeting. With these criteria, we selected six additional excerpts for the 'introduction of figurative visual representations' meeting.

Thus, in our meeting corpus, six excerpts come from the excerpt corpus and six excerpts were added in the second selection. As a result, our meeting corpus encompasses twelve excerpts taken from the two meetings following a conceptual shift.

For the numbering of the excerpts in our corpora, we will use the number of the meeting followed by the number of the excerpt within the meeting, *e.g.* M7E2 is the second excerpt of the seventh meeting in our corpora.

3.3.2. Transcription of our corpora

Our corpora were transcribed. We also enriched the transcription with gestures and uses of external representation by designers/participants. In order to provide an illustration, the transcription and the gestures and uses of external representation are depicted in the following table (table 5). Gestures and uses of external representation are attributed, within the verbatim, to their performer with the following symbols: '§' is for the designer O, '*' is for M or another participant if M is absent and '£' is for a third designer/participant different from O and M. The symbols '< >' indicate the length of a gesture or use of an external representation.

No	Loc	Verbatim
10a	P	<§=un mec qui joue un instrument\ <§*plays with proto*
10b	P	*tu fais ton artiste qui coure derrière [toi avec le mec en costard qui joue du piano qui roule* <**gestural simulation* *stops simulation**>
11	O	[ça peut être ça

Table 5. Example of transcription with gesture/use of external representation

3.4 Participants: diverse designers and participants in our corpora

For the designers and participants, we categorized them in four categories. We will detail each category with their respective designer/participants involved in our corpora, *i.e.* through their presence in meeting/s or through reported speech.

The **core team** is composed of two designers with different institutional roles and expertise. We will name them O and M[6]:

- O is the project director and the creative director. He is the one that had the idea of designing *Hanabi*. He was in charge of managing the project and selecting proposals that have to be integrated in the prototype. O has considerable experience in both game design and project management.

[6] In order to preserve the anonymat, we will use the first letter of each designer's name or participant's name.

- M is the coder of the project. He first started as a volunteer in Febuary 2009 and he started to work as an employee of O in January 2010. M was responsible for the implementation of the game and worked under the supervision of O. M has some experience in the video game design although he has no educational background in this domain.

The **contractual designers** are the three following designers with different institutional roles and expertise:

- A is an apprentice coder. He started to work for O from May to July 2009. Unlike the other contractuals, A worked in the game studio during his entire apprenticeship. He worked under the supervision of O for the solutions to implement and of M for the code. A was responsible for the implementation of visual representations of musical soundtracks.
- Jt is a freelance graphic designer. He started to work for O in October 2009 until December 2009. As a graphic designer working in video games since 1996, he has a considerable expertise in video games. Jt was responsible for the integration of figurative visual representations, *i.e.* the character, the figurative game's environment and musical soundtracks' visual representation. He was under the supervision of the project director O.
- U is a freelance musician. He has been contacted by O in October 2009 and worked for O until March 2010. He was responsible for the design of new musical compositions. U had no specific experience in the domain of video games. Like the other contractual designers, U was under the supervision of O.

The **surrounding workers** are composed of three designers with different institutional roles and expertise:

- S is an expert graphic artist, game designer and CEO of another video game company. He was currently working on a musical video game during the design of *Hanabi*.
- Pr is an expert coder who worked for another video game project conducted by O. Pr worked in some occasions in the studio where *Hanabi* is designed. He is considered as a hardcore gamer of musical games.
- L is a senior developer who worked for a video game project that was initiated by O and then sold to another company. He worked at some occasions in the design studio. He started in the video games with the video game project initiated by O.

The **external participants** are composed of the following participants:

- F is an expert game designer and CEO of a video game company that developed Track Mania, an innovative game (Parmentier and Mangematin, 2007). F worked previously with O in another game company in which O and F were the CEOs. F is also a friend of O.
- P is an expert game designer and a CEO of an edition company for video games. P is a friend of O.
- St is an expert game designer. O met him at a Game Design conference.
- As is working for the public relations of a very famous game design company. She has considerable knowledge on video games.
- Various types of players.

The core team, contractuals, surrounding, and external participants are summarized in the following table (table 6). The table gives an overview of the evolution of the collective involved in our corpora according to each prototype.

Prototypes	*Core team*	*Contractual*	*Surrounding*	*External*	*Play-testers*
Abstract *païdian* interaction-sound prototype (Feb. to May)	O and M				X
Abstract *païdian* interaction-sound-image prototype (May to Aug.)	O and M	A	S, Pr and L	P and As	X
Abstract half *païdian* half *ludus* interaction-sound-image prototype (Aug. to Dec.)	O and M			P and F	X
Figurative half *païdian* half *ludus* interaction-sound-image prototype (Oct. to Dec)	O and M	Jt		St	X
Figurative half *païdian* half *ludus* interaction-sound-image prototype with new music (Oct to Dec.)	O and M	U			X

Table 6. Designers and participants in the types of prototype

Our excerpt corpus is composed of excerpts from different prototypes with several designers and participants - present or their speech being reported -:

- Nine excerpts from the 'abstract *païdian* interaction-sound-image prototype' with participants from the core team O and M; contractual A; surrounding S, Pr and L; external P and As;
- Four excerpts from the 'abstract half *païdian* half *ludus* interaction-sound-image prototype' with participants from the core team O and M; external P and F;
- Four excerpts from the 'figurative half *païdian* half *ludus* interaction-sound-image prototype' with participants from the core team O and M; contractual Jt; external St;
- One excerpt from the 'figurative half *païdian* half *ludus* interaction-sound-image with new music prototype' with participants from the core team O and M; contractual U.

Our meeting corpus encompasses:

- Eight excerpts from the 'figurative half *païdian* half *ludus* interaction-sound-image prototype' with designers from the core team O and M; contractual Jt;
- Four excerpts from the 'abstract half *païdian* half *ludus* interaction-sound-image prototype' with designers from the core team O and M; external P and F.

In this dissertation, we will refer to 'designers' for the core team and contractual designers and to 'participants' for the surrounding workers and external participants. We will provide the specific category of population if needed.

3.5 Analyses of our corpora

In this section, we will detail the analyses that will be performed for the processes and products in each viewpoint. For the processes analyses, *i.e*. third-person viewpoint, our approach will combined content, interactional and longitudinal approaches. The product analyses with the first-person viewpoint will be conducted on the basis of our content analysis, *i.e.* the identified problems and solutions. In this first-person viewpoint, quantitative and thematic analyses will be performed. Additionally, the identified solutions could be validated by the designers at the same time. Finally, we will cross the processes and products to highlight whether, if any, collaboration formats and design processes are involved in the generation of the most creative solutions compared to the less creative ones. For that, quantitative analyses will be conducted.

In this section, we will first develop the analyses of the processes and then of the products. We will end this section with the analyses performed to cross the processes and products.

3.5.1. Analyses of the collaborative and design processes with a third-person viewpoint

The analyses of the design and creative processes will be conducted with three analyses (figure 6). A primary analysis with a content approach will enable us to identify collaborative design activities and problems with their solutions. On the basis of this primary analysis, a secondary analysis with a sequence and interactional approaches will be added. It is a question of adding another layer of analysis in order to shed light on the relations between generated problems and solutions and the collaborative interactions of designers/participants. This will highlight collaboration formats. Lastly, we will proceed to a tertiary analysis with a longitudinal approach combined with collaborative problem solving. It will be performed on the basis of the primary and secondary analyses. Here, this approach will consist in the depiction of socio-cognitive design processes carried out by designers/participants and their temporality with collaboration formats.

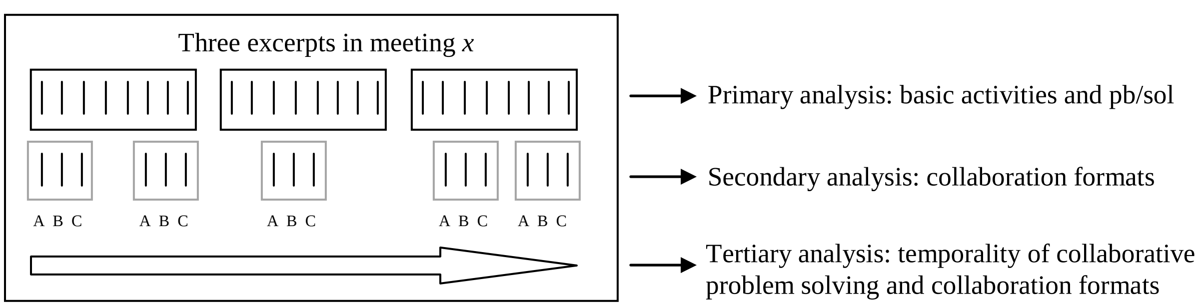


Figure 7. Three analyses to invest processes in a meeting

PRIMARY ANALYSIS: content analysis

For each unit coded by a number referring to a turn-taking (n), eventually segmented into smaller units, *e.g.* na, nb…, and combined with the respective verbatim, we will identified:

- Collaborative design activities, *i.e.* content-related and process-related activities;
- Perspective taken by the locutor, *i.e.* player's perspective or designer's perspective;
- Polyphony in the discourse, *i.e.* locutor and enunciator.

With these categories, we will be able to clearly identify and characterize design activities. Additionally, the problems and solutions will be identified. This primary analysis will be performed on our corpora.

Collaborative design activities. The collaborative design activities are content-related and process-related activities (Détienne et al., 2004). The latter authors and Baker, Détienne, Lund and Séjourné (2009) identified several indicators related to the aforementioned collaborative design activities in collaborative engineering design and architectural design respectively. The indicators of these authors were combined and iteratively refined in some cases in order to cover the whole range of collaborative design activities that we identified in our corpora (table 7).

Collaborative design activities				*Definition*
Content-related	Problem solving	Generate	Gen	Designer elaborates solution, problem, constraint
		Refine	Refi	Designer enhances a solution by bringing precisions to a solution with supplementary and complementary design ideas or details
		Argue	Argu	Designer describes why a solution should or should not be adopted on the basis of the problem's criteria, constraints or future users
		Analyze	Ana	Designer makes links between problem, state of the prototype, experience of players, solution, etc.
	Congitive synchroni-zation	Inter-comprehension	Inter	Designer ensures that a common ground related to a discussed design topic is sustained amongst the design team
		Rephrase	Reph	Designer says in other words a design solution
		Persona	Perso	Designer reports a profile of a player who play-tested the game
		Debrief	Deb	Designer reports play-tests done by players, experience and/or comprehension of the prototype by a play-tester and reports contribution/s of other designers/external participants
Process-related	Project/ interaction	Manage	Mana	Designer plans, allocates a task, prioritizes and orders meeting's topics
		Agree	Agre	Designer accepts a solution, a task allocated

Table 7. The indicators of the collaborative design activities

We refined several indicators of the content-related activities. In the problem solving activities, we added the indicator 'analyze'. This indicator highlights the analysis of results of play-tests and player's experience. We also developed the cognitive synchronization activity in order to provide further details on how the designers/participants could engage in this collaborative design activity in game design. Thus, we added indicators in order to distinguish if the designers were engaged in cognitive synchronization related (1) to generated solution 'rephrase', (2) to play-tests (a) 'persona' to ground the type of players and (b) 'debrief' to ground the feedbacks of players and (3) to the other design topics 'inter-comprehension'.

The 'generate' indicator will be combined with its object. The object can be problem, solution or constraint. These objects and their notation are defined in the following table (table 8). This will enable us to identify especially problems and solutions.

Objects	*Notation*	*Definitions*
Problem	Pb(a) … P(n)	All elements that are encompassed in the problem space
Solution	Sol(a)1	All elements that are encompassed in the solution space; design ideas included in the solution space for a particular problem Pb(a)
Alternative solutions	Sol (a)1 … Sol(a)n	A problem Pb(a) can be solved by different solutions which we term as alternative solutions
Variant solutions	Sol (a)1’ … Sol (a)1’’	A solution can be achieved through different possibilities which we term variants of a solution for a particular problem Pb(a)
Higher level solution	Sol $^{+}$(a)n	A solution that is stated at a meta-level for a particular problem Pb(a)
Refined solution	Sol(a)n^{+}	A solution that is enhanced for the Pb(a)
Constraint	Const	An evaluative referent that can be readily applied

Table 8. Objects of ‘generate’

We will use the term problem (Pb) for the design ideas that belong to the problem space and constraint (Const) for evaluative referents. Solutions (Sol) as design ideas affiliated to the solution space can be further defined. The term alternative solution is used for a solution that can replace another one, *e.g.* for the problem ‘construction of the scenery’, designers generated two alternative solutions: ‘implement beautiful things with minimal staging’ noted Sol(a)1 and ‘exploit the environment’ noted Sol(a)2. A solution can have a second level of alternatives. We termed it variants in order to identify the two possibilities, *e.g.* for the alternative solution ‘exploit the environment’, designers generated two variants: ‘effect that impact the environment’ noted Sol(a)2’ and ‘put a reflexive surface’ noted Sol(a)2’’. Finally, solutions for a problem *x* that are generated with a meta level are noted as Sol^{+}(*x*)n and refined are noted as Sol(*x*)n^{+}.

Perspective taken by designer/participant. We added a category of indicators related to the perspectives taken by designers/participants. These perspectives are (1) ‘design’ *per se* that includes several domain areas of game design and (2) ‘players’ that includes different types of users (table 9). Thus, we integrate a new category of indicators to study the perspectives taken by the designers that is retrieved neither in Détienne et al. (2004) nor in Baker et al. (2009).

Perspectives	*Examples*
Design (Dsg): the designer’s perspective consists of focusing on the co-development of problems and solutions in order to progressively refine the designed product by taking into account the numerous domain areas of the design product.	-“*Y’a vraiment un problème au niveau d’la façon dont **y** parse le ficher midi* ” ‘there is a problem a the level where you parse the midi file’ -“*tu vas jusqu’à la note off de celle là et là **tu** mets un fade out fuite* ” ‘you go to the note off of this one and there you put a fade out phit’ -“*Là en avoir deux (inc) ça choque pas parce que **elles** correspondent aux deux espace de aux deux typologies de de jeux*” ‘there having two (inc) it does shock because they correspond to the two spaces of, two typologies of the game’
Player (Ply): the player’s perspective consists of considering the final users by focusing on generic knowledge of players, the players experience, profiles or simulations of player’s experience.	-“***ton** cerveau il est fait pour ça (inc) avec le traitement de l'image*” ‘you brain is made for that (inc) with the image treatment’ -“*Pour **elle** c’était magique*” ‘for her i twas magical’ -“*tu dois comprendre que la haie les variations de crêtes de la haie déjà tu vois **t’**entends pas le tac tac tac tac tac parce qu’y est à la même hauteur*” ‘you need to understand that the hedge, the variations of the peaks’ hedge you see you don’t hear the tac tac tac tac tac because they are at the same pitches’

Table 9. The indicators of the perspective category

Polyphony in the discourse. Some designers reported the speech of absent participants. Therefore, it seemed important to distinguish the locutor from the enunciator on the basis of the linguistic of enunciation (Bakhtine, 1997 quoted in Baker et al., 2009). Accordingly, these authors proposed a category of indicators locutor and enunciator; the locutor refers to the person who is talking and the enunciator is the person whose voice is reported by a locutor. For example, the designers could refer to the speech of participants absent from the discussion under hand (table 10):

No	*Verbatim*	*Loc*	*Enun*
4	mais ça c'est l'idée de Florent le **Florent <u>y</u>** disait y disait lui/ euh=	O	F
…	…		
6b	c'est overwhelming on voit trop de chose au départ	O	F
34c	Et **<u>Loïc c'qui dit</u>**	O	L
34d	Pour moi ça l'interagit pas	O	L

Table 10. Illustration of the references made by designers

On the one hand, we will identify the locutor during the transcription of the video-recorded excerpts. On the other hand, the enunciator will be identified with denomination and/or personal pronoun used during an exchange, *e.g.* "*y"* 'he' refers to the absent and previously denominated participant Florent (no 4), and with polyphonic markers, *e.g.* "*c'qui dit*" 'what he said' (no 34c). The interest of this category of indicators is to highlight how co-design is distributed amongst designers/participants that can be present or absent (Baker et al., 2009).

In sum, the choice of these categories of indicators was strengthen by their ability to provide a view on the generated and co-elaborated solutions paired to a problem and the perspective adopted in the designer/participant's contribution, and to underline contributions of designers or participants even if they were absent during the meeting. These categories were coded iteratively by two coders until a common agreement was reached and that for one meeting encompassing four excerpts. Additionally, the problems and solutions were validated by the designers of the core team.

We will use these categories of indicators to code each unit of turn-taking and sub-units. In order to provide an illustration, the categories of indicators and gesture/use of external representation are depicted in the following table (table 11). From left to right, the columns refer to 'no' for the number of unit/sub-unit, 'loc' for locutor, verbatim, 'enun' for enunciator, 'pers' for perspective taken, 'D.A.' for collaborative design activities and Pb/Sol for labelling the generated problem and solution.

No	Loc	Verbatim	Enun	Persp	D. A.	Pb/Sol
1a	O	t'as un mode de replay orienté gamer	O	Dsg	Gen Pb(a)	Performance score (replay)
1b	O	c'est-à-dire que tu vas avoir je sais pas le (.)§ droit de *activates sound*§ choisir un objet par exemple qui va habiller§ ton perso *gesture toward the prototype*§	O	Dsg	Gen Sol(a)1	Adding player's attribute as a gain
1c	O	§ et si tu veux je garde dans dans §activates sound	O	Dsg	Refi	
2a	P	ou des nouveaux sons/	P	Dsg	Gen Sol(a)2	Adding sound track
2b	P	tu pourrais remplacer un son de [base de base avoir le choix§ tu vois au lieu d'avoir un piano t'aurais un §*activates one sound* piano un un:n=	P	Ply	Refi	
3	O	[peut-être § peut-être *plays with prototype*<§	O	Dsg		
4	O	mais ça c'était l'idée de Florent le Florent y disait y disait lui/ euh=	F	Dsg		
5	P	=tu t'es fais racheter par par lui ou euh/§ *Stops playing*§>	P			
6a	O	(inc)§ c'qui disait y disait euh:h <§ *starts playing*	F	Dsg		
6b	O	§ c'est overwhelming on voit trop de chose au depart §*O has locked two soundtracks*	F	Ply	Arg-	
6c	O	c'est mieux d'en avoir un ou deux au [début	F	Ply	Arg+	
7	P	[oué tu pourrais les faire gagner	P	Dsg	Reph	
8	O	les faire gagner à chaque fois qui rejoue peut-être on fera ça\	O	Dsg	Reph	
9	P	§ c'est une récompense qui peut satisfaire à la fois le <§*plays with prototype* gamer aussi parce qu'y a des cacahouètes au bout et à la au bout et à la fois euh\ à la fois le casual parce qu'y sera content d'avoir des violons en plus du piano§ *stops playing*§>	P	Ply	Arg +	

Table 11. Example of the categories of indicators in the primary analysis

SECONDARY ANALYSIS: sequence and interactional analyses to identify collaboration formats

This analysis aims to answer our research question 'what are the collaboration formats and how are they characterized?' Based of the primary analysis, the sequence and interactional approaches will enable us to underline how designers/participants were implicated and participated in diverse forms of collaboration, *i.e.* collaboration formats.

On the basis of the primary analysis, we will identify recurrent adjacency pairs of collaborative design activities performed by at least two designers - present or absent - within a problem-solution pair or within a design period, *i.e*. generation of solution/s to solve a problem. We will take into account indicators of (1) collaborative design activities with content-related and process-related activities, (2) perspective taken by designer/participant, (3) polyphony in the discourse and (4) modalities and/or uses of external representation. This analysis will be performed on our corpora.

This approach aims to highlight how different interactional formats in collaborative design are brought into play. This analysis will underline the interactional dynamic involving different stakeholders, uses of modalities/external representations and design contributions with their perspective. From this, collaboration formats will be identified, defined and characterized.

Additionally, our analysis for the excerpt corpus will be deepened. Indeed, collaboration formats will be quantified. Furthermore, institutional roles and expertise, and modalities and external representations will be quantified as well. This will allow us to characterize how different contexts impact the way designers collaborate, *i.e.* impacts of socio-technical contexts on collaboration formats. Thus, it will enable us to answer our research question ‘how different contexts impact the way designers collaborate and thus, the collaboration formats?’

TERTIARY ANALYSIS: longitudinal analysis to identify socio-cognitive design processes and their temporality with collaboration formats

The longitudinal analysis aims to answer our research question related to socio-cognitive design processes ‘what are the socio-cognitive design processes and how are they characterized?’ On the basis of the primary analysis, we will carry out a longitudinal approach combined with collaborative problem solving identification. This approach will enable us to stress how designers/participants contributed to the global design process with cognitive design processes distributed amongst the designers/participant, thus socio-cognitive design processes. This analysis will be performed on our corpora.

With the identification of problems and their solutions, we will be able to follow their evolution throughout a design period or a problem-solution pairing. These evolutions will be analyzed in terms of socio-cognitive design processes. We operationalized the socio-cognitive design processes as follows:

- ***Problem framing*.** We refer to problem framing when a designer *x* designates features of a problem space to which he choose to solve - identify the problem - and then another designer *y* identifies areas of the solution space to explore - framing the problem -.
- ***Co-evolution of problem-solution*.** Co-evolution of problem-solution refers to a sequence of three steps. First, a designer *x* names a problem. Second, this designer and/or designer *y* pairs the problem with solution/s. Third, one of the two designers generates a new problem from the first problem-solution/s pairing. Solution is distinguished from problem on the basis of if it is an output or input respectively (Visser, 2006b).
- ***Combination*.** We refer to this socio-cognitive design process when a designer *x* generates an idea and then another designer *y* associates and merges it with another distinct one.
- ***Analogical reasoning*.** We refer to this process when a designer *x* evokes a source and a designer *y* transfers this source entirely or partially into a design solution - the target -.
- ***Composition*.** This socio-cognitive design process consists in changing an object’s location in an external or mental representation. However, locations in a video game might be trickier to follow; the location of an object in the video game *Hanabi* could be in several spaces: (1) the scenery displayed on the screen and (2) the experiential spaces, *i.e.* the *païdian* and the *ludus* spaces. This means that each experience becomes a space of its own. In that line, we consider a composition process as (1) a designer *x* allocates a specific location to an object in the scenery and then a designer *y* changes the object’s location or (2) a designer *x* puts an object

in a specifc experiential space and a designer *y* shifts the object to the other experiential space.

This analysis will underline the design processes distributed amongst the designers/participants. From this, socio-cognitive design processes will be identified and the distribution of contributions amongst the designers and participants will be described.

Additionally, we will further deepen our analysis of the meeting corpus; we will add the secondary analysis to highlight the collaboration formats involved in the meeting corpus. With this enhancement, we will depict the temporality of both the socio-cognitive design processes and collaboration formats in the two conceptual meetings. This will enable us to characterize the temporality of both socio-cognitive design processes and collaboration formats. Thus, it will allow us to further characterize collaborative and design processes.

3.5.2. Analyses of the products with a first-person viewpoint

The analyses of the creative products with a first-person viewpoint aim to answer our research questions related to the distinction of the most creative solutions from less creative ones and to the characterization of the creative solutions. A secondary aim was to validate the problems and solutions identified in our content analysis.

On the basis of the problems and solutions identified in the content analysis, we conduct with the core team individual semi-structured interview combined with a questionnaire (*cf*. annexes 3 and 4). This chosen methodology provides two advantages. On the one hand, the designers' viewpoint enabled a validation of our analysis with their knowledge of the design process; it provides a way to validate the problems and solutions we identified. On the other hand, it could highlight the subtleties of each solution through the designers' justifications. In other words, the designers could bring further information on how solutions were brought up, evolved and in which way they considered them creative. This information would have been impossible to gather with an evaluation by independent experts. This first-person viewpoint is performed on the excerpt corpus.

Quantitative analysis. The questionnaire used Likert scales. Quantitative analyses will be conducted on the Likert scale ratings. We will perform a third quartile quantitative analysis. This analysis will provide a means to distinguish the most creative solutions from the less creative ones by selecting the solutions whose total score, *i.e.* the sum of the two designers' ratings on both creativity dimensions *novel* and *feasible*, were above the third quartile value. With these results, we will be able to answer our research question related to the identification of creative solutions. Thus, creative solutions will be distinguished on a basis of their score on creativity dimensions.

In addition, we will characterize the inter-rater agreement on the ratings of each creativity dimension with a correlation analysis and on the solutions selected as creative by the designers, *i.e.* selected on the basis of both creativity dimensions together in the 'free' condition, with a Kappa of Cohen analysis.

The Kappa coefficients allow quantifying the quality of inter-rater agreement between the designers on the selected creative solutions. Conventionally, values of Kappa are interpretated as follows : an agreement is considered strong K>0,80; substantial 0,80>K>0,61; moderate 0,60>K>0,41; fair 0,40>K>0,21; slight 0,20>K>0,00; no agreement K< 0,00.

Thematic analysis. For our research question ‘how are the creative solutions characterized?’, we will perform a thematic analysis. This analysis will allow us to stress themes that designers relate to creative solutions. We will perform this analysis on the verbatim of the designers from the interviews and questionnaires, *i.e*. transcription of the interview and questionnaire with the justification of the solution’s rating. This complementary analysis will provide characteristics of creative, novel, original solutions and in some cases, descriptions of cognitive design processes leading to them.

3.5.3. Identification of processes involved in creativity with the crossing of the third-person and first-person viewpoints

This final step aims to answer our main research question ‘what are the specific collaboration formats and socio-cognitive design processes involved in the generation of the most creative solutions compared to the generation of less creative ones and how are they characterized?’ For that, we will cross the processes and products, *i.e.* collaboration formats and socio-cognitive design processes with identified creative solutions. In turn, we will be able to highlight which collaboration format and socio-cognitive design process are involved in the generation of the most creative solutions. This step will be performed on the excerpt corpus.

Quantitative analysis. The collaboration formats, socio-cognitive design processes and the most/less creative solutions are quantified. With these, we will perform relative deviation analyses. These analyses characterize the strength of association between variables. The variables taken into account are (1) collaboration formats and the most/less creative solutions, (2) socio-cognitive design processes and the most/less creative solutions and (3) collaboration formats and design processes. This will be performed at a global level with the Cramer’s V^2 and at a local level with relative deviations.

At the global level, the strength of association is considered low for $0<V^2<0,04$; intermediate for $0,04<V^2<0,16$ and strong for $V^2>0,16$. At the local level, the conventional value 0,20 is used to consider an attration or repulsion. The attraction refers to the positive value (+0,20) and repulsion refers to the negative value (-0,20).

In the next part, we will introduce our empirical results. First, the processes with a third-person viewpoint will be developed. On the one hand, we will identify and characterize collaborations formats and impacts of the contexts on them in the chapter 7. On the other hand, we will identify and characterize the socio-cognitive design processes in conceptual meetings and their temporality with the collaboration formats in the chapter 8.

Second, the products with a first-person viewpoint will be developed with the identification and characterization of solutions judged as creative by two designers. This first-person viewpoint will be elaborated in the chapter 9.

Finally, the crossing of the processes and products will be explored to identify collaboration formats and socio-cognitive design processes involved in the generation of the most creative solutions compared to the less creative ones. This last conclusive viewpoint will close the results part with the chapter 10.

Summary

As few studies in group creativity analyze interactions of professional designers in their ecological settings, the need to take this direction became essential. In that respect, we aim to identify and characterize collaboration formats and socio-cognitive design processes that are brought into play in the generation of the most creative solutions compared to the less creative ones. That aim is carried out with an interactional approach among others. This approach is not commonly adopted in group creativity research to our knowledge. For our aim, we invested the innovative domain of video games with professional designers in their ecological settings through an ethnographic study.

To reach our aim, we will adopt an original approach that accounts for both processes and products to study creativity. We aim to answer several research questions related to processes, products and their crossing. Indeed, we will seek to answer ‘what are the collaboration formats and socio-cognitive design processes in collaborative design and how are they characterized?’ Furthermore, as several socio-technical contexts will be analyzed, we will aim to answer ‘how different socio-technical contexts impact the way designers?’ In regard to the product, we will seek to answer ‘which solutions are judged as creative by the designers themselves and how are they characterized?’ As for the crossing of the processes and products, we will aim to bring new light with our main research question ‘what are the specific collaboration formats and socio-cognitive design processes involved in the generation of the most creative solutions compared to the less creative ones?’

To answer our research questions, we will invest the processes with three levels of analysis in a third-person viewpoint, *i.e.* the viewpoint of the analyst, on corpora of video excerpts. Indeed, we will conduct a primary level of analysis in which we will adopt a content approach. Based on this primary analysis, we will perform a secondary level of analysis in which we will apply sequence and interactional approaches to highlight collaboration formats. Then, a tertiary level of analysis will be conducted based on the primary and secondary analyses. This third level will consist in a longitudinal approach combined with collaborative problem solving. It will allow us to underline socio-cognitive design processes and their temporality with the collaboration formats.

For the products analyses, we will adopt a first-person viewpoint, *i.e.* the viewpoint of the designers themselves. On the basis of the problems and solutions identified in the primary level of analysis, designers judged and characterized solutions as creative or not through a semi-directive interview combined with a questionnaire. Quantitative and thematic analyses will be performed for the analyses of the products.

Finally, we will cross the processes and products to answer our main research question. In this final step, quantitative analyses will be performed to highlight collaboration formats and design processes involved in the generation of creative solutions.

PART III - RESULTS

Chapter 7 Collaboration formats

In this chapter that opens the third-person viewpoint analyses, *i.e.* the viewpoint of the analyst, we will develop how the designers/participants were interacting while performing design activities collaboratively. Our aim is to identify and characterize forms of collaboration emerging from design interactions between designers/participants in terms of collaboration formats. This identification and characterization of collaboration formats will enable us to distinguish different forms of collaboration driven by designers/participants to serve different collaborative purposes. We posit that dialogue is a means to approach cognitive and collaborative mechanisms intervening in a collective activity such as design. In addition, a second aim is to identify contextual elements that impact these collaboration formats. The consideration of the situations in which collaboration formats unfold will pinpoint to variables that impact collaboration formats and thus, could impact collaborative design activities.

1. *Identifying and characterizing collaboration formats: content and interactional analyses*

To identify collaboration formats, we proceed to content and interactional analyses. These analyses are conducted on the excerpt corpus that provides a variety of design solutions, designers/participants, modalities/external representations and design moments. In the content analysis, we used categories of indicators related to:

- Collaborative design activities with content-related activities, *e.g.* ‘generate’, ‘refine’ and ‘argue’, and of process-related activities, *e.g.* ‘management’ and ‘agree’.
- Participant/s incorporated in each contribution, namely the locutor, *i.e.* the one that is doing the talking, and the enunciator, *i.e.* the one whose voice is being reported;
- Perspective taken by the locutor, *i.e.* player’s perspective or designer’s perspective.

The content analysis enabled us to highlight and name problems and their solutions and collaborative design activities involved in each design period.

On this basis, an interactional analysis identified collaboration formats emerging from interactions between designers/participants. These collaboration formats were identified in the temporality of interaction through recurrent adjacency pairs of collaborative design activities undertaken by at least two designers - present and/or absent - within a problem-solution pairing or within a design period. In this analysis, we took into account indicators of (1) collaborative design activities, both content-related and process-related activities, (2) polyphony in the discourse, (3) perspective taken by designer/participant and (4) modalities.

These content and interactional analyses allowed us to answer our research question ‘what are the collaboration formats in a collaborative design and how they are characterized?’

We also generated contingency table of the collaborative format and quantified variables linked to collaboration formats, *i.e.* institutional roles and expertise, design activities and external representations. These quantitative data enable us to characterize each collaboration format. It allowed us to answer the following research question 'how different contexts impact the way designers collaborate and thus, the collaboration formats?'

We will describe these forms of collaboration as collaboration formats that stood out of our corpus. We will also underline their functions. Finally, we will stress the situations that were seen to impact collaboration formats.

2. Three collaboration formats: directive, relational and representational

Collaboration formats can be defined as multi-functional and recurrent adjacent pairs of collaborative design activities that are mainly initiated by the generation of a solution. These adjacent pairs are undertaken by at least two designers - present or absent - and are principally enacted in verbal exchanges, but also with other modalities, *e.g.* gestures, graphics, etc., during collaborative work. We identified three types of collaboration format namely directive, relational and representational (table 12).

Collaboration formats	*Formats*
Directive formats Specific forms of collaborative design activities serving to trigger evolution and definition of the design spaces - problem and solution -.	Generation of a flow of solutions by a designer *x* to trigger problem framing from a designer *y*
	Generation of solution with delay mark/s by a designer *x* to elicit an alternative solution generation from a designer *y*
	Task allocation by a designer *x* to trigger agreement crystallization from a designer *y*
Relational formats Construction of relations between a design idea under discussion with another one - reified or not - within or outside the design project to apprehend the design idea under discussion through another design idea.	Construction of relations between a design idea under discussion with reified one/s by designers *x* and *y*
	A designer *x* constructs relations between the design idea under discussion with another design idea evoked previously in the design project by a designer *y*
Representational formats Co-construction of representations of a design idea under discussion in order to develop multiple points of view around this design idea.	Co-construction of a design solution representations through alternations of player's and designer's perspectives taken by designers *x* and *y*
	Co-construction of a design solution representations by designers *x* and *y* through complementary modalities

Table 12. Collaboration formats

These collaboration formats entail different design focuses. Some collaboration formats are applied to design ideas which include design problems, solutions and evaluations, *e.g.* player's experience, and others are applied only on design solutions. Differently, for the directive format triggering agreement crystallization, the design focus consists in an agreement on a solution. This latter is the only one that is mutually exclusive.

In our corpus, all the excerpts encompass at least one collaboration format. We found sixty-five occurrences in seventeen excerpts for the representational formats, twenty-six occurrences in sixteen excerpts for the relational formats and nineteen in twelve excerpts for the directive formats (table 13). Respectively, it corresponds to 59% of representational formats, 24% of relational formats and 17% of directive formats. We could underline that the representational formats are more frequent than the relational formats and directive formats.

Formats	*Number of excerpts*	*Total occurrences*
Directive	12	19 (17%)
Relational	16	26 (24%)
Representational	17	65 (59%)

Table 13. Occurrences of the collaboration formats in eighteen excerpts

We will now introduce and describe the collaboration formats and their generic forms. Then, we will present some illustrations of collaboration formats and their functions. In complement, we will provide a synthesis of the participative framework for each excerpt taken to illustrate our collaboration formats in order to underline the context in which they occurred.

2.1 Directive formats

The directive formats described in this section can be defined by the execution of specific forms of design activities by a designer *x* serving to trigger evolution and definition of the design spaces - problem and solution - by a designer *y*. First, a designer *x* performs specific forms of collaborative design activities such as generation of solution/s, *i.e.* solutions generated in a specific way, or allocation of task. Second, these specific collaborative design activities trigger a designer *y* to perform problem framing, generation of alternative solution or agreement crystallization. In other words, the directive formats consist in implicit directives given by a designer *x* that trigger a designer *y* to contribute to the evolution of the design process.

The directive formats subsume (1) triggering problem framing, (2) eliciting alternative solution generation and (3) triggering agreement crystallization (table 14).

Directive formats	*Description*
Triggering problem framing	A designer *x* proceeds to a specific form of design generation: enumeration of a flow of potential design solutions. It can suggest to another designer *y* to frame the problem.
Eliciting alternative solution generation	A designer *x* proceeds to a specific form of design generation: generation of a solution encompassing delay mark/s. It can encourage another designer *y* to contribute by generating alternative solution.
Triggering agreement crystallization	A designer *x* allocates a task to a designer *y*. This task allocation - implementation of a solution - conveys an implicit common agreement over a solution. It can trigger a designer *y* to crystallize an agreement on the solution when this latter agrees to the allocated task.

Table 14. The directive formats

The directive formats were observed in a total of twelve excerpts. We noticed that a majority of these excerpts encompass the directive format to elicit alternative solution generation that is found in nine excerpts with twelve occurrences (table 15). In addition, we found six occurrences in six excerpts of the directive format to trigger agreement crystallization. Differently, the triggering problem framing format can be considered as less frequent in the observed design process as we detect only one occurrence in one excerpt.

Directive formats	*Number of excerpt*	*Total occurrences*
Triggering problem framing	1	1 (5%)
Eliciting alternative solution generation	9	12 (63%)
Triggering agreement crystallization	6	6 (32%)

Table 15. Occurrences of the directive formats in eighteen excerpts

We will develop futher each directive format by providing a definition, an example and their function/s. Then, we will end this section by summarizing the functions found in the directive formats.

2.1.1 Directive format to trigger problem framing

This directive format to trigger problem framing can be described by (table 16) a sequence A in which a designer *x* names a problem and then a sequence B follows with the same designer *x* who generates a flow of potential solutions. It ends with a sequence C where a designer *y* frames the problem.

Sequence	Designer *x*	Designer *y*
A	Names a Pb	
B	Generates a flow of Sol	
C		Frames the Pb

Table 16. Directive format to trigger problem framing

This directive format is dealing with design ideas that is to say design problems and solutions. It is detected through the indicator of the content-related activities ‘generate’ and more precisely generation of problems and solutions. We will next describe an example of this directive format.

Example of the directive format to trigger problem framing

This directive format can be illustrated by the excerpt M7E1. This excerpt is taken from a meeting between the creative and project director O, the coder M and the freelance graphic artist Jt (photo 3). This latter designer just integrated the design team to work on the new orientation of the prototype, *i.e.* figurative visual representations, that is related to his expertise in graphic art. In this meeting, O, M and Jt were gathered to discuss about the new orientation of the prototype. The 'abstract interaction-sound-image prototype', used in this meeting, will be replaced by a 'figurative interaction-sound-image prototype'. In order to do the transition, the designers will have to translate the abstract visual representations and the scenery into figurative ones.

Photo 3. The excerpt M7E3 with from left to right O, M and Jt

In this excerpt, the stake of the designers is to find a way to display an appropriated stream speed for the user's feedbacks, *i.e.* the visual representations of soundtracks, and a way to do this within the global construction of the scenery with figurative visuals. The excerpt began with O who reported a problem related to the speed of visual stream. Then, both designers M and Jt generated solutions in order to solve the identified problem. It is only the solution of M that was co-elaborated by M and O. After that, these designers focused their discussion on another problem generated by M to which he generated two solutions followed by the generation of an alternative one by O. The following segment focuses on the problem that the designer M identified and the solutions paired to it.

The segment of M7E1 (table 17) starts with a problem identified by the designer M *" l'idéal niveau restitution niveau pour la prod (inc)*" 'the ideal in terms of production restitution (inc)' (sequence A). Then, M generated two variant solutions for the construction of the scene: first "*de faire de scripter le déplacement de la caméra tu vois/ de faire l'univers en un seul*" 'to script the movement of the camera you see to do the univers in only one' and second "*ou tronconner et se démerder pour les faire venir uniquement produire (inc)*" 'or to cut and to manage to get them coming only producing (inc)' (sequence B). In reaction, the designer O generated an alternative solution that proposes a specific area of the solution space "*c'qui serait vraiment cool c'est qu'y ai une interaction de block en block*" 'what would be cool is that there would have interactions between blocks' (sequence C). Thus, M generated solutions involving an independency between components and O reframed the problem by generating an area of the problem where components interact between them and are dependent.

No	Loc	Seq	Verbatim	Pers	D.a.	Pb/Sol
14b	M	A	et alors c'que je veux dire ca :a le problème de ce que je veux dire c'est surtout pour moi ça se-serait presque l'idéal niveau restitution niveau pour la prod (inc) *and thus what I want to say is it has the problem of, what I want to say is it's for me it would be ideal at the restitution level for the prod (inc)*	Dsg	Gen Pb(b)	Ideal for production restitution
14c	M		c'est de pas faire de :e tiles mais faire carrément une scène qui est le :e alors une scène énorme qui *est le *both hand wide open and go in the middle** morceau en fait *it's not doing tiles but doing a scenery that is, a huge scenery that is the piece in fact*	Dsg	Gen Sol(b)1	Produce the whole scene with one tile
14d	M	B	de faire de scripter le déplacement de la caméra tu vois/ de faire l'univers en un seul *to do, to script the movements of the camera you see, to do the universe in only one*	Dsg	Gen Sol(b)1'	Script mvt of camera
14e	M	B	ou tronconner et se démerder pour les faire venir [uniquement produire [(inc) *or to chop into sections and manage to make them come, only producing (inc)*	Dsg	Gen Sol(b)1''	Cut mvt
15	O		[tu peux pas faire ça *You can't do that*	Dsg	Arg-	
16	O	C	[mais c'est pas (inc) le problème le problème que je pense c'est que là tu l'pense avec des morceaux qui sont indépendant les uns des autres mais c'qui serait vraiment cool c'est qu'y ai une interaction de block en block\ *But it's not (inc) the problem that I think of is now you think with pieces that are independent from each other, but what would be cool is an interaction between blocks*	Dsg	Gen $Sol^{+}(b)2$	Integrate interaction between blocks

Table 17. Directive format to trigger problem framing in the excerpt M7E1

In this example, the directive format to trigger problem framing unfolds like this:

- The sequence A Names a problem: M names the problem "*l'idéal niveau restitution niveau pour la prod (inc)*" 'the ideal in terms of production restitution (inc)';
- The sequence B Generates a flow of solutions: M generates two variants solutions for the scenery construction namely "*scripter le déplacement de la caméra*" 'script the movement of camera' and "*tronconner*" 'cut the movement';
- The sequence C Frames the problem: O frames the problem by specifying that components should not be independent, but dependent by interacting between them.

Directive format as a strategy to trigger problem framing

In this example (see annex 7 for another example), we believe that naming a problem and then generating a flow of potential solutions might be a strategy to invite another designer to frame the problem. In other words, this directive format might be initiated in order to trigger problem framing about the design project from the other designer/s.

This example and another one (annex 7) of this format were observed in the beginning of a conceptual shift, *i.e.* figurative visual representation of soundtracks and in the situation of a newcomer in the design project.

2.1.2 *Directive format to elicit alternative solution generation*

The directive format to elicit alternative solution generation is defined as (table 18) a designer *x* who generates a solution with delay mark/s in the sequence A. We consider delay marks as modal verbs, *e.g.* may, could, etc., and hedge words, *e.g.* I think, maybe, etc. Then, a designer *y* generates an alternative solution with vagueness in the sequence B. In other words the alternative solutions included vague and imprecise terms, elements or components.

Sequence	Designer *x*	Designer *y*
A	Generates Sol with delay mark/s	———
B	———	Generates Sol(*alternative*) with vagueness

Table 18. Directive format to elicit alternative solution generation

This directive format is dealing with design solutions. We took into account the indicator of the content-related activities 'generate' to detect this directive format. In addition, we also took into account the presence of (1) modal verbs, (2) hedge words and (3) vagueness in solutions. These uses of delay mark/s in generated solutions were in majority followed by the generation of an alternative solution.

Example of the directive format to elicit alternative solution generation

An illustration will be developed with the excerpt M8E1. This excerpt comes from a meeting between the creative and project director O and the external game designer P (photo 4). This meeting started with P who play-tested the prototype and then debriefed on his player's experience with O.

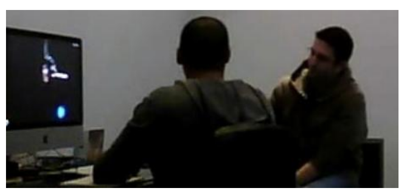


Photo 4. The excerpt M8E1 with from left to right O and P

In this excerpt, the stake of the participants was to search for types of gain to give to players for the new orientation of the prototype, *i.e.* the performance score. The excerpt starts with both participants generating a solution for this score. First, O generated a solution and P generated an alternative one. Then, both participants co-elaborated the alternative solution. The segment illustrated below will focus on the generation of O's solution followed by P's alternative solution.

In this segment (table 19), the designer O generated his solution "*tu vas avoir je sais pas le (.) droit de choisir un objet par exemple qui va habiller ton perso*" 'you will have I don't know the right to choose an object for example that will dress you character' in the sequence A. This solution encompasses delay marks namely "*je sais pas*" 'I don't know' and "*par exemple*" 'for example'. In reaction to this solution, the designer P generated an alternative solution "*ou des nouveaux sons*" 'or new sounds' in the sequence B. The solution "*nouveaux sons*" 'new sounds' can be considered as vague as the new sounds were not defined and how the players would win these new sounds was not elaborated.

No	Loc	Seq	Verbatim	Persp	D.a.	Pb/Sol
1a	O		t'as un mode de replay orienté gamer *you a replay mode oriented gamers*	Dsg		
1b	O	A	c'est-à-dire que tu vas avoir je sais pas le (.)§ droit de *activates sound§* choisir un objet par exemple qui va habiller§ ton perso *gesture toward the prototype§* *that is to say you'll have I don't know the right to chose an object for example that will dress your character*	Dsg	Gen Sol(a)1	Adding player's attribute as a gain
1c	O		§ et si tu veux je garde dans dans *§activates sound* *and if you want I keep in*	Dsg	Refi	
2a	P	B	ou des nouveaux sons/ *or new sounds*	Dsg	Gen Sol(a)2	Adding sound-tracks

Table 19. Directive format to elicit alternative solution generation in the excerpt M8E1

We can summarize the directive format to elicit alternative solution generation as:

- The sequence A Generates solution with delay mark/s: O generates a solution with the hedge words "*je sais pas*" 'I don't know' and "*par exemple*" 'for example';
- The sequence B Generates alternative solution with vagueness: P generates the alternative solution "*des nouveaux sons*" 'new sounds' that is vague.

Directive format to encourage other designer's contributions

We suppose that the use of delay marks in the generation of a solution can be perceived as an invitation for the other designer to enhance the pool of solutions by generating an alternative solution. Moreover, the use of a delay marks might also have a function of postponing the decision on the considered solution.

The invitation to enhance the pool of solutions and the deffered decision making could be considered of as means to make the design process progress and go further.

2.1.3 Directive format to trigger agreement crystallization

The directive format to trigger agreement crystallization (table 20) is defined as a sequence A where a designer *x* generates a solution followed by a sequence B where a designer *y* allocates a task to a designer *z*. In the sequence C, the designer *z* agrees to the allocated task specified by the designer *y*.

Sequence	Designer *x*	Designer *y*	Designer *z*
A	Generates Sol		
B		Allocates a task	
C			Agrees to the allocated task

Table 20. Directive format to trigger agreement crystallization

In contrast to the two other directive formats, this one is dealing with implicit agreement on a solution through the allocation of a task instead of dealing with design ideas. To identify triggering of agreement crystallization, content-related as well as process-related activities were taken into account; it was identified with the indicators 'generate', 'manage' - that refers to allocation of task amongst others - and 'agree'. We found that this directive formats appears in every occasion in which a task was explicitely allocated to a designer.

Example of the directive format to trigger agreement crystallization

An example of this directive format is found in the excerpt M10E1. This excerpt comes from a meeting between the creative director and director of the project O, the coder M and the freelance music artist U (photo 5). This latter integrated the design group to compose new musical soundtracks - second meeting with U -. This excerpt is taken from a debriefing meeting where O and M reported to U results of musical experiences with the first composition of U and of play-tests with this new music composition.

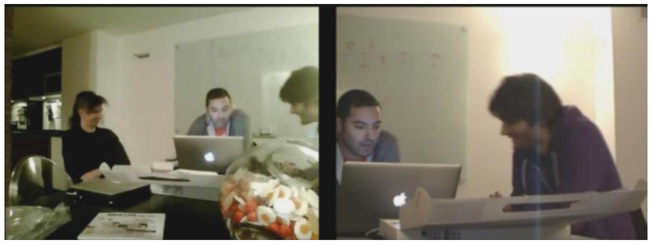


Photo 5. The excerpt M10E1 with from left to right M, O and U

The stake of the designers in this excerpt was to consider all the parameters of the music composition that could impact the player's experience. Therefore, the designers considered the players' needs, *e.g.* simple composition, and the information given through the music composition, *e.g.* how the rhythm is emphasized. This excerpt began with O and M who shared their evaluations of the music composed by U. This led U to generate a first solution in reaction to these evaluations. All participants co-elaborated the solution. The co-elaboration of the solution led the participants to engage in a discussion around the information, *i.e.* the rhythm, that should be conveyed in the music composition for the players. For that issue, M generated a first solution that was co-elaborated with O. Then, O generated an alternative solution that was argued by U who proposed another plan - and a solution - in order to get all the parties satisfied. All participants agreed on U's solution and O prescribed to M to implement U's solution. The illustration shown below corresponds to the solution generated by U for which O allocated a task to M.

The segment of the excerpt (table 21) starts with the generation of U's solution "*peut-être on pourrait essayer d'intégrer celle-là et voir comment les gens réagissent/*" 'maybe we could try to implement this on and see how people react' (Sequence A). U argued his solution by integrating the results of the experiences and play-tests reported by O and M. Then, O and M agreed to the solution. After that, O prescribed to M the task to implement U's solution and identified the following step "*Rentre une boucle de ça on fait une boucle de ce:e celui-là on la rentre et on essaye de comparer on met on met ma boucle pourrie et celle-là à coté et on voit comment les gens la (inc) quoi/ (.) ouais*" 'implement a loop of this, we do that a loop of this, we implement it and we try to compare, we put my crapy loop and this one and we see how people (inc)' (Sequence B). This was followed by M who agreed explicitly to the allocated task "*ok/*" (sequence C).

No	Loc	Seq	Verbatim	Persp	D.A.	Pb/Sol
28a	U		[ouais ben voilà oué oué j'suis d'accord mais du coup est-ce qu'on avant de tout euh de tout revoir la première partie parce que j'ai l'impression qu'on va se barrer dans un:n j'ai l'impression que je vais devoir tout enlever désosser complètement et tout refaire et sans savoir [où on va quoi\ donc *Yeah well that's yeah I agree, but as a result do we, before changing everything from the first part because I have the impression that we will go toward, I have the impression that I will have to remove, to go over completely and redo everything and without knowing where we go so*	Dsg	Arg-	
29	O		[oué *yeah*			
28b	U	A	peut-être on pourrait essayer d'intégrer £celle-là et *hand points to the computer*£ voir comment les gens réagissent/ *maybe we could try to integrate this one and see how the people react*	Dsg	Gen Sol(a)2	Test with players for info
28c	U		si vous pensez qu [elle est plus enthousiasmante if you think that it's more enthousiatic	Ply	Arg+	
30	O		[oué oué je pense que c'est j'pense que c'est (inc) on peut essayer ça/ *Yeah yeah I think that it's, I think that it's (inc) we could try that*	Dsg	Agree	
31	M		/oué j'suis d'accord\ Yeah I agree	Dsg	Agree	
32	O to M	B	Rentre une boucle de ça on fait une boucle de ce:e celui-là§ on la rentre et on essaye de comparer§ on met §*Hand points to computer* §*hand goes from R to L* on met ma boucle pourrie et celle-là à coté et on voit comment les gens la (inc) quoi/ (.) ouais *implement a loop of that, we make one loop of this one, we implement it and we try to compare it, we put my crappy loop and this one beside and we will see how the people (inc) yeah*	Dsg	Mana	
33	M	C	ok/ *ok*	Dsg	Agre	

Table 21. Directive format to trigger agreement crystallization in the excerpt M10E1

In this example, the directive format triggering of agreement crystallization can be reviewed as:

- The sequence A Generates solution: U generates a solution related to the integration of another music composition;
- The sequence B Allocates a task: O allocates a task to M, the implementation of a music composition in the current prototype;
- The sequence C Agrees to the allocated task: M agrees to perform the implementation of the other music composition.

Triggering agreement crystallization and mutual awareness on solutions agreed on and tasks
This directive format implies agreement on a solution through the allocation of a task related to a solution and through the acceptation of the allocated task by the designer who is responsible for it. It seems to secure a mutual agreement. First, the task allocation could be considered as an implicit agreement on the generated solution. Second, the agreement on the allocated task could be considered as an explicit one.

As a consequence, we could presume that there is a resulting mutual awareness of the design process's development; the designers could be aware of the accepted solutions - as they agree to select and implement a solution - and of the distribution of the tasks in the design project.

2.1.4. Functions of the directive formats

To sum up, the directive formats entail functions ranging from strategy to frame a problem, encouraging alternative solution generation to securing a mutual agreement on a solution (table 22). We could say that they cross over a large number of design activities: analysis of problem, generation of ideas and project management with task allocation. Furthermore, they involve divergence by encouraging alternative solution generation and convergence by converging toward shared problems and agreed on solutions.

Directive formats	*Functions*	*Occurrences*
Trigger problem framing	Strategy to trigger the framing of a problem	1
Elicit a new design solution	Invitation to generate alternative solution and postponing the decision	9
Trigger agreement crystallization	Securing a mutual agreement	6

Table 22. Functions of the directive formats in the eighteen excerpts

2.2 Relational formats

The relational formats can be defined by the generation of a design idea by a designer *x* that is related to another design idea - reified or not - coming from inside or outside the design project by a designer *y*. More precisely, a designer *x* generates a design idea. Then, a designer *y* relates this design idea to reified solutions or to a design ideas discussed previously in the design project. Therefore, the relational formats refer to making relations between design ideas under discussion and existant or discussed solutions. These relations might be brought up to apprehend the design idea under discussion through other design ideas. The relational formats subsume (1) relations to reified solutions and (2) relations to an anterior design idea (table 23).

Relational formats	*Description*
Relations to reified solutions	A designer *x* and *y* construct relations between a design solution under discussion to reified ideas from the same or other domains. The relations can convey additional information through the reified solution/s.
Relations to an anterior design idea	A designer *x* constructs relations between a design idea under discussion to design ideas evoked previously in the design project by another designer *y*. The relations can help the designers to describe links between the design idea under discussion and solutions that were previously generated or problems found in player's experience.

Table 23. Relational formats

The relational formats were detected in a total of sixteen excerpts. We observed that relations to reified solutions and relations to anterior design ideas formats are almost equal in proportions. Indeed, we found twelve occurrences in nine excerpts of the relations to reified solutions format and fourteen occurrences in eight excerpts of the relations to anterior design ideas format (table 24).

Relational formats	*Number of excerpt*	*Total occurrences*
Relations to reified solutions	9	12 (46%)
Relations to anterior design ideas	8	14 (54%)

Table 24. Occurrences of the relational formats in eighteen excerpts

We will turn next to a more precise description of the relational formats. This will highlight how designers relate design ideas under discussion with reified solutions or anterior design idea. Examples will be given and functions will be underlined. Lastly, we will summarize the functions of these relational formats.

2.2.1 Relational format involving reified solutions

We summarized this relational format involving reified solutions (table 25) as a sequence A where a designer *x* generates a solution. Then, a designer *y* relates the generated solution to reified one/s in sequence B. Finally, the designer *y* refines the generated solution in the sequence C.

Sequence	Designer *x*	Designer *y*
A	Generates Sol	———
B	———	Relates Sol to a Sol(*reified*)
C	———	Refines Sol

Table 25. Relational format involving reified solutions

This relational format entails design solutions, generated and reified ones. The reified solutions are from other domains, the same domain or from the designed video game itself, *e.g.* movies, other video games and visual representation in the prototype respectively. To detect it, we considered indicators of the content-related activities namely ‘generate’ and ‘refine’. In addition, we took into account evocation of reified solutions. This relational format appears every time reified solution/s mentioned by a designer was/were related to the design discussion.

Example of relations to reified solutions

An instance of this relational format will be described with the excerpt M8E3. This excerpt is taken from a meeting between the creative director and director of the project O and the external game designer P (photo 6). It is a meeting where P play-tested the video game prototype and then debriefed on his player's experience with O.

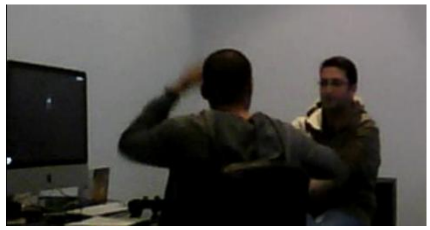


Photo 6. The excerpt M8E3 with from left to right O and P

The stake of the participants in this excerpt is to consider the new orientation of style score's gain as the prototype now encompasses a score scale. It started with O who generated a first solution and P followed by generating an alternative solution. The alternative solution was co-elaborated by both participants O and P. We will concentrate on the generation of P's alternative solution and its co-elaboration to detail this relational format.

The segment (table 26) can be described by the designer P who generated an alternative solution "*faut que tu gagnes des bêtes*" 'you need to win pets' (sequence A) and argued it. This was followed by the evocation of a relation between P's solution and a musical video game by O "*t'as t'as joué t'as vu Jum-mping Maestro/ de Pasta Games (inc) français c'est un bon jeu musical et c'est sur DS/ et eux y font ça*" 'did you play, see Jumping Maestro of Pasta Games (inc) french, it's a good musical game on DS and they do that' (sequence B). This was followed by a description of the video game Jumping Maestro by O.

Then, O refined the solution generated by P with an element of Jumping Maestro "*alors moi ce que je me disais peut-être probablement ce qu'on va faire c'est que ça sera parmi parmi les intruments\ c'est-à-dire que tu va /happer un instrument et cet instrument ça sera un pet qui va te suivre un truc qui va venir courir avec toi ou euh*" 'well me what I was thinking maybe problably what we will do is that it's gonna be amongst the instruments that is to say you will activate an instrument and this instrument, it will be a pet that will follow you, that will run with you' (sequence C).

No	Loc	Seq	Verbatim	Persp	D.A.	Pb/Sol
2	P	A	=faut que tu gagnes [des bêtes *Have to win pets*	Ply	Gen Sol(a)2'	Win pets
3	O		[il relève euh y quoi/ *It stands up, it what*	Dsg		
4	P		des bêtes *pets*			
5	O		non alors ça/ ça/ c'que j'ai envie de faire c'est §peut-être *activates sound*§ c'est alors\\ *no well this I would like to do is maybe, it's well*	Dsg		
6	P		=tu fais gagner des bêtes après tu vends des peluches *You make the people win pets and then you sell cuddly toy*	Dsg	Arg+	
7a	O	B	t'as t'as joué t'as vu Jum-mping Maestro/ de Pasta Games (inc) français c'est un bon jeu musical et c'est sur DS/ et eux y font ça *have you played, have you seen Jumpring Maestro of Pasta Games (inc) French? It's a good musical game and it's with the DS and they do that*	Dsg	Arg+	Ana-log
7b	O		c'est-à-dire §qu'ils ont un petit oiseau qui coure sur <§*gestural simulation* des :es des poteaux télégraphiques et c'est des cordes en fait et à chaque fois qu'y arrive dessus tu dois sur la musique tu dois gratter la corde et y saute (inc)§ c'est *stops simulation* §> vachement bien fait §si tu l'fais bien y'a d'autres petits <§*gestural simulation* oiseaux qui se mettent à te suivre [t'as des:s§ *stops gestural simulation*§> *that is they have a little bird that runs on telegraphic poles and they are ropes in fact and at each time that it arrives on it you have to, on the music, scratch the rope and it jumps (inc). It's really well made. If you do it well, there are other little birds that start to follow, you have*	Ply	inter	
8	P		[mm oué c c ça que je pensais (inc)£ *arms wide open and little mvts*£ *Mm yeah that what I was thinking (inc)*	Dsg	Reph	
9a	O	C	alors moi ce que je me disais § peut-être probablement ce <*plays with prototype*§ qu'on va faire c'est que ça§ sera parmi parmi les *stops playing*§> intruments\\ *well what I was saying to myself is that maybe, probably what we'll do is that it will be amongst the instruments*	Dsg	Refi	
9b	O	C	c'est-à-dire que § tu va /happer un instrument et cet <§*plays with prototype* instrument ça sera un pet §qui va te suivre un truc qui va *hand from computer to him*<§ venir courir avec toi ou euh§= §> *hand from computer to him* *that is you will snatch an instrument and this instrument will become a pet that will follow you, a thing that will run toward you or euh*	Ply	Refi	

Table 26. Relations to reified solutions in the excerpt M8E2

In this example, the relational format involving reified solutions can be depicted as:

- The sequence A Generates a solution: P generates the solution "*faut que tu gagnes des bêtes*" 'win pets';
- The sequence B Relates solution to a reified solution: O relates P's solution to a video game Jumping Maestro;
- The sequence C Refines solution: O refines P's solution by transferring in it an element from the reified solution Jumping Maestro that is "*un pet qui va te suivre*" 'a pet will follow you'.

Reified solutions as evaluative and inspirational sources

We can underline the fact that reified solutions can serve as an evaluative source. In the example above, the designer O relates P's solution to a video game Jumping Maestro that O qualified as a good musical game "*c'est un bon jeu musical*" 'it's a good musical game' (no7a). As Jumping Maestro reifies P's solution, we suppose that O indirectly evaluate P's solution through this reified solution. Accordingly, we could argue that this relational format can provide an evaluation of the generated solution through the evaluation of a reified solution.

Similarly, reified solutions might provide an opportunity to apprehend the player's experience of generated solutions. Designers could have had a player's experience with reified solutions that they can related to "*c'est vachement bien fait*" 'it is really well done' (no 7b). This player's experience through reified solutions may help designers to apprehend the player's experience of generated solutions.

Furthermore, relating a generated solution to reified solution/s can provide a source of inspiration. Also in the example above, the designer O took an element from Jumping Maestro "*y'a d'autres petits oiseaux qui se mettent à te suivre*" 'there are other little birds that start to follow you' (no 7b) and transferred it into P's solution in order to refine it. This format could be considered as opportunities to find source of inspiration in the reified solutions. Consequently, the relations to reified solutions might help the designers to refine generated solutions by providing them inspirational source/s.

At last, relating a reified solution to a generated solution can provide an opportunity to secure a mutual understanding. A related reified solution can be a way to give feedbacks on the understanding of a generated solution. This can be illustrated in the description of the video game Jumping Maestro that reifies P's solution. Following this description, P confirmed the shared basis of understanding "*c'est ça que je pensais*" 'this is what I was thinking' (no 8).

We highlighted that this relational format drives important functions in a design process. We underlined that it can help to evaluate solution, to apprehend player's experience, to inspire further refinement and to reach a mutual understanding.

2.2.2 *Relational format involving anterior design ideas*

The relational format involving anterior design ideas has two variants. The variants are distinguished on the basis of the nature of the anterior design ideas. The first variant refers to an anterior design idea that is a design solution. Differently, the second variant refers to a problem related to a player's experience debriefed by play-tester/s.

The first variant (table 27) can be defined by a sequence A where a designer *x* generates a solution. After, the designer *y* relates the solution to one generated by an absent designer/player *z* in the sequence B. The relation brought up encompasses a polyphony marker. At last, the designer *x* or *y* argues or refines the generated solution.

Sequence	Designer *x*		Designer *y*	Designer/player *z* (*absent*)
A	Generates Sol		—	—
B	—		Relates Sol to Designer z	Generated Sol (*previously*)
C	Argues or refines Sol	or	Argues or refines Sol	—

Table 27. First variant of relational format involving anterior design ideas

The second variant (table 28) can be described as a sequence A where a designer *x* generates a problem. Then in the sequence B, the designer *x* relates the problem to a player's experience of an absent designer/player *y*. This relation encompasses a polyphony marker. Finally, the sequence C ends with the designer *x* generating a solution to pair to the generated problem.

Sequence	Designer *x*	Designer /player *y (absent)*
A	Generates Pb	—
B	Relates Pb to player's experience of *y*	Debriefed on his player's experience
C	Generates Sol	—

Table 28. Second variant of relational format involving anterior design ideas

This relational format involves design ideas; anterior design ideas are either design solutions or design problems related to a debriefed player' experience of an absent designers/players. To pinpoint to this relational format, the indicators of the content-related activities 'generate' - solution and problem -, 'argue' and 'refine' were taken into consideration. Moreover, the notions of locutor and enunciator are at the core of this format; a locutor is the person who does the talking and the enunciator is the person whose voice is been reported by a locutor. This relational format is perceptible by markers of polyphony such as 'he said' or 'he reported a point that is'.

We found the first variant in four excerpts that encompass seven occurrences and the second variant in three excerpts with a total of seven occurrences (table 29). Both variants were found in the same proportions.

Relational format involving anterior design ideas	*Number of excerpt*	*Tot. occurrences*
First variant with anterior design solution	4	7 (50%)
Second variant with anterior design problem	3	7 (50%)

Table 29. Occurrences of the two variants of relations to anterior design ideas in eighteen excerpts

Examples of the relational format involving anterior design ideas

Two examples will be illustrated, one for each variant of this relational format. We will depict the first variant with the excerpt M8E1 (see annex 8 for another example). This excerpt is encompassed in a meeting between the creative director and director of the project O and the external game designer P (photo 7). It is a meeting where there was a play-test followed by a debriefing on the player's experience of P.

Photo 7. The excerpt M8E1 with from left to right O and P

In this excerpt, the stake of the participants was to search for types of gain to give to players for the new orientation of the prototype, namely the performance score. The excerpt starts with both participants generating a solution for this score. First, O generated a solution and P generated an alternative one. Then, both participants co-elaborated the alternative solution. The segment illustrated below will focus on the generation of P's alternative solution.

The portion of M8E1 (table 30) can be described as a sequence A where the designer P generated an alternative solution "*ou des nouveaux sons*" 'or new soundtracks'. Then, O relates this solution to one generated by the absent designer F that previously play-tested the prototype; O used a polyphony marker "*c'qui disait y disait*" 'what he was saying' and then reported the solution generated by F "*c'est mieux d'en avoir un ou deux au début*" 'it's better to have one or two at first' (sequence B). The segment ends with the argumentation of the solution by P "*c'est une récompense qui peut satisfaire à la fois le gamer aussi parce qu'y a des cacahouètes au bout et à la au bout et à la fois euh\ à la fois le casual parce qu'y sera content d'avoir des violons en plus du piano*" 'it's a reward that can satisfy both the hardcore gamer because there are peanuts at the end and the casual gamer because he will be happy to have violin in addition to the piano' (sequence C).

No	Loc	Seq	Verbatim	Enun	Persp	D.A.	Pb/Sol
2a	P	A	ou des nouveaux sons/ *or new sounds* ?	P	Dsg	Gen Sol(a)2	adding soundtracks
2b	P		tu pourrais remplacer un son de [base de base avoir le choix§ tu vois au lieu d'avoir un §*activates one sound* piano t'aurais un piano un un:n= *you could replace a basic sound, have the choice you see ? Instead of having the piano, you would have the*	P	Ply	Refi	
3	O		[peut-être § peut- *plays with prototype*<§ être *maybe, maybe*	O	Dsg		
4	O	B	=mais ça c'était l'idée de Florent le Florent y disait y disait lui/ euh= *but this was the idea of Florent, Florent, he said, he was saying euh*	F	Dsg		
5	P		=tu t'es fais racheter par par lui ou euh/§ *Stops playing*§> *you were bought by him or euh ?*	P			
6a	O	B	(inc)§ c'qui disait y disait euh:h <§ *starts playing* *(inc) what he was saying euh*	F	Dsg		
6b	O	B	§ c'est overwhelming on voit trop de chose *§O has locked two soundtrack and then the proto is passive* au départ *it's overwhelming, we see too much things at the beginning*	F	Ply	Arg-	
6c	O	B	c'est mieux d'en avoir un ou deux au [début *it's better to have one or two at the beginning*	F	Ply	Arg+	
7	P		[oué tu pourrais les faire gagner *yeah your could make them win*	P	Dsg	Reph	
8	O		les faire gagner à chaque fois qui rejoue peut-être on fera ça\\ *make them win at each time that they replay, maybe we'll do that*	O	Dsg	Reph	
9	P	C	§ c'est une récompense qui peut satisfaire à la <*§plays with prototype* fois le gamer aussi parce qu'y a des cacahouètes au bout et à la au bout et à la fois euh\\ à la fois le casual parce qu'y sera content d'avoir des violons en plus du piano§ *stops playing*§> *it's a reward that could satisfy at the same time the hardgamer because there is something at the end and at the same time the casual gamer because s/he will be happy to have the violine plus the piano*	P	Ply	Arg+	

Table 30. First variant relations to anterior design ideas in the excerpt M3E1

In this example, the relational format involving anterior design ideas can be depicted as:

- The sequence A Generates a solution: P generates the solution "*des nouveaux sons*" 'add new soundtracks';
- The sequence B Relates solution to a solution previously generated by an absent participant: O relates P's solution to a solution previously generated by F "*mais ça c'était l'idée de Florent*" 'but this is the idea of Florent';
- The sequence C Argues solution: P argues his solution.

The second variant of this format is illustrated with the excerpt M3E1 (see annex 9 for another example). This excerpt is taking place during a meeting between the creative director and director of the project O, the coder M and the apprentice coder A (photo 8). During this meeting, O, M and A shared the results of multiple play-tests that the designers conducted with various players.

Photo 8. The excerpt M3E1 with from left to right O, M and A

In M3E1, the stake of the designers is to consider the results of play-tests and to stress the possible *revelations* from the debriefings of these play-tests. In this excerpt, O and A first debriefed to M the results and the persona of a play-tester, *i.e.* a typical hardcore gamer. Then, O ended this first debriefing with the generation of a solution that could suit the player's experience of hardcore gamers. After that, M debriefed several play-tests that he carried on with various types of players. In reaction to a debriefing of one play-test, O linked a type of player mentioned by M - players that have little knowledge in music - with a play-test done by the designer L who works in the design studio. It resulted in the generation of a second solution that could suit the players that have little knowledge in music. The relations to anterior design ideas will be illustrated with the second generated solution that is meant for players that have little knowledge in music.

The portion of M3E1 (table 31) can be described as a sequence A where the designer O generated a problem "*le cas du mec la musique c'est pas son truc y'en a rien à branler et du coup y percute pas du tout ce qui s'passe dans la musique*" 'the case of a guy that the music is not his thing and thus he don't get what is going on in the music'. Then, O related the problem to the debriefing of the play-test of the absent designer L; O used a polyphony marker "*et Loic c'qui dit*" 'and Loic what he say' and then reported the speech of L that describes his player's experience "*pour moi ça l'interagit pas*" 'for me it does't interact' (sequence B). The segment ends with the generation of a solution by O "*Ah oué les effets interagissent pas les uns avec les autres et euh et euh d'où ma réflexion autour de (inc) bon*" 'ah yeah the effects do not interact with each other and euh hence my thinking around (inc) well' (sequence C).

No	Loc	Seq	Verbatim	Enun	Persp	D.A.	Pb/sol
34b	O	A	y'a ce cas aussi\ le cas du mec la musique c'est pas son truc y'en a rien à branler et du coup y percute pas du tout ce qui s'passe dans la musique *there's the case of the guy that the music is not his thing, he doesn't care and thus he doesn't get at all what is going on in the music*	O	Ply	Gen Pb(b)	Players that do not get the music
34c	O	B	et Loic c'qui dit *and Loic, he said*	L	Dsg	Deb	
34d	O	B	pour moi ça l'interagit pas *for me, it's not interacting*	L	Ply	Arg	
34e	O		Tu vois c'était ça son truc *You see ? It was his thing*	O	Dsg	Deb	
35	M		oué *yeah*	M	Dsg		
36	O	C	Ah oué les effets§ interagissent pas les uns §*hands going to the other side* avec les autres et euh et euh d'où ma réflexion autour de (inc) bon *oh yeah the effects are not interacting with each other and euh hence my thinking about (inc) well*	O	Dsg	Gen Sol(b)1	Effects interact with each other

Table 31. Second variant relations to anterior design ideas in the excerpt M3E1

In this example, the relational format can be summarized as:

- The sequence A Generates a problem: O generates the problem "*le cas du mec la musique c'est pas son truc*" 'players that do not get the music';
- The sequence B Relates problem to a player's experience: O relates the problem to the debriefing of the player's experience of L;
- The sequence C Generate solution: O generates a solution involving effects interacting with each other which is related to the problem underlined in the player's experience of L.

Relating external participants'contributions to the problem and the solution spaces

The first example illustrates that one designer can relate a solution to one generated previously by an external designer or participant. This can be viewed as a re-attribution of authorship to two participants. This distribution of authorship could be a way to bring more weight on the generated solution; the fact that two different individuals had the same design idea might be considered as convergence toward that solution and that this solution might be worth to consider. This example and another one (annex 9) illustrate that the notion of re-attribution is involved in the relational format involving anterior design ideas. The annex (annex 9) underlines another notion; the one of re-appropriation. In this example, we highlighted that when a designer performs a modificationon on an anterior design idea, *e.g.* a design process, the designer re-appropriates to himself the reported idea.

The second example points out that one designer can relate a design problem to a debriefed player's experience. This relation led a designer to generate a new solution to pair with a problem related to a player's experience, *i.e.* negative element underlined in a debriefed player's experience.

Consequently, we can assume that this relational format could help the designers to expand the problem and solution spaces by taking into account the ideas generated previously by participants and their debriefed players' experiences. Moreover, the report of a participant/player's voice might insure that the designers consider end-users in the (co)-elaboration of a solution which is shown is these examples.

The designers do not only relate solutions or problem, they also provide a description of the player, *e.g.* "*y'a ce cas aussi\ le cas du mec la musique c'est pas son truc y'en a rien à branler* [de la musique]" 'there is the case of a guy who music is not his thing he doesn't care' and "*c'est un gamer pur et dur*" 'it's a hardcore gamer'. Thus, a persona is shared with the other designers. This might help the designers to build a mutual understanding on the discussed solution/problem; designers are informed of who generated or had a particular player's experience. This could be considered important as some personas were selected as targets for the designed product and some were discarded. This could provide a criterion to evaluate the validity of the player's solution/experience; in other words, if the solution or experience of the player should be taken into account or not. For example, the hardcore gamers were not targeted at first and started to be taken into account with the third prototype - half *païdian* half *ludus* -. Furthermore, we assume that it can help the designers to acquire knowledge on the types of experience depending on the persona of players.

This complementary information through persona could also provide insights on how to add new types of players to the ones formerly targeted by integrating elements deduced from their reported solution or player's experience. We could assume that this information might help designers to expand the range of the future users. Furthermore, it could provide some insightful and inspirational information for the designers to reframe the problem and to generate new solutions when taking into account new targeted types of players.

This relational format highlights first the follow up of generated design ideas evoked by external designers/participants. Second, it highlights that the design team can expand problem and solution spaces with contributions of absent designers/participants. These contributions can be either generated solutions or debriefed player's experience. It seems that the designers took into account these contributions as inspirational and evaluative sources - feedbacks on players' experience and to strengthen the weight of a generated solution -.

2.2.3 Functions of the relational formats

To sum up, the relational formats provide different functions (table 32). These functions are mainly related to the generation and evaluation of design ideas, but also to construct mutual understanding and to follow up design ideas.

We underlined that the designers were sometimes relating design idea under discussion to reified or not solutions, problems or experiences. These relations brought new information to the designers about the design ideas under discussion.

Relational formats	*Functions*	*Occurrences*
Relations to reified solutions	Provide an evaluative source	7
	Help to construct a mutual understanding	7
	Provide a source of inspiration	3
	Identify problem	4
	Apprehend player's experience	3
Relations to anterior design ideas	Reported speech as an evaluative source	5
	Reported speech as an inspirational sources to expand types of users	1
	Reported speech as an inspiration source for problem and solution spaces	4
	Follow up design ideas	6
	Apprehend player's experience - mutual understanding -	4

Table 32. Functions of the relational formats in the eighteen excerpts

2.3 Representational formats

The representational formats can be defined by a designer *x* representing a design idea under discussion and a designer *y* elaborating further the representation with another complementary point of view. This co-construction of representations aims to develop multiple points of view around a design idea under discussion. This can be achieved through perspectives such as the player's and the designer's perspectives or different and complementary modalities, *e.g.* verbal, gesture, graphical, etc. In other words, the representational formats refer to the co-construction of representations of a design idea by two designers.

The representational formats subsume (1) alternations of player's and designer's perspectives and (2) complementary modalities (table 33).

Representational formats	*Description*
Alternations of player's and designer's perspectives	Designers *x* and *y* co-construct sequentially representations of a design idea through alternations of their perspectives - player and designer -. It provides a way to apprehend the design ideas through different perspectives.
Complementary modalities	Designers *x* and *y* co-construct sequentially or synchronously representations of a design solution through multiple and complementary modalities. It provides a way to depict the design solution through multiple channels.

Table 33. The representational formats

The representational formats were observed in the majority of our corpus that is to say in seventeen excerpts. We found the format alternations of player's and designer's perspectives in forty-four occurrences within seventeen excerpts and the format involving complementary modalities in twenty-one occurrences within eleven excerpts (table 34). We could advance that the alternations of player's and designer's perspectives format is the dominant representational format.

Representational formats	*Number of excerpt*	*Total occurrences*
Alternation of player's and designer's perspectives	17	44 (68%)
Complementary modalities	11	21 (32%)

Table 34. Occurrences of the representational formats in eighteen excerpts

We will shed light on these representational formats by defining them, underlining their occurrences, providing examples and stressing their functions. Finally, we will end this section with the functions retrieved in the representational formats.

2.3.1. Representational format alternations of player's and designer's perspectives

The representational format alternation of player's and designer's perspectives has two variants. The two variants are differentiated by the valence of the argumentation, *i.e.* the solution is positively argued - implicitely or not - and then refined or the solution is negatively argued and discarded.

The first variant (table 35) is defined as a sequence A where a designer *x* generates a solution with a perspective *a*. This is followed by a sequence B where a designer *y* argues positively the solution with a perspective *b*. The first variant ends with a sequence C where the designer *x* or the designer *y* argues or refines the generated solution with a perspective *a* or *b*.

Sequence	Designer *x*		Designer *y*
A	Generates Sol with perspective *a*		
B			Argues/refines Sol positively with perspective *b*
C	Argues/refines Sol with perspective *a/b*	or	Argues/refines Sol with perspective *a/b*

Table 35. First variant alternations of player's and designer's perspectives

The second variant (table 36) can be described as a designer *x* generating a solution with a perspective *a* in the sequence A. This is followed by a negative argumentation of the solution with a perspective *b* by a designer *y* in the sequence B. This negative argument is complemented by the generation of a new constraint by the designer *y* in the sequence C. In the sequence D, an alternative solution is generated by the designer *x* or *y* that takes into account the generated constraint.

Sequence	Designer *x*		Designer *y*
A	Generates Sol with perspective *a*		
B			Argues negatively Sol with perspective *b*
C			Generates constraint
D	Generates Sol(*alternative*)	or	Generates Sol(*alternative*)

Table 36. Second variant of alternations of player's and designer's perspectives

This representational format involves design ideas that is to say solutions and constraints. It is detected through the indicators of the content-related activities 'generate' - solutions, alternative solutions and constraints -, 'argue' and 'refine'. The valence of the argumentation was also taken into account. In addition, the indicators related to perspectives taken by the designers were considered.

Each design activity was qualified with its respective perspective that is to say either a player's or a designer's perspective. The player's perspective consists of designers focusing on their generic knowledge of players, player's experience, *i.e.* emotion, sensation, fun, comprehension, etc., of users playing the game, persona of players or simulations of player's experience in order to consider the final users. Alternatively, the designer's perspective consists of focusing on the development and details of problems and solutions and their implementation in the prototype in order to progressively orient it toward its final state.

We found the first variant in seventeen excerpts that encompass a total of thirty-six occurrences and the second variant in seven excerpts with a total of eight occurrences (table 37). The first variant is found in greater proportion (82%) than the second variant (18%).

Alternations of player's and designer's perspectives	*Number of excerpt*	*Tot. occurrences*
First variant with positive argument	17	36 (82%)
Second variant with negative argument	7	8 (18%)

Table 37. Occurrences of the two variants alternations of player's and designer's perspectives in eighteen excerpts

Examples of alternations of player's and designer's perspectives

An example will be given for each variant. An illustration of the first variant comes from the excerpt M8E3 (see annex 10 for another example). This excerpt is taken from a meeting between the creative director and director of the project O and the coder M (photo 9). This is a debriefing meeting where O reported to M the contributions of an external designer F.

Photo 9. The excerpt M8E3 with from left to right M and O

In the excerpt, the stake of the participants is to find ideas to re-orient the game toward its former goal that is to create a soft sensorial experience for the players. This stake was brought up in reaction to the debriefed player's experience of F who underlined that the prototype had a rigidity in the music-interaction experience. Therefore, the designers focused their discussion toward solutions that could re-introduce more softness to the experience. The excerpt began with O who reported the problem evoked by F. The problem was then paired with a solution generated by O. After the co-elaboration of O's solution, M generated an alternative solution that was also co-elaborated. The segment that will be described is focused on the generation and co-elaboration of O's solution.

The segment of M8E3 (table 38) starts with the designer O generating a solution with the player's perspective "*l' idée ca s'rait de dire pour passer la boucle euh :euh d'après il faut qu't'ai fait au moins x pression de boutons*" 'the idea would be to say to go to the second loop you need to have pressed *x* buttons' (sequence A). Then later in the co-elaboration, the designer M refined O's solution with first the designer's perspective "*tu peux réintroduire différemment le concept de niveau de difficulté easy medium hard*" 'you can reintroduce differently the difficulty levels concept easy medium hard' (sequence B). After, M refined O's solution with the player's perspective "*j'veux une session courte ou longue ok j'veux pas rester blocké ou je reste mais j'veux que ça dure plus longtemps*" 'I want a short session or a long one ok I don't want to be stuck or I stay but I want it to last longer' (sequence C).

No	Loc	Seq	Verbatim	Persp	D.a.	Pb/Sol
5b	O		actuellement t'as pas ton mot à dire t'arrive clack<§ *follows the rectangles*§ t'enchaine sur la deuxième boucle t'enchaine sur la troisième boucle> *now you don't have the choice, you arrive clack, you follow on the second loop, you follow on the third loop*	Ply	Inter comp	
5c	O	A	l'idée ca s'rait de dire pour § passer la boucle euh :euh §*draws a curve from the first rectangle to the second* d'après il faut qu't'ai fait §au moins x pressions boutons §*writes a number above curve* *The idea would be to say to pass the loop euh following, you would need to have pressed at least x buttons pressures*	Ply	Gen Sol(a)1	*x* pressed buttons to go to 2nd loop
		…	…			
28a	M	B	Tu peux réintroduire c'que dans tout autre contexte tu hurlerais tu dirais c'est mal c'est mal tu peux réintroduire différemment le concept de niveau de difficulté *easy *straight hands going forward 3 times** medium hard en changeant juste les euh ca s'rait pas easy medium hard c'est juste *you could reintroduce what in all other context you'd screamed, you'd say it's bad, it's reintroducing differently the concept of difficulty levels easy, medium and hard by changing only the, it's not easy, medium, hard, it's just*	Dsg	Refi	
28b	M	C	j'veux une session courte ou longue ok j'veux pas rester blocké ou je reste mais j'veux que ça dure plus longtemps *I want a short or long session ok I doesn't want to get stuck or I stay, but I want it to last longer*	Ply	Refi	

Table 38. First variant alternations of player's and designer's perspectives in the excerpt M8E3

In this example, the relational format can be depicted as:

- The sequence A Generates a solution with perspective *a*: O generates the solution "*pour passer la boucle euh euh d'après il faut qu't'ai fait au moins x pressions boutons*" 'x pressed buttons to access the second loop' with the player's perspective;

- The sequence B Refines solution with perspective *b*: M refines O's solution with the designer's perspective "*le concept de niveau de difficulté easy medium hard*" 'difficulty levels concept easy medium hard';
- The sequence C Refines solution with perspective *a*: M refines O's solution with the player's perspective with the player's desire "*j'veux une session courte ou longue*" 'I want a short or long session'.

The second variant is illustrated by the excerpt M2E1 (see annex 11 for another example). This excerpt is a segment of a meeting that occurred between the creative director and director of the project O, the coder M and the apprentice coder A (photo 10). A graphic designer and game designer S who works in the studio for another game company was also participating in the meeting. In this meeting, S play-tested the prototype and then debriefed his player's experience with O, M and A.

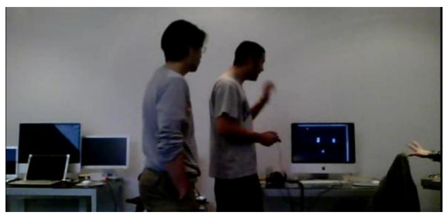


Photo 10. The excerpt M2E1 with from left to right S and O

The stake of the participants in the excerpt is to find visual representations for sounds that would be comprehensible for the players. In other words, to find the visual representation that suits each type of sound, *e.g.* staccato, legato, etc., and each type of inputs, *i.e.* long or short. The excerpt started with O who generated a solution which was followed by M reporting S's incomprehension of a solution in the prototype that reifies the solution generated by O. In turn, O, M and S discussed the reified solution that corresponds to the generated solution of O. After, S brought a constraint that could help to enhance the player's comprehension of the visual representations by confronting two different reified solutions - one that corresponds to the generated solution of O and a different one -. In reaction, O generated an alternative solution and prescribed the implementation of that solution to A. Then, all participants co-elaborated the alternative solution. We will focus on the generation of O's solution and the confrontation with reified solutions in the prototype by S that led O to generate an alternative solution.

The portion of the excerpt (table 39) starts with the generation of a solution by O with a designer's perspective "*Ce qui faut c'est que la représentation visuelle des shorts soit inspirée comme t'as fait avec les-es ça*" 'what we need is that the visual representation of the short is inspired, like you did with that' (sequence A). This was followed by S arguing O's solution through his player's experience and thus S took a player's perspective "*Non l'image va dans l'autre sens*" 'no the image goes in the opposition direction' (sequence B). Then, S underlined an evaluative referent with the player's perspective "*(inc) t'as pas de rupture dans la direction (inc) ... t'as juste pas d'indice*" 'you don't have a rupture in the direction (inc) … you don't have cues' (sequence C). After, O generated an alternative solution that considered S's evaluative referent with a designer's perspective "*je vois ce que tu veux dire inverse le*" 'I see what you're saying reverse it' (sequence D).

No	Loc	Seq	Verbatim	Pers	D.A.	Pb/Sol
1	O	A	<§*plays with prototype* Ce qui faut c'est que la représentation visuelle des shorts soit inspirée comme t'as fait avec les-es ca§ *activates one short*§ *What we need is that the visual representation of the short is inspired like you did with the, this*	Dsg	Gen Sol(a)1	short representat° inspired by the longs
2	A		Oué ça ressemble bien sûre *Yeah, it looks the same, for sure*	Dsg		
3	O		Qui parte du truc et qui fasse§ vtgioum voler comme § *gesture spiral* un *that come from the thing and that makes vtgioum, fly like one*	Dsg	Refi	
4	M		Si par exemple le blanc en fait y'a pas compris qu'y avait un short dessus parce que la représentation [c'était trop proche *If for example the white in fact, he didn't understand that it had a short with it because the representation was too similar*	Ply	Arg-	
5	O		[Ca c'est pas assez claire pour toi/ *This is not enought clear for you* ?	Dsg	Inter	
6	S	B	Non l'image va dans l'autre sens *No, the image goes in the other direction*	Ply	Arg-	
7	M		Mais l'autre ça marche super bien parce *But the other, it works perfectly because*	Dsg	Arg+	
8	O		Tu vois bien que c'est pas la même chose/ *You see that it's not the same thing*	Dsg		
9	S	C	(inc) t'as pas de rupture dans la direction (inc) l'autre le short va pas dans le même sens t'es bien en opposition donc là tu te dis c'est pas pareil et là pour la trompette t'es dans le même sens dans la même direction t'as juste pas d'indice *(inc) there is not a rupture in the direction (inc) the other short doesn't go in the same direction, you have an opposition and thus you can say it's not the same thing and there, for the trumpet, you're in the same direction, you just don't have any cue*	Ply	Gen Const	
10a	O		Mais là on est pas dans la direction cest une illusion *But, here were are not in the direction, this is an illusion*	Dsg	Refi	
10b	O	D	mais je vois ce que tu veux dire inverse le et déjà on va voir si ça donne *but I understand what you are saying, inverse it and we will see what it results in*	Dsg	Gen Sol(a)2	Representat° in opposite direction of the long

Table 39. Second variant of alternations of player's and designer's perspectives in M2E1

In this example, the representational format can be depicted as:

- The sequence A Generates a solution with perspective *a*: O generates the solution "*la représentation visuelle des shorts soit inspirée comme t'as fait avec les-es ca*" 'visual representation of the short inspired by the longs' with the designer's perspective;
- The sequence B Argues solution with perspective *b*: S argues negatively O's solution with the player's perspective;

- The sequence C Generates constraint: S underlines an evaluative referent "*t'as pas de rupture dans la direction… t'as juste pas d'indice*" 'rupture in the direction to give cues';
- The sequence D Generates an alternative solution: O generates the alternative solution "*inverse le*" 'representation in the opposite direction of the long'.

Representational format in co-evolution of problem-solution

We can stress how the player's perspective can be engaged differently (*cf*. annex 11 for illustrations):

- A projected player's experience "*qui peut être sympa*" 'that can be cool';
- A hypothesized player's experience of a potential player "*ta mère qu'est-ce qu'a l'aurait dit/*" 'your mother what would she say';
- A typical player's experience of a specific population: "*comme on a dit t'a l'heure y* [hardcore gamers] *s'attendent à ce qu'y ai un score un objectif clairement qui dit y faut faire tel machin*" 'like we said before they [hardcore gamers] expect a score a goal that tells them clearly what to do'.

These examples stress how the designers can use the player's perspective in various ways by resorting to specific, hypothetical players or specific populations of players. In addition, the designers can underline different elements of a player's perspective:

- Cognitive : "*ton cerveau il est fait pour ça*" 'you brain is made for this' ;
- Fun : "*ah c'est cool*" 'ah it's cool";
- Sensation : "*t'entend pas le tac tac tac tac tac parce qu'y est à la même hauteur*" 'you don't hear the tac tac tac tac tac tac because they have the same pitch';
- Emotional : "*pour elle c'est magique*" 'for her it's magical' ;
- Behavioral : "*y s'est précipité sur tous les boutons après il s'est calmé*" 'he rushed on all the buttons after he calmed down' ;
- Desires : "*j'veux une session courte ou longue ok j'veux pas rester blocké ou je reste mais j'veux que ça dure plus longtemps*" 'I want a short session or a long one ok I don't want to be stuck or I stay but I want it to last longer'.

These examples can be evaluation, experience, needs or constraints that designers and participants report in the player's perspective.

The same applies to the designer's perspective, it can be engaged differently:

- The classic rules of the domain "*non mais y'a rien à faire de cla-classique d'un jeu*" 'no but there is nothing to do that is classic for games';
- The classic rules of the domain with the evocation of other video games "*si tu dis qui faut un personnage je te dis ok dans tétris y'a pas de personnage*" 'if you say that it needs a character, I say ok in Tetris there is no character;
- The characteristics of the prototype itself "*C'est pour ça qu'aujourd'hui justement le fait qu'y a pas d'interface elle est pas celle d'un jeu*" 'it's for that that today the fact that they is not interfact, it's not an interface of a game;
- The task related to the design process: "*inverse le*" 'reverse it';

- Technical knowledge of a domain: “*si tu mets si t’élargies le phobe mathématiquement ça va donner une impression de vitesse*” ‘if you widen the phoebe mathematically it will give an impression of speed’.

These illustrations underline how the designers can unfold designer’s perspectives by putting forward a domain’s and technical knowledge and rules, and multiple facets of the design process.

This representational format shows that the designers use alternatively and in a complementary manner different perspectives. As a result, designers/participants can provide rich information related to the player’s and designer’s perspectives.

The two perspectives seemed to bring useful information related to either the (1) type/s of players’ potential uses/experiences, players’ needs or (2) the solutions’ aims, principles, relations with the other features of the design product and what has been done in the domain with their knowledge. Taken together, we could say that the designers adopted both perspectives to apprehend solutions, to generate constraints and alternative solutions. We believe that alternating player’s perspective to designer’s perspective during co-elaboration of a solution can result in the enhancement of solutions and/or the co-evolution of the problem - by the generated constraints - and solution spaces.

2.3.2. Representational format involving complementary modalities

The representational format involving complementary modalities has two variants that are distinguished by the the temporality of the uses of the modalities: asynchronously, *i.e.* where designers bring subsequently different modalities into play, or synchronously, *i.e.* where designers bring into play concomitantly two or more modalities. The first variant is an asynchronous use of complementary modalities and the second variant is the synchronous use of complementary modalities. Modalities used by the designers range from verbal, gesture, graphical, etc. to interaction with a prototype. We will detail further the range of modalities that we observed during the design process in a next section (section 3.2.1).

The first variant (table 40) is defined by a sequence A where a designer *x* generates a solution through the modality *a*. This is followed by a sequence B where a designer *y* refines or argues the generated solution using the modalities *a* and *b*… *n*.

Sequence	Designer *x*	Designer *y*
A	Generates Sol through modality *a*	
B		Refines or argues Sol through modalities *a*+*b*…*n*

Table 40. First variant of the representational format involving complementary modalities

The second variant (table 41) is described by a sequence A where a designer *x* generates a solution. This is followed by a sequence B where the designer *x* refines the solution through a modality *a* and *b* and at the same time a designer *y* resorts to a modality *c* and/or…*n.* This format ends with a sequence C where the designer *x* argues the solution he generated with the player’s perspective.

Sequence	Designer *x*	Designer *y*
A	Generates Sol	
B	Refines Sol through modality *a+b*	Refines Sol through modality *c+…n*
C	Argues Sol with player's perspective	

Table 41. Second variant of the representational format involving complementary modalities

These variants of complementary modalties deal with design ideas, solutions and problems. These could be expressed through several modalities. These modalities were identified in the transcriptions of excerpts; it subsumes the verbal modality. In addition to this transcription, the use of gestures, graphics, external representations with their modalities were added to provide a richer description of the excerpts analyzed. In combination with these identified modalities, we took into consideration the indicators of the content-related activity 'generate', 'argue' and 'refine' to detect occurrences of this representational format.

Globally, we found the asynchrone variant in seven excerpts that encompass a total of fifteen occurrences and the synchrone variant in four excerpts with a total of six occurrences (table 42). The first variant is found in our corpus more frequently (71%) than the second variant (29%).

Complementary modalities	*Number of excerpt*	*Tot. occurrences*
First variant asynchrone	7	15 (71%)
Second variant synchrone	4	6 (29%)

Table 42. Occurrences of the two variants of the representational format involving complementary modalities in eighteen excerpts

Examples of complementary modalities

We will first provide an example of the asynchronous variant and then of the synchronous one. The asynchronous variant is illustrated with the excerpt M7E4. The excerpt is a segment of a meeting between the creative director and director of the project O, the coder M and the graphic artist JT. In this meeting, all designers contributed to the shift from abstract to figurative visual representations. The designers went through all soundtracks and proposed a figurative representation for each of them. They were doing so with different visual inputs, midi files and wave files, *i.e.* visual representations of soundtracks (photo 11). Moreover, O put on the music file of the soundtrack under discussion so the designers had also auditory inputs.

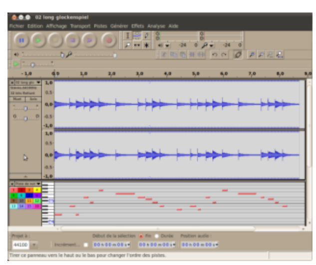


Photo 11. From top to botton wave file (blue) and Midi file (red)

The stake of the participants in this excerpt was to define a figurative visual representation for the tambourine soundtrack. In this excerpt, M generated two solutions. The first one was co-elaborated by all designers and the second one was co-elaborated by M and O. The example below concerns the first solution generated by M that was co-elaborated with the other designers O and Jt.

In the segment of the excerpt M7E4 (table 43), M generated a solution using the verbal and the gestural modalities "*moi là d'sus je vois bien une haie qui eu qui euh*" 'me for this I see a hedge that euh' (photo 12 and sequence A). Then, the designer O argued the solution of M by using the verbal, gestural and vocal modalities "*j'ai peur que ça soit pas assez visible tu vois/ j'essaie d'imaginer la haie tu dois comprendre que la haie les variations de crêtes de la haie déjà tu vois t'entend pas le tac tac tac tac tac parce qu'y est à la même hauteur (.) donc tu vas avoir une haie comme ça eiin ta eiin ta ta tu vois/*" 'I'm afraid that it won't be visible, I try to imagine the hedge, you need to understand that the hedge, the variations of the peaks already you see you don't hear tac tac tac tac tac because they have the same pitch thus you'll have a hedge like this eiin ta eiin ta ta you see' (photo 13 and sequence B).

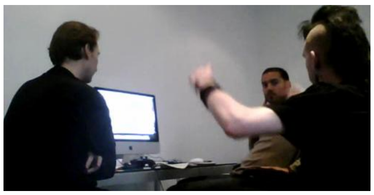


Photo 12. M proposed "Une haie" with several modalities such as verbal and gestures on the music

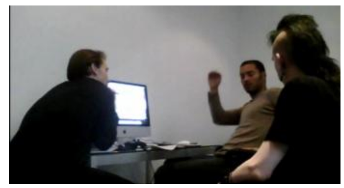


Photo 13. O simulated the solution "une haie" with the verbal, gestural and vocal simulation modalities on the music

No	Loc	Seq	Verbatim	Persp	D.a.	Pb/Sol
4	M	A	moi là d'sus je vois bien une haie qui eu * [qui euh *both hands parallel and go up and down in the rhythm* *me, for that I see an hedge that euh that euh*	Dsg	Gen Sol(b)1	represent by an hedge
5	O		[mais est-que ca sera assez rapide/ *But, would it be fast enough?*		Arg-	
6a	M		<*comme comme les serpentins> **on hand does a circle in the air* *Like, like the serpentines*	Dsg	Arg+	(Analog)
6b	M		<*mais en ligne droite> **both arms are straighten in a parallel* *But, in a straight line*	Dsg	Refi	
7	O		ça ferait décor/ *it would make the scenery?*	Dsg	Reph	
8	M		décor mais *proche oué décor proche<* **both hand parallel* **both hands parallel and go up and down in the rhythm* *the scenery, but near, yes the near scenery*	Dsg	Reph	
9	O		ah oui*> **hands parallel go up and down in the rhythm* *oh yes*			
10	M		une haie *de chaque côté de chaque coté **mvt of both hands going straight in parallel* *a hedge at each side, at each side*	Dsg	Refi	
11a	O		Ça veut dire que même le vide tu'l rempli quoi avec juste de la haie normal ensuite tu fais §des variations sur le:e (.)	Dsg	Refi	

			hands sequently up and down§ *this means that even the empty space you'll fill it up with only a hedge and then you'll make variations on the*			
11b	O		ah ouè ça peut être du décor *oh yeah it can be the scenery*	Dsg	Agree	
12	M		sinon on peut l'caller sur une luciole *otherwise we could put a firefly*	Dsg	Gen Sol(b)2	represent by firefly
13A	O		j'ai peur que ça soit pas assez visible tu vois/ *I'm afraid that it would be enough visible you see?*	Dsg	Arg-	
13b	O	B	j'essaie d'imaginer la haie tu dois comprendre que la haie <§ les variations de crêtes de la haie déjà tu vois> t'entend §*hand goes up and down in the rhythm* pas le <§tac tac tac tac tac> parce qu'y est à la § même § *mvt of saccade* §*hand flat goes from R to L* hauteur (.) *I try to imagine the hedge, you have to understand that the hedge, the peaks variation of the hedge already you see? You don't hear the tac tac tac tact ac because there have the same pitch*	Ply	Arg-	
13c	O	B	donc tu vas avoir une haie comme ça <§eiin ta eiin ta ta> *hand goes up and down in the rhythm*§ tu vois/ *thus you will have a hedge like that eiin ta eiin ta ta you see?*	Dsg	Arg-	

Table 43. First variant of representational format involving complementary modalities in the excerpt M7E4

In this example, the representational format can be depicted as:
- The sequence A Generates a solution through modality *a*: M generates the solution "*une haie*" 'hedge' with verbal and gestural modalities;
- The sequence B Argues solution through modalities *a*+*b*…*n*: O argues M's solution with the verbal, vocal and gestural modalities.

The synchronous variant is illustrated with the excerpt M8E2. This excerpt is encompassed in a meeting between the creative director and director of the project O and the external game designer P (photo14). It is a meeting where there was a play-test followed by a debriefing on the player's experience of P.

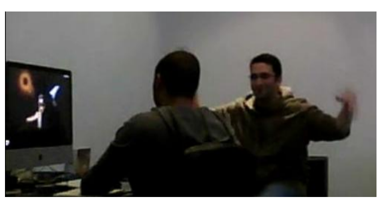


Photo 14. The excerpt M8E2 with from left to right O and P

In this excerpt, the stake of the participants is to consider the issue of how to give style score's feedbacks to players as the prototype now encompasses a score scale. The excerpt begins with the designer O generating a solution followed by the designer P generating an alternative solution. The alternative solution of P was co-elaborated by both O and P and variants of P's alternative solution were proposed by both O and P. The example that will be described below focuses on the second variant of the alternative solution generated by P.

The portion of the excerpt M8E2 (table 44) starts with the designer P generating a variant solution with the verbal modality "*un mec qui joue un instrument*" 'a guy that plays an instrument' (sequence A). It continues with the designer P who refined his variant solution "*tu fais ton artiste qui coure derrière toi avec le mec en costard qui joue du piano qui roule*" 'you do your artist that runs after you with this artist in a suit that plays on a rolling piano' with verbal and gestural modalities while the designer O recreated the context in which the variant solution would unfold in a player's interaction (sequence B and photo 15); O regularly added new sounds (photo 15 peaks on the right side of the computer screen) on the rhythm of an activated soundtrack (photo 15 circle at the left corner of the computer screen) which is the requirement to gain rewards for the style score. Then, the designer P evaluated the solution with the player's perspective in the verbal modality "*/ça peut être marrant/*" 'it could be cool' (sequence C).

Photo 15. From left to right O recreates the context through interaction with the prototype and P refines his solution with verbal and gestural modalities

No	Loc	Seq	Verbatim	Persp	D.a.	Pb/Sol
10a	P	A	<§=un mec qui joue un instrument\ <§*plays with proto* *A guy that plays an instrument*	Dsg	Gen Sol(a)2''	gain an guy playing an instrument
10b	P	B	*tu fais ton artiste qui coure derrière [toi avec le mec <**gestural simulation* en costard qui joue du piano qui roule* *stops simulation*> *you make you artist that runs behind you with the guy in a suit that plays the piano rolling*	Ply	Refi	
11	O		[ça peut être ça *This can be it*	Dsg		
10c	P	C	et /ça peut être marrant/§ *stops playing*§> *and it could be cool*	Ply	Arg+	

Table 44. The second variant of representational format involving complementary modalities in the excerpt M8E2

In this example, the synchrone variant can be summarized as:

- The sequence A Generates a solution through modality *a*: P generates the solution "*un mec qui joue un instrument*" 'a guy that plays an instrument' with verbal modality;
- The sequence B Refines solution through modality *a*+*b* for designer *x* and modality *c…n* for designer *y*: P refines his solution through the verbal and gestural modalities while O refines P's solution with his interaction with the computer ;
- The sequence C Argues solution with player's perspective: P argues his solution with the player's perspective "*ça peut être marrant*" 'it could be cool'.

Complementary modalities to embody solution

We can underline for this representational format several functions. These functions are related to the embodiement of solution, recreation of the context of the solution deployment, mutual understanding, apprehension of the player's experience and inspirational and evaluative sources.

Complementary modalities can help designers to embody a solution. In the first example, the designer M gestured the form of the 'hedge' solution and O embodied the 'hedge' solution with the vocal and gestural modalities. In the second example, the participant P used gesture to embody the 'guy that plays an instrument' solution. These designers simulated and expressed the two solutions with complementary modalities to embody solutions.

The use of complementary modalities not only can serve to embody the solution, but also can serve to recreate a global context. In the first example, the designers resorted to several modalities all of which provided distinct information; the musical track might have helped to recreate the musical experience of the players, the vocal simulation might have helped to highlight each note of the soundtrack and the gestures might have helped to recreate the visual and dynamic representation of the future visual feedback for the players. We could suggest that designers might resort to a set of modalities in order to immerge themselves in the multi-modal context of the future solution.

Notwithstanding, the concomitant uses of complementary modalities can also provide a global and synchronous view of the dynamic context of a solution. In the second example, both P and O embodied several aspects of the solution: the dynamic visual representation of the 'guy playing an instrument' solution is recreated by P with the gestural modality and the situation and conditions where the solution would be displayed in the video game is provided by O with his interaction with the prototype. In this case, the embodiment of the solution is enacted during the recreation of the context of deployment of the generated solution. Therefore, the temporality of the solution's deployment is 'preserved' by the synchronous character of multi-modal representations depicted by both designers; the global context of the solution is recreated by the complementary modalities used simultaneously by the designers.

The embodiement of solution and the recreation of the context that the designers represent with complementary modalities might also ensure a mutual understanding of the solution as the complementary modalities depict several components of a solution and communicate information through several channels.

Furthermore, the use of modalities seemed to play another function related to the apprehension of the player's experience. In the first example, the designer O explicitly underlined what the experience of the players could be with the 'hedge' solution by using the verbal, gestural and vocal simulation on the playing tambourine's soundtrack; he described how the solution might be understood by the players "*t'entend pas le tac tac tac tac tac parce qu'y est à la même hauteur donc tu vas avoir une haie comme ça eiin ta eiin ta ta*". From that, we could argue that the use of several and complementary modalities might play a role in the apprehension of the player's experience. In that vein, apprehending the player's experience through complementary modalities might support the evaluation process of a solution; by apprehending and simulating a player's experience, designers can evaluate a solution through its numerous components, especially through its (simulated) experience.

At last, in the first example, we mentioned that the designers were searching for visual representation solutions while listening to and viewing the tambourine's soundtrack - with the midi and wave files (*cf*. photo 11, p. 119) -. We suggest that the tambourine soundtrack with its auditory and visual inputs might have provided a source of inspiration for the designers.

To conclude, we have underlined that the modalities used might have given a way to embody and express the generated solutions that is to say the designers represented a solution by complementing the verbal modality with other modality/ies and by providing additional information, *e.g.* the dynamics. Additionally, the set of modalities brought into play might have given a global view of the generated solution by providing numerous channels for the depiction of the solution. These could help designers to secure a mutual understanding of the solution generated. Second, the uses of multi-modalities might have given to the designers an opportunity to apprehend the player's experience. This could be linked to the fact that the uses of multi-modalities were seen to enable the designers to immerge themselves in the context of the generated solution through simulations and thus, the designers might have encountered possible player's experiences.

We could believe that the designers resorted to multiple modalities in order to get sources of inspiration and evaluation. This might have been the case when the designers were immerged in a visual and auditory context provided by the music and the visual representation of the tambourine soundtrack. We could suggest that it is not only the modalities brought into play by the designers, *e.g.* verbal, gestural, interaction with the prototype, etc., but also the multi-modal context set up by the designers during the design process, *e.g.* music and visual display of soundtracks, that can help the designers to generate, refine or argue solutions.

2.3.3. *Functions of the representational formats*

To sum up, different functions are entailed in the representational formats (table 45). These functions are sources of inspiration - for solution generation and refinement, but also for constraints -, and of evaluation - for the solutions and player's experience - and mutual understanding.

We found that designers were represententing through different means design idea under discussion. These means are alternations of player's and designer's perspectives and complementary modalities. These representations brought complementary information to designers about the design ideas under discussion.

Representational formats	*Functions*	*Occurrences*
Alternations of player's and designer's perspectives	Providing information - mutual understanding -	11
	Inspiring constraint - from player's experience -	11
	Apprehend – evaluate -, simulate, predict player's experience	17
Complementary modalities	Embodying the solution -and mutual understanding -	9
	Creating the global context	3
	Apprehend – evaluate - and simulate player's experience	7
	Set up the multi-modal context	2
	Inspire	1

Table 45. Functions of the representational formats in the eighteen excerpts

3. *Socio-technical contexts that impact collaboration formats*

Collaboration formats can unfold in different socio-technical contexts; designers and participants with different institutional roles, *i.e.* responsibilities in the design process, and expertise were seen to be involved in collaboration formats and different external representations were seen to be used by them. Thus, it seems interesting to seek if these socio-technical contexts and design activities impact collaboration formats.

In this section, we will refer to socio-technical contexts as institutional roles and expertise of the designers and external representations used during the design process. These will be replaced in the different positions of the collaboration formats' sequence.

We found that the three collaboration formats seemed to be impacted by socio-technical contexts. We found that institutional roles and expertise impact two directive formats triggering problem framing and agreement crystallization and one relational format involving anterior design ideas. Additionally, the external representations impact the representational format involving complementary modalities. The collaboration formats impacted are summarized in the following table (table 46).

Elements impacting	*Collaboration formats*		*Impacts*
Institutional roles and expertise	Directive	To trigger problem framing	-Experts generate solution -Project director frames the problem
		To trigger agreement crystallization	-Experts generate solution -Project director allocates a task -Implementers agree to the allocated task
	Relational	Relations to anterior design ideas	-Member of the core team relates solutions/problem -Play-testers/participants generated solution or debriefed their player's experience
External representations	Representational	Complementary modalities	-Verbal and gestural with or without external representations -Vocal modality with sensorial representations -Interaction with prototype modality with interactive representations -Graphical and textual modalities with sketching representations

Table 46. Elements impacting collaboration formats

It is worth to note that the the directive format to elicite alternative solution generation, the relational format involving reified solutions and the representational format alternation of player's and designer's perspective were neither impacted by the institutional roles and expertise of the designers/participants, nor by external representations.

We will distinguish each of these contextual elements, *i.e.* institutional roles and expertise and external representations, to shed light on how some collaboration formats are impacted.

3.1 Institutional roles and expertise impacting some directive formats and a relational format

Different participants/designers were engaged in the design process in different ways. These designers/participants were seen to be involved in collaborative design activities and/or play-tests. This extended design team encompassed several individuals with different institutional roles and expertise. On the one hand, we consider an institutional role as the responsibility/ies of a designer or participant toward the design project. It ranges from different types of designers, *e.g.* game designer, graphic designer, etc., to players. On the other hand, we consider the expertise that an individual has in a particular task. It ranges from novice to expert in a specific domain, *e.g.* M could be considered as an expert in coding, but novice in game design. We will consider the institutional roles and expertise of the designers/participant in regard to their positions in the collaboration formats' sequence of activities.

The impacts of the institutional roles and expertise were highlighted with the identified collaboration formats combined with professional-related information collected on the designers/participants. In order to detect an impact, we added professional-related information to each occurrence of the collaboration formats identified; for each occurrence of a collaboration format, we notified the institutional roles and expertise of the designers and participants involved in its sequence of activities. This will allow us to stress if some positions in collaboration formats are dependent or not of the institutional roles and expertise of designers/participants. Furthermore, it will allow us tho highlight any asymmetry unfolding in collaboration formats.

We found that institutional roles and expertise of designers/participants are recurrent in the configuration of two directives formats triggering problem framing and agreement crystallization. However, we found no asymmetry in the directive format eliciting alternative solution generation. Furthermore, we also found a recurrent configuration in one relational format involving anterior design ideas. Thus, representational formats and the relational format involving reified solutions are not impacted by institutional roles and expertise and are conducted symmetrically by designers/participants.

We will detail each of them. In order to do so, we will replace the institutional roles and expertise of designers involved in these formats.

3.1.1 Directive format to trigger agreement crystallization

We will develop further this directive format by giving a description of the institutional roles and expertise of the designers and participants involved, and observations of the configurations of the designers and participants. We will end by detailing further the given examples.

Description of triggering agreement crystallization with institutional roles and expertise

With the integration of the institutional roles and expertise, triggering agreement crystallization would be defined as follows (table 47). The sequence A is undertaken by a designer that is responsible and expert in a specific domain of the design process, *e.g.* the graphic designer Jt, the musician U, etc. This expert designer is the one who will generate a solution. The sequence B will be handled by a designer who is responsible for the design project and has hierarchical relation with implementers. This particular designer will operate the allocation of a specific task related to the implementation of the generated solution. For the sequence C, the designer involved has the responsibility for and expertise to implement solutions. The implementer will agree to the task allocated to him.

Sequence	Expert Designer	Project director	Implementer
A	Generates Sol	———	———
B	———	Allocates a task	———
C	———	———	Agrees to the allocated task

Table 47. Institutional roles and expertise in directive format to trigger agreement crystallization

This sequence stresses how crystallization of an agreement can be reached in the design team by incorporating the responsibility and expertise of each designer.

Observations of triggering agreement crystallization with institutional roles and expertise

In the six occurrences of this triggering agreement crystallization, five occurrences follow the above description (table 48).

Sequences		*Designers/participants and their institutional role and expertise*	*Total occurrences in the sequence*
Generates solution	S	Expert game/graphic designer	1
	U	Expert musician	1
	O	Expert game designer	3
	M	Novice graphic designer	1
Allocates of a task	O	Project director	6
Agrees to the allocated task	M	Implementer of code	4
	A	Implementer of code	1
	JT	Implementer of graphic designer	1

Table 48. Occurrences of institutional roles and expertise in directive format to trigger agreement crystallization

In the sequence A, we found five occurrences where a solution is generated by an expert designer, *e.g.* S generated a visual representation which is related to his expertise in graphic design, but M generated a solution of graphic design that is not related to his expertise. This latter accounts for the one occurrence that does not follow the description above. For the sequence B where a designer allocates a task, we found all six occurrences performed by the designer O who is the project director. Finally, in the sequence C where a designer agrees to the allocated task, we found five occurrences performed by implementer of code - M and A - and one occurrence performed by Jt the implementer of graphic design, *i.e.* figurative visual representations.

Examples of triggering agreement crystallization with institutional roles and expertise

We described an example above (section 2.1.3) with an excerpt where the designers O, M and U were having a meeting focused on the music composition. For this excerpt, the integration of the designers' institutional roles and expertise would have been described as follows. The designer who generated the solution related to music in the sequence A is U who is the expert of and responsible for music composition in this design process. Following the generated solution, the activity of allocation of a task was operated by O in the sequence B; the project director O is responsible for the conduct of the design process. The task is related to the implementation musical soundtrack in the prototype and was allocated to M. In reaction to this allocated task, the designer M responsible for and expert of the implementation agreed to the task allocated.

Another example (see annex 12) differs slightly from the first one but respects the configuration of the institutional roles and expertise. It is worth to note that at this period of the design process, the only responsible for and expert of game design is the designer O who is also responsible for the conduct of the design project. In this example, the generated solution in the sequence A consisted in a game design solution for the new 'interaction-sound-image prototype' which was generated by O. In this case, O applied his responsibility for and expertise of game designer. Then, O as the project director allocated a task of implementation to M (sequence B). After, M agreed to perform the allocated task that is directly link to his institutional role and expertise in the design project that is to say the coder of the design project.

We illustrated that the directive format to trigger agreement crystallization's configuration is mostly based on the institutional roles and expertise of the designers and participants. We could suggest that it highlights a form of asymmetry in the collaboration as it is only one designer that allocates tasks, which is the project director.

3.1.2 Directive format to trigger problem framing

We will detail further this directive format to trigger problem framing by giving a description of the institutional roles and expertise of the designers and participants involved, observations of the configurations of the designers and participants and we will end this section by providing examples.

Description of triggering problem framing with institutional roles and expertise

This directive format enhanced by details on the designers' institutional role and expertise (table 49) begins with the contribution of a designer that is responsible for and expert of a specific domain in the design process. This domain could be graphics, code, music, etc. The designer responsible for this domain will first name a problem and then generate a flow of solutions (sequence A and B respectively). Then, a designer who knows the goals and the expected state of the final prototype will intervene by framing the problem (sequence C). This will be done by the project director that has a hierarchical relation with the responsibles for and experts of a domain.

Sequence	Responsible/expert of a domain	Project director
A	Names a Pb	———
B	Generates a flow of Sol	———
C	———	Frames the Pb

Table 49. Institutional roles and expertise in directive format to trigger problem framing

Observations of triggering problem framing with institutional roles and expertise

For the observation of this directive format, we take into account the examples in the annex (annex 13) which gives a total of four occurrences. We found that all occurrences have the same configuration that is described above. The sequence A and B are operated by M, expert coder, in one occurrence and by Jt, expert in graphic design, in three occurrences (table 50). The sequence C is performed in all four occurrences by the designer O who is responsible for the design project.

Sequences	*Designers/participants and their institutional role and expertise*		*Total occurrences in the sequence*
Names a problem	M	Expert coder	1
	Jt	Expert graphic designer	3
Generates a flow of solutions	M	Expert coder	1
	Jt	Expert graphic designer	3
Frames the problem	O	Project director	4

Table 50. Occurrences of institutional roles and expertise in directive format to trigger problem framing

Examples of triggering problem framing with institutional roles and expertise

We depicted this directive format with the excerpt M7E1 (section 2.1.1). In this excerpt, the problem named by M concerns the implementation of the scenery. This domain is the responsibility and the expertise of the designer M. This was followed by the generation of a flow of solutions by M. In reaction, the project director O who holds the global expected state of the final prototype generated a solution in order to frame the problem. In other words, M proposed two solutions that involved an independency of the components of the scene and conversely, O framed the problem by identifying an area of the solution space that is targeted and that involves dependencies between components of the scene.

In the same meeting, another illustration is seen (annex 13). This excerpt concerns the transition from abstract to figurative visual representations prototypes with the designer O, M and Jt. This latter was hired in order to do the transition between abstract to figurative representations. We underlined that the designer Jt named a problem and generated a flow of solutions related to figurative representations. These solutions are related to his responsibility and expertise of graphic design. In reaction to this flow of solutions, the designer O framed the problem. As O is the project director, we can consider him as the person who knows the goals and the expected state of the final prototype. This excerpt had three occurrences of the triggering problem framing format with Jt and O. These occurrences had all the same configuration of institutional roles and expertise.

We have depicted two illustrations of directive format to trigger problem framing by integrating institutional roles and expertise of the participants. Both examples support the fact that this directive format seems impacted by the institutional roles and expertise of the participants.

3.1.3 Relational format involving anterior design ideas

We will introduce in more details the relational format involving anterior design ideas by giving a description of the institutional roles and expertise of the designers and participants involved, observations of the configurations of the designers and participants. Then, we will end this section by depicting two examples.

Description of relations to anterior design ideas with institutional roles and expertise

This relational format has two variants. The first variant enhanced by details on the designers' institutional roles and expertise (table 51) begins with a designer *x* generating a solution (sequence A). Then, this solution is related to a solution previously generated by a play-tester/participant. It is a member of the core team that relates the generated solution to the solution previously generated (sequence B); the members of the core team are responsible for the play-tests. Then, the designer *x* or a core team member argues or refines the solution (sequence C).

Sequence	Designer *x*	Designer responsible for play-test	Play-tester/participant *(absent)*
A	Generates Sol		
B		Relates Sol to Designer *z*	Generated Sol (*previously*)
C	Argues/refines Sol or	Argues/ refines Sol	

Table 51. Institutional roles and expertise in first variant of relations to anterior design ideas

The second variant encompassing details on institutional roles and expertise (table 52) starts with the generation of a problem by a member of the core team that is responsible for the play-tests in the design process. This member of the core team will relate the problem to a player's experience of a play-tester/participant (sequence B). Then, the designer responsible for the play-tests will pair a solution to the problem (sequence C).

Sequence	Designer responsible for play-test	Play-tester/participant *(absent)*
A	Generates Pb	
B	Relates Pb to player's experience of *y*	Debriefed on his player's experience
C	Generates Sol	

Table 52. Institutional roles and expertise in second variant of relations to anterior design ideas

Observations of relations to anterior design ideas with institutional roles and expertise

In the fourteen occurrences of this relational format, we found that for thirteen occurrences it is the designer O of the core team that relates a generated solution to a solution previously generated by external participants or problems to debriefed player's experiences; O is the main responsible for play-tests (table 53). In one occurrence, it is the designer M that relates a problem to a debriefed player's experience. M, to a lesser extent, carried on play-tests as a designer from the core team.

For the sequences involving external participants, in ten occurrences, the solution generated previously or the debriefed player's experience came from play-testers of different kinds: experts designers of different domains related to video games such as game design, graphic design and development. Similarly, we found two occurrences of a play-tester who is a typical hardcore gamer and one occurrence of a play-tester who works in public relation of a famous video game company. Differently, we found one occurrence of a scientific community that we can consider as experts and one occurrence of a participant from public relation. However, the two latters are not from the video game domain.

Sequences of relational format	*Designers/participants and their institutional role and expertise*		*Total occurrences in the sequence*
Relates solution or problem	O	Responsible for play-tests (core team)	13
	M	Responsible for play-tests (core team)	1
Generated previously solutions or debriefed player's experience	S	Tester & expert game/graphic designer	1
	L	Tester & senior developer	1
	F	Tester & expert game designer/CEO	6
	P	Tester & expert game designer/edition	1
	St	Tester & expert game designer	1
		Tester & typical hardcore gamer	2
	As	Tester & public relations	1
		Scientific community	1

Table 53. Occurrences of institutional roles and expertise in relations to anterior design ideas

Examples of relations to anterior design ideas with institutional roles and expertise

We showed two examples (section 2.2.2) that encompassed relations to anterior design ideas. In both examples, it is the designer O who related a solution and a problem to a generated solution and a debriefed player's experience respectively. As mentioned, O is a member of the core team that is responsible for conducting the play-tests and for gathering feedbacks of play-testers - feedbacks that can be solutions or player's experience -. Regarding the generated solution and the debriefed player's experience, they were both evoked by F and L who are play-testers/participants.

3.2 External representations impacting representational formats involving complementary modalities

Different external representations were used by designers and participants during the whole design process. These different external representations were used in order to sketch, to simulate or to create a sensorial context (table 54).

External representations	*Description*	*Examples*
Sketching	They are representations that enable designers to depict, sketch, display components of a design solution and their inter-relations.	White board Paper/pencil
Interactive	They are representations that enable designers to act on the content of the design artifact that will give a reaction, a feedback.	Game prototype Video games
Sensorial	They are representations that provide sensorial inputs. These inputs can be visual, auditory or both.	Music files Music soundtracks Photo Video

Table 54. Types of external representation

We crossed the external representations with the modalities that designers and participants used in order to highlight impact of external representations on this representational format. To do so, we used the three categories of external representations and the modalities used by designers.

We will first review the modalities that the designers and participants used in the design process. Then, we will describe quantitatively the use of external representations and their modalities. Finally, examples of external representations and their modalities will be given.

3.2.1 Modalities in the representational format

Verbal. The verbal modality is principally used by the designers throughout the design process for a large range of purposes. This modality could be complemented by other modality/ies. Additionally, the verbal modality through vocalizations was also used as to simulate music; designers produced sounds with their voice to simulate or to emphasize soundtracks or notes of a soundtrack.

Gestural. Designers were seen to resort to gestures in various ways. We observed two ways in which designers used them. First, we underlined that designers made gestures in order to indicate or refer to a design element or to frame a location/space. This concerns the deictic gestures (photo 16). Second, other gestures were made by designers to embody and express a particular shape, a movement, a sequence of actions, behaviors of a player, etc. (photo 17).

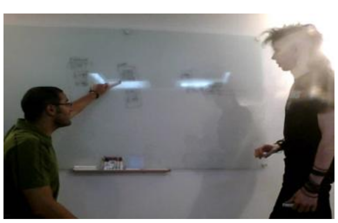


Photo 16. The designer O at the left points to an object

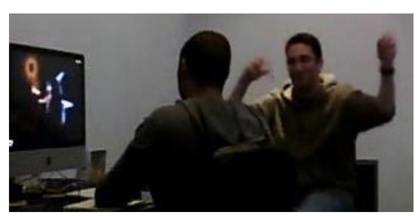


Photo 17. The designer in the right uses gestures to express his solution

Graphical. Graphics were used either on a sheet of paper or on the white board to sketch. We observed that the designers used them both for example to draw and display design elements (photo 18) or to illustrate the architecture of the code (photo 19). The graphics could be associated with textual annotations.

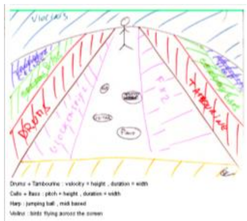


Photo 18. Graphics

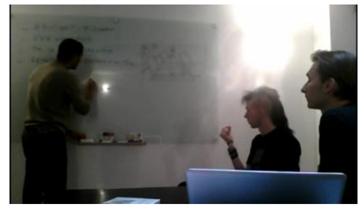


Photo 19. White boardThe designer M and O co-draw the architecture of the code

Textual. The textual modality as we said was used in association with graphics, but the designers also used it to write task lists (photo 20). Texts has also used in a management tool, *i.e.* the wiki of the design team (photo 21).

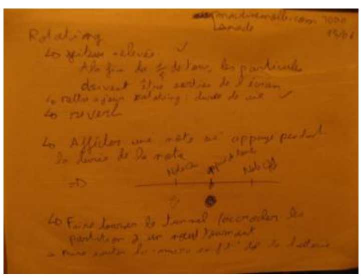


Photo 20. A task list of the designer A

Photo 21. The wiki

Interaction with prototype[7]**.** This modality is the most typical modality of video game design. It allowed the designers to simulate player's behaviors and interactions, to refer to an element in the game by activating it - deictic interaction - and to evaluate - play-test - the prototype (photo 22).

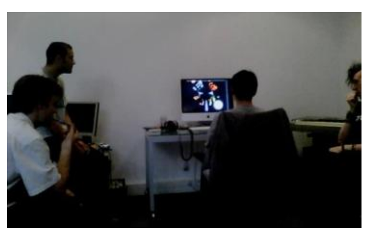


Photo 22. A play-tester interacts with the prototype

This modality is often coupled with the verbal modality, but it can be autonomous. There is one occasion where this case was seen. We could think that this might be allowed by the flexibility that is provided by the prototype.

[7] We consider that interaction with the prototype in this case as a modality as it convey meaning through activations on the prototype that provide a set of outputs. The interaction is not reduce to practical aim, but has a real experiential function and can transform the cognitive state of the addressee/s.

Visual and auditory. We found that the designers used the visual modality when they accessed visual representations, *e.g.* visual representations of musical tracks with midi files and wave files (photo 23), visual representations of elements in a prototype or pictures taken from books, websites (photo 24). In addition, the designers used the auditory modality when they listened to music soundtracks, play music with instruments and recreate vocally soundtracks.

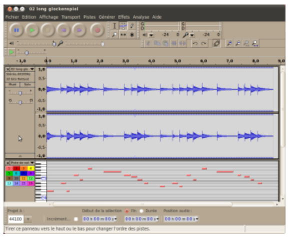


Photo 23. Representation of midi and wave files

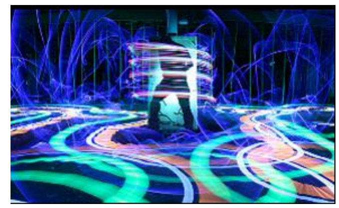


Photo 24. A link from the Wiki leading to a picture

3.2.2 Observation of types of external representation and modalities

We can underline that the verbal and gestural modalities were used in the majority of the cases with or without any external representation (table 55). Thus, it seems that these modalities are not impacted by external representations. We can highlight that the external representations white board, paper and pencil, prototype and auditory involved other modalities: graphical and textual modalities were found in five and four occurrences respectively with use of the sketching representations; the modality interaction with the prototype was found in all uses of the interactive prototype; the vocal modality was found in all uses of the auditory representation uses.

Type of external representation		*Occurrences*	*Modalities*	*Occurrences*
Sketching	White board Paper and pencil	5	Verbal	5
			Gestural	5
			Graphical	5
			Textual	4
Interactive	Prototype	11	Verbal	11
			Gestural	10
			Interaction with prototype	11
Sensorial	Auditory (*e.g.* soundtracks)	2	Verbal	2
			Gestural	2
			Vocal	2
	Visual (e.g midi files)	1	Verbal	1
			Gestural	1
N/A		2	Verbal	2
			Gestural	2

Table 55. Occurrences of external representations and modalities in the representational format involving complementary modalities

3.2.3 Examples of representational format involving complementary modalities with external representations

We developed two examples previously (section 2.3.2), one with sensorial external representations, *i.e.* visual and auditory representations, and one with the interactive representation, *i.e.* prototype. In both examples, the uses of the verbal and gestural modalities were observed. Moreover, vocal modality was used with the sensorial representations and the interaction with the prototype was used with the interactive representation.

We depicted a number of modalities that were observed with the use of external representations. We will illustrate further how the external representations can orient the use of specific modalities in the representational format.

Sensorial representations with verbal, gestural and vocal modalities

Sensorial representations can be visual such as midi files, *i.e.* graphical representation of each note in a soundtrack (*cf.* photo 23, p. 133), and auditory such as musical soundtracks. We found three occurrences of sensorial representations in our corpus. These sensorial representations were used with modalities such as verbal, gestural and vocal. We will provide further details on the excerpt analyzed above (section 2.3.2) exemplifying an illustration of the use of sensorial representations with an excerpt focused on the design of a visual representation of the tambourine soundtrack.

Example with the sensorial representation. The excerpt entails two sensorial representations that were used to create a visual representation of the tambourine soundtrack: auditory with the musical soundtrack and visual with the midi and wave files. With these design representations, the designers used verbal (all in photos 25), gestural (all in photos 25) and vocal (13b and 13c in photos 25) modalities.

Photos 25. Verbal, gestural and vocal modalities with sensorial external representations

Functions of the modalities with the sensorial representation. The visual representations to be designed have some constraints; the designers must generate ideas that are adapted to the musical parameters such as pitch, duration of the notes and rhythm amongst others. Some of these musical parameters were depicted on the screen of the computer, *i.e.* the midi and wave files, and some were perceptible by listening to the musical soundtrack which was playing during all the sequence reported above.

As the visual representation must be dynamic like the music, the designers resorted to multiple gestures that can recreate the dynamic character of visual representation. The gestural modality seemed to have helped the designers to embody movements that are in respect with the structure of the music composition - the variation of the pitch and the rhythm -. Moreover, they used the playing soundtrack as a dynamic support for the gestural simulation. Furthermore, one designer emphasized a sequence of the musical track by vocally reproducing it and by associating it with the gestures he was performing to support his evaluation; the designer seemed to emphasize components of the music composition, *i.e.* each note of the soundtrack.

Taken together, a visual representation was co-elaborated with the help of the verbal, gestural and vocal modalities that were used with visual and auditory representations. The modalities almost all depicted a dynamic character - except for the verbal modality - in order to represent a dynamic visual representation with sensorial representations.

Interactive representations with verbal and interaction on the prototype

Our corpus encompasses eleven occurrences of musical game prototype uses in order to act on the content of this interactive representation to display or provoke a reaction, a feedback. When the designers brought into play this interactive representation, they used several modalities such as verbal, gestural and interaction with the prototype (example in the section 2.3.2). We will illustrate another example of the use of an interactive representation.

Example with the interactional representation. The excerpt M9E2 comes from a meeting between the creative director and director of the project O, the coder M and the graphic artist Jt. It is a debriefing meeting where the designer O shared the feedbacks of an external designer.

The excerpt is focused on a solution generated by St, an external game designer that O met at a game design conference. The stake of the designers is to consider a new type of interaction, a short loop pattern generated by St. In this excerpt, O reported the new interaction. This solution was co-elaborated by O and M. Then, M and O discussed about how it could be implemented in the prototype. After that, O and M shifted toward a new problem, the feedbacks related to this new interaction. All the problems and solutions were co-elaborated by O and M and Jt participated by asking questions. The illustration below focuses on the presentation of the new interaction by O.

The sequence (table 56) starts with an emphasis on one particular interaction, the possibility to 'lock the longs' that O activated in the prototype with verbal explanation (line 3a). The fact that O emphasized this type of interaction might be a way to give insights on the solution of St as it is an analog interaction. Then, the solution 'short loop pattern' was reported by O with the verbal modality and through his interaction with the prototype (sequence A, photo 26); O shared the solution by verbally orienting the focus of the designers "*c'est sur les shorts*" 'it's on the shorts' and then simulating the outputs of the new interaction on the prototype. As the new interaction is simulated by O, M refined the solution with the verbal modality "*qu'il appren:ne qu'il apprenne les loops ouais .. ah genre si je l'fais trois fois d'affilé il* [prototype] *s'en souvient*" 'it will learn the loops yeah like if I do this three times in a row it [prototype] will remember it'(sequence B).

3b O (right screen) "*c'est sur les shorts si je fais attends*"

Photo 26. Verbal and interaction with prototype modalities with interactive representation

No	Loc	Seq	Verbatim	Enun	Persp	D.a.	Pb/Sol
3a	O		ca s'rait mortelle/ si (.) alors sur les shorts alors sur <§ les longs je reste stock (.) il lock le m- il <§*activates long* lock le long ok/ §> ce qui serait bien §>*stops long* *It would be cool if, so on the shorts, so on the longs I stay stocked, it locks the, it locks the longs ok? What would be gook*	O	Dsg		
3b	O	A	c'est sur les shorts si je fais § attends <§*activates 3 shorts' patterns* *it's on the shorts, if I do that, wait*	ST	Ply	Gen Sol(a)1	Short loop pattern
4	M	B	qu'il appren:ne qu'il apprenne les loops ouais .. ah genre si je l'fais trois fois d'affilé il s'en souvient *that the game learns, that it learns the loop, yeah like if I do three times in a row, it remembers it*	M	Dsg	Refi	
5	O		exactement *exactly*	O	Dsg		
6	M		ouais ouais c'est class\ .ouais ca s'rait /vachement class\ *yeah yeah, it's classy, yeah it would be very classy*	M	Ply	Arg+	

Table 56. The excerpt M9E2 with the interactive representation

Functions of the modalities with the interactional representation. This example highlights an interactive representation that was used in order to share and co-elaborate a new type of interaction. During the interaction/simulation with the prototype, the designer O and M resorted to verbal modality. It is an example of a synchronous use of complementary modalities where O started with the verbal modalities to signal on what the new interaction applies. Then he used the interaction with the prototype while the designer M used the verbal modality to refine the solution (3b and 4).

In this case and in the ten others cases - encompassing the example in section 2.3.2 - involving this type of external representation, simulated interaction must respect some constraints such as creating an immediate reaction and giving relevant feedback to the players. Accordingly, the interaction/simulation with the prototype might give opportunities to simulate at least the first constraint of immediate reaction; three short pattern that becomes locked in the above example.

As an interaction requires a dynamic such as action-reaction, a designer can resort primarily to simulation on the prototype to co-elaborate a new solution involving an interaction. The prototype might have helped the designers to recreate the dynamic action-reaction that is to say to simulate the prototype's behavior involved in the new interaction. Furthermore, the implemented functions in the prototype can serve to depict a new interaction by highlighting an analog interaction as in the example above (line 3a). These implemented functions or features can be resorted to as to exemplify and depict a new solution of interaction.

The assent of O to M's refinement (line 5) might signify that the use an interaction made possible by the prototype and the simulation of an analog interaction on the prototype provided a good channel to pass on the information related to the new interaction.

We could argue that the use of simulation on the prototype might help the designers to reach a mutual understanding on generated solutions implying an interaction. It might also give an opportunity to see and visualize a solution through its simulation. This opportunity could help the evaluation process as the solution is somehow enacted on the interactive representation.

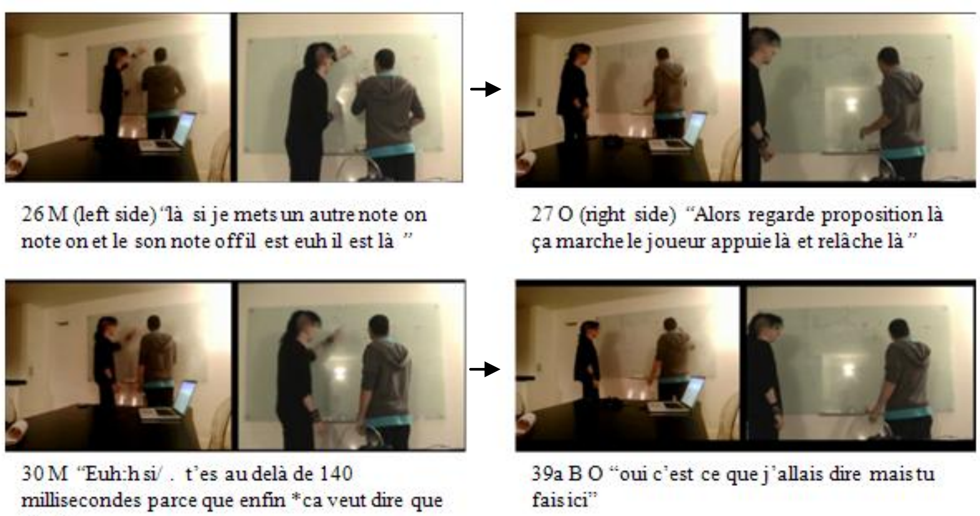
Sketching representations with verbal, gestural, graphical and textual modalities

Our corpus contains five occurrences of use of the white board and paper and pencil; the designers used these sketching representations in order to depict, sketch, display components of a design solution and their inter-relations. The uses of these sketching representations were carried on with the verbal, gestural, graphic and textual modalities. We will present the use of the white board sketching representation.

Example with the sketching representation. The following example taken from the excerpt M9E1 illustrates the use of the white board sketching representation for the co-elaboration of a solution. This solution is related to the code architecture. With this design representation, the designers resorted to modalities such as verbal, gestural, graphic and textual. The excerpt is taken from a meeting with creative director and director of the project O, the coder M and the graphic artist Jt. However, Jt did not participate in the sequence below.

In this excerpt, the stake of the designers was to consider how the prototype displays the visual representation of an activated sound and how this visual feedback can be incoherent with some player's interactions. The excerpt started with M who reported a problem related to the visual feedbacks that can be inconsistent with an interaction initiated by the players. Then, M and O generated solutions in order to solve the identified problem. After that, they focused their discussion on the current state of the prototype in order to fully understand how some types of player's interactions can affect both the visual and auditory outputs. This constituted a major part of mutual understanding phase on how the current prototype behaves. Then, M identified another problem. This was followed by another phase of mutual understanding which led the designer O to generate a solution for the new problem evoked by M. The following illustration will focus on the second problem generated by M that was paired with a solution generated by O.

The excerpt (table 57) starts with M who used verbal, gestural, graphical and textual modalities to generate a problem "*là si je mets un autre note on note on et le son note off il est euh il est là quoi et comment je gère ce cas là/*" 'there if I put another note on and the note off, it is there, how I deal with this case' (sequence A, photos 27(26)). This problem was followed by a phase of mutual understanding on the current state of the prototype (lines 29 to 38). During this phase, the designers used the verbal, gestural and graphical modalities (photos 27(27 and 30)). Then, the designer O generated a solution with the verbal and gestural modalities "*non pour moi ce que tu fais ce que tu fais oui c'est ce que j'allais dire mais tu fais ici c'est-à-dire que tu vas jusqu'à la note off de celle là et là tu mets un fade out 'fuite'*" 'no for me what you do is yes that's what I was gonna say but you do that here that is to say you go to the note off of this one and there you put a fade out "phit"' (sequence B and photos 27(39a)).



Photos 27 . Verbal, gestural, graphical and textual modalities used with sketching representation

No	Loc	Seq	Verbatim	Persp	D.A.	Pb/Sol

26	M	A	Mein ouai parce que enfin regarde *c'est encore pire que *erases drawing* ça regarde/ mais ça s'overlap mais ok genre *là si je *draws+annotation ** mets un autre note on note on et le son note off il est euh il est *là quoi et comment je gère ce cas là/ **points and marks with a marker on the board* *Well because still look it's worst than this, but it overlaps, but ok like if I put other note on and the sound of the note off is there, how I deal with this case?*	Dsg	Gen Pb(a)	Consisten-cy of input-output
27	O		Alors regarde proposition là ça marche <§ le joueur *highlights a distance with a pen §* appuie là et relâche là >c'est ça / *well look, a proposition, now it works. The player activate here and release it there, is that it?*	Ply	Inter comp	
28	M		ouais *yeah*	Dsg		
29	O		Ok y'appuie §ici donc normalement y doit avoir §ce truc *§points* *§points* là mais on l'a pas entendu parce que c'est140 millisecondes c'est ca/ *ok the player activate here thus normally it should have this thing there, but we didn't hear it because it's 140 milliseconds, isn't it?*	Ply	Inter comp	
30	M		Euh:h si/ . t'es au delà de 140 millisecondes parce que enfin *ca veut dire que (inc) **points on the board* *Euh yeah you are above 140 milliseconds because well it means that (inc)*	Dsg	Inter comp	
31	O		Si si si §là ce qui se passe [(inc) *§points on the board* *Yeah yeah here what is going on (inc)*	Dsg		
32a	M		[(inc) *de toute façon je lance **points on board* *(inc) any way I start*	Dsg	Inter comp	
32b	M		quoi lui y l'as activé *là **points* *what the player he activate here*	Ply	Inter comp	
32c	M		là les 150 millisecondes dont tu parles elles sont* ici *points** c'est si on *c'est si on relâche entre là et là [y joue le **joins two points* short *here the 150 milliseconds that you're speaking of are there. It's if we release between here and here, the player activates the short*	Dsg	Inter comp	
33	O		[Ah ouai ouai *Oh yeah yeah*	Dsg		
34	M		Mais euh\ *là il est bien après et là c'est d'la quanti la <**points toward several elements* quanti elle dit ok le long est activé mais on est pas encore sur un événement j'attend le prochain événement je joue le truc et lui reste après [(inc)* *>*stops pointing* *but euh here, he is pretty well after and there is the quanti. The quanti says ok the long is activated, but we*	Dsg	Inter comp	

			are not already on an events, I wait the following one, I play the thing and it stays afterward (inc)			
35a	O		[donc §y reste juste après y reste après <§*points to several elements* *Yet it stays just after, it stays after*	Dsg	Inter comp	
35b	O		toi tu joue donc tu vas normalement tu dois aller jusqu'à la note off ici\§ §> *stops pointing* *you, you play thus you will normally you will go as far as the note off here*	Ply	Inter comp	
36	M		Ben oui *Well yes*	Dsg		
37	O		§Mais ce que tu peux faire c'est qu'arrivé jusqu'ici= <§*points toward several elements* > *But what you can do is when you arrive here*	Dsg		
38	M		=Normalement moi dans ce cas là\ norma[lement (inc) *Normally, me in this case, normally (inc)*	Dsg	Inter comp	
39a	O	B	[§non pour moi *stoping gesture*§ ce que tu fais ce que tu fais oui c'est ce que j'allais dire mais tu fais §ici c'est-à-dire que tu vas jusqu'à la note <§*points and follows elements* off de celle là et là tu mets un fade out 'fuite'§ *stops pointing and following elements*§> *no, for me what you need to do, yes this is what I was gonna say, but you do it here that is you go up to the note off of this one and there you put a fade out fuite*	Dsg	Gen Sol(a)1	Put a fade out at the end

Table 57. The excerpt M9E1 with the sketching representation

Functions of the modalities with the sketching representation. This example encompasses the use of a sketching representation. While designers used this external representation, they resorted to verbal, gestural, graphical and textual modalities. We can underline that the gestures were mainly deictic in nature; they used gestures to point to specific elements (lines 26, 29, 30 to 32c, 34 to 35b, 37 and 39a) or to highlight a temporality, *i.e.* to underline the time between two inputs or outputs (lines 27,32c, 39a and 39b). Differently, the graphical modality was mainly used to depict the components of the code (line 26a) and their organization. The textual modality was used to annotate some depicted components of the code (line 26a).

The code is a structural object of the design product that needs to attribute to each player's input an output. In this musical video game, the outputs are visual and auditory and they need to be consistent with the player's inputs. Consequently, the use of graphics on the whiteboard might allow the designers to draw the structure and from that the designers can pinpoint or draw inputs that they could link to outputs.

In addition, the designers used the whiteboard that allows them to depict the whole structure of the code or part of it. This depiction of the structure can help the designers to reach a mutual understanding of how the game behaves and reacts. In addition, they can simulate playing situations as they can display inputs in the structure and underline the resulting outputs. By that, they can recreate a simulated temporality on the drawn structure by the use of space between the input and output. Moreover, graphics provide a mean to display the structural components that designers can frame, refer to and point at in order to maintain a consistency of joint attention.

The example stresses that the designers co-elaborated a solution related to the code architecture with the support of graphics and texts on a sketching representation complemented by verbal and gestural modalities. The designers created the drawing in order to reach a mutual understanding, they used the drawing with gestures in order to have joint attention and simulated playing situations which led to the generation of a solution that solved the problem.

3.2.4 Specific modalities with each type of external representations

In sum, we provided examples of design representations associated with verbal and gestural modalities in addition to others; (1) sensorial representation with vocal, (2) interactive representation with interaction/simulation on prototype and (3) sketching representation with graphical and textual modalities.

4. Conclusion

In the first sections of this chapter, we have highlighted collaboration formats. We underlined three types of collaboration formats: directive, relational and representational. Several functions were underlined through illustration/s of these collaboration formats in our corpus. We found that collaboration formats all undertake one or more functions that can be considered essential in collaborative design process.

In the last section, we have underlined impacts of socio-technical contexts on these collaboration formats. Our results underlined that a number of the collaboration formats were impacted by the contexts in which they evolved. For socio-technical contexts, we found that institutional roles and expertise impact the directive formats and a relational format and external representations impact a representational format.

We will now review the three collaboration formats and draw some conclusions. For that, we will first recapitulate their definition, their function/s and the impacts of contexts.

4.1 Directive formats: divergence and convergence

The directive formats are characterized by specific forms of collaborative design activities performed by a designer serving to trigger evolution and definition of the design spaces, *i.e.* problem and solution, from another designer. The directive formats subsume (1) triggering problem framing, (2) eliciting an alternative solution generation and (3) triggering agreement crystallization. These three directive formats can be considered as strategies to frame the problem, to encourage contributions of other designer/participant in the form of alternative solution and to secure a mutual agreement on a solution respectively.

We considered the directive formats as providing useful information to the designers. With this information, designers are able to progress forward in the design process and co-elaborate solutions. The directive formats are mainly supporting functions related to divergence and convergence.

Concerning the divergence, it is supported by the eliciting alternative solution generation format. This format involves a function that invites and encourages the contributions of other designers, *i.e.* to generate alternative solution/s. In turn, it can help to enhance the pool of solutions and participate to the divergence of the design process; it triggers divergent thinking by encouraging the generation of new idea/s. This function may bring designers further toward the final state of the artifact or at least may bring potential orientations for the design process.

This divergence was highlighted by ‘encouragement to contribute’ through the use of delay marks defined as hesitation, *i.e.* a solution generated with modal verb/s, and as tentativeness, *i.e.* characterized by hedge words (McDonnell, 2010a; McDonnell, 2010b). These two are suggested to play a positive role in support of the collaboration’s purpose and are indicative of constructive collaboration (McDonnell, 2010a).

The eliciting alternative solution generation’s function might be used in the brainstorming technique as the idea is to encourage participants to generate a considerable pool of solutions (Nickerson, 1999). Indeed, generation of solutions with delay mark/s encourages the contributions of others in terms of alternative solution generations.

In regard to the convergence, this function is supported by the triggering problem framing format. Within this format, designers proceed to the (re)-formulation of a problem. Through that, designers can define design goals to achieve (Darses and Falzon, 1996) and can refine their mental representation of the problem (Bonnardel, 2000; Bonnardel and Sumner, 1996) and thus, converge toward a shared design problem.

The triggering of problem framing was stressed with uses of hesitation, *i.e*. also described as explicit enumeration of possible design variations, that is also considered as an ‘encouragement to contribute’ (McDonnell, 2010a). In this case, the contribution is the framing of problems.

The function of convergence is also supported by the triggering agreement crystallization format; this format is related to decision making and thus, convergent thinking. The triggering agreement crystallization format is stressed by an allocation of a task. Its function ensures that a mutual agreement on a solution is reached, partly implicitly. This is consistent with the fact that in co-located collaboration, decision making appears more implicitly (Marty and Darses, 2001).

We found that the institutional roles and expertise of designers and participants impact the configuration of two directive formats, *i.e.* triggering problem framing and triggering agreement crystallization formats. These results highlighted that for two directive formats, the activities in each directive format’s sequence are performed by specific designer/participant that reflect her/his hierarchical position and her/his status in the design group. In that vein, we found asymmetries related to the position of a designer/participant in these two directive formats; it is mainly the project director O who framed problems and crystallized agreements. Thus, we could suggest that O controlled the convergence of the global design process.

Differently, we did not find any institutional roles and expertise impacting the directive format to elicit alternative solution generation. This could suggest that divergent directive format was undertaken by all designers and participants and thus, not controlled by a specific designer.

4.2 Relational formats: open up the research space

Relational formats refer to the generation of a design idea by a designer *x* that is related by a designer *y* to other one/s - reified or not - coming from inside or outside the design project to apprehend the idea under discussion through other/s. Two formats were highlighted: (1) relations to reified solution/s and (2) relations to anterior design idea.

The relations to reified solutions format was mainly described as sources of inspiration and of evaluation. In this relational format, we provided illustrations of designers relating design ideas under discussion to reified solutions of various kinds, *i.e.* intra-domain and inter-domain reified solutions.

Several studies have advanced that design is built on previous designs. Our results stressed that the design process is not only built up on what has been done previously, but also on what others have said. This can be linked to the polyphonic context (Baker et al., 2009) underlined by the relations to anterior design ideas format. This relational format highlights the polyphony in interactions by making all the voices heard even the ones from absent participants.

The report of ideas generated by absent participants/play-testers was undertaken by the project director who is the main responsible for the play-tests. The project director O pooled and shared participants/play-testers' ideas that were then built on. This can be interpreted as a role of facilitator; bringing the ideas generated by participants to the design team (Jeffries, 2011).

This relational format can characterize the composition of the group and more precisely to the 'extended' design group; the diversity of the extended group. Reporting speeches of diverse participants/play-testers might be a mean to bring diversity in the composition of the group. Our results highlighted that this diversity is not only supported by the reported participations and eventually contributions of several designers, but also of (end)-users. This format could be an indication of participatory design that seeks to involve (end)-users as co-designers in the design process (Fischer, 2003) and iterative design as design ideas were mainly generated following play-tests. An overall function of this relational format and diversity of the extended group can be qualified as a source of information and/or ideas; the various speeches brought up during the design process brought specific information and knowledge, and design ideas to the design group.

Furthermore, we stressed that the reports of participants' speech was combined in some occurrences with characteristics of the enunciator and thus, a persona. It is advanced that targeted audience, and thus a targeted persona, is involved in the design process of game design (Zimmerman, 2003). Contrastingly, our results stressed that targeted personas as well as non-targeted personas were involved. Thus, this could highlight a means to enhance the diversity of the group. It could also be a way to renegotiate the targeted audience. Indeed, we underlined that targeted audience went from casual gamers to both casual and hardcore gamers.

This relational format highlights reports of divergent ideas coming from diverses occasional participants. This was noticeable by the follow up of design ideas generated by external participants. These ideas were reintroduced in the design process. Our results highlighted that design discussions and 'brainstorming' exceeded the boundary of the design team and even more of the core team contrarily to what is advanced by Schell (2008). This author restricts brainstorming sessions to the boundaries of the design and core team.

Thus, both relational formats seem to open up the research space by relating ideas to reified ones and to other ideas generated by play-testers, *i.e*. surrounding workers and various external participants with different designers and players, and participants from outside the video game domain.

4.3 Representational formats: co-construction of complementary representations

Representational formats consist in the co-construction of representations of a design idea under discussion in order to develop multiple points of view around this design idea. The representational formats include (1) alternations of player's and designer's perspectives and (2) complementary modalities.

The alternations of player's and designer's perspectives format focuses on the diverse perspectives that can be taken by designers/participants. More specifically, it focuses on two facets of the object-to-be-designed namely the perspective of the designers encompassing various elements, *e.g.* classic rules of the domain, feasibility, etc., and the perspective of the (end)-users as players, *e.g.* knowledge on specific population of players, player's experience, etc.

The alternations of the player's and the designer's perspectives bring into the design process a considerable amount of information as reported in the literature by Wolff et al. (2005). This information, coming from the two perspectives, is handled by the designers in a complementary manner; a solution is co-elaborated with alternations of the two perspectives both brought by designers and participants.

As the designer/s and the (end)-users 'don't see' the object-to-be-designed in the same way (Bucciarelli, 2002; Wolff et al., 2005), both perspectives can enrich the design process. On the one hand, we have highlighted that a perspective take into account the complexity of design with its numerous domain areas. On the other hand, we stressed that it provides access and information on the experiences and uses, characteristics of users, etc. specific to various users' activities. Even further, we underlined that this player's perspective encompassing player's experience spreaded over its spheres, *i.e.* cognitive, emotional, sensational, behavioral, fun and desire. In turn, we could suggest that this perspective takes into account, in a wide extent, the users into the design process.

It is also suggested that participants see the design object differently according to the constraints specific to their discipline (Détienne et al., 2005). When a designer or participant shares a player experience, we underlined that they can extracted constraints. In turn, we could suggest that new constraints from player's perspective can result in a co-evolution of problem-solution; the problem space is reinvested by the generation of constraint and the solution space, by the generation of alternative solutions - in the second variant of this representational format -.

The fact that the consideration of different perspectives is essential for the success of design processes as it eases the construction of a shared representation of the problem and of resources for solutions (Wolff et al., 2005) can explain the numerous occurrences of this representational format found in almost all our excerpts. In addition, our results underlined that this representational format is supporting mutual understanding on both the design and the experience of players.

The representational format involving complementary modalities covered a large range of functions reported in the literature (Visser, 2009c):

- Communication to other designers through external representation/s to reach a mutual understanding;
- Communication to the designers themselves in order for them to get inspired;
- Apprehension of the experience through the interaction with aspects of the object-to-be-designed;
- Coordinate the focus of attention by providing cues, *i.e.* joint attention.

We could argue that this representational format emphasized numerous functions of external representations and essential one for collaboration design.

Moreover, our results underlined several functions related to the experiential role of external representations: global context and multi-modal context. These functions have been emphasized by Vyas, Heylen and Nijholt (2009), Vyas, Heylen, Nijholt and van der Veer (2009) and Vyas, van der Veer, Heylen and Nijholt (2009). For these two functions, it seems that a rich environment in which all the functions listed above could take another meaning; mutual understanding, ‘conversation with materials’ and apprehension of experience could be consider in their full range that is with the mulitiple channels of information implied around the object-to-be-designed.

Complementary modalities were found to be brought up sequentially or concomitantly. This latter is an integrated activity (Détienne and Visser, 2006). This situation is interesting by the complementarity of the modalities brought up without any redundancy; modalities depict a whole that would not be meaningful if taken apart and convey distinct information (Détienne and Visser, 2006). This is consistent with our findings. We underlined that these integrated activities convey different channels of information to provide a global multi-modal context of the potential solutions’ deployment.

Furthermore, these modalities can be mobilized in order to access different perspectives. Indeed, we highlighted that the embodiment of an idea can serve the designer’s perspective, *e.g.* sketches the architecture of the scene, graphics for the code architecture. Additionally, we stressed that simulating an interaction can provide insights from the player’s perspective, *e.g.* simulation of an interaction on a prototype with an experiential function. Thus, it seemed that modalities can convey design-oriented and experience-oriented information.

Lastly, our results highlighted that the two types of representations, found throughout the design processes in a considerable amount, support that design is, amongst others, a construction of representations (Visser, 2006a; Visser, 2006b). Notwithstanding, our findings highlighted that these representations are not only constructed, but co-constructed through the complementary perspectives and modalities brought alternatively or concomitantly by designers and participants.

Summary

In this chapter, our goal was to identify and characterize collaboration formats entailed in a collective design process. Furthermore, we aimed to identify the situations impacting these collaboration formats. In order to reach these goals, we applied an original approach that combines content and interactional analyses on interactions between designers and participants.

Our findings underlined that there are three collaboration formats retrieved in our corpus:

- First, the directive formats consist in specific forms of design activities by a designer *x* serving to trigger evolution and definition of the design spaces –problem and solution– by a designer *y*. It encompasses three sub-categories namely triggering problem framing, eliciting alternative solution generation and triggering agreement crystallization;
- Second, the relational formats refer to the generation of a design idea by a designer *x* that is related by a designer *y* to other one/s –reified or not– coming from inside or outside the design project to apprehend the idea under discussion through other/s. It includes two sub-categories named relations to anterior design ideas and relations to reified solutions;
- Third, the representational formats are defined as a designer *x* representing a design idea under discussion and a designer *y* elaborating further the representation with another complementary point of view. It subsumes two sub-categories namely alternations of player’s and designer’s perspectives and complementary modalities.

The majority of the collaboration formats were found to be impacted by different socio-technical contexts:

- Institutional roles and expertise of the participants impact the configuration of the directive formats triggering problem framing and triggering agreement crystallization and the relational format involving anterior design ideas;
- External representations used by designers impact the representational format involving complementary modalities.

This chapter highlights that the analyzed design process is characterized by several three collaboration formats that covers several functions.

Chapter 8 Collaborative problem solving: a longitudinal analysis

In this chapter that closes the third-person viewpoint, *i.e.* viewpoint of the analyst, we will develop how designers contributed to the design process by focusing on the collaborative problem solving processes. Our aim is to identify and characterize the temporality of socio-cognitive design processes involved in collaborative design. This enabled us to highlight how design processes are constructed in the designers' interactions and thus, how designers/participants engaged in collaborative problem solving in meetings. Additionally, our aim is to depict this temporality with the collaboration formats that we underlined (chapter 7).

1. *Identifying and characterizing socio-cognitive design processes: content, longitudinal and interactional analyses*

The identification and characterization of socio-cognitive design processes is conducted on the meeting corpus. These excerpts cover two conceptual meetings M7 and M8. We supposed that this corpus encompasses a wider range of creative socio-cognitive design processes; they are taking place in conceptual phases, moments in which creativity is likely to occur (Bonnardel, 2006). These conceptual phases correspond to re-orientation, *i.e.* transition from one type of prototype to another for which designers need to define new problems and characteristics of the object-to-be-designed. With this corpus, we performed content, longitudinal and interactional analyses.

The content analysis enabled us to distinguish problems and their solutions in design periods or problem-solution pairings with the following categories of indicators:

- Collaborative design activities with content-related activities, *e.g.* 'generate', 'refine' and 'argue', and of process-related activities, *e.g.* 'management' and 'agree'.
- Participant/s incorporated in each contribution, locutor, *i.e.* the one that is doing the talking, and the enunciator, *i.e.* the one whose voice is being reported;
- Perspective taken by the locutor, *i.e.* player's perspective or designer's perspective.

On this basis, we performed a longitudinal analysis. We used the operationalization of five design processes (*cf.* chapter 6, section 3.5.1):

- Co-evolution of problem-solution refers to a sequence where at least two designers are engaged in naming a problem, generating solution/s that is/are then transferred into the problem space;
- We refer to problem framing when designers designate a feature of the problem space to which an area of the solution space to explore is specified;
- We refer to combination when designers associate and merge an idea with another distinct one;
- We refer to analogical reasoning when designers transfer a source entirely or partially into a design solution - the target -;
- We consider a composition process as designers changing an object's location in (1) the scenery or (2) to the other experiential space.

The identification and characterization of socio-cognitive design processes allowed us to answer our research question 'are there socio-cognitive design processes in collaborative design and how they are characterized?'

Also on the basis of the content analysis, we performed an interactional analysis to highlight the collaboration formats in this corpus. For that, we used (1) collaborative design activities, both content-related and process-related activities, (2) polyphony in the discourse, (3) perspective taken by designer/participant and (4) modalities/external representations. With these, we identified collaboration formats in the temporality of interaction through recurrent adjacency pairs of collaborative design activities undertaken by at least two designers - present or absent - within a problem-solution pairing or within a design period. These highlighted collaboration formats were then situated in the temporality of each excerpt alongside to the socio-cognitive design processes identified. The parallel evolution of both collaboration formats and socio-cognitive design processes allowed us to answer our research question 'how different contexts impact the way designers collaborate?'

Complementary to these analyses, we will detail the context in which the meetings were taken place[8].

We will first describe the two conceptual meetings and then pinpoint to their socio-cognitive design processes. For that, each conceptual meeting will be developed separately with their socio-cognitive design processes. After, we will introduce the collaboration formats in each conceptual meeting with their socio-cognitive design processes.

2. Socio-cognitive design processes in conceptual meetings

We will introduce two meetings, the M7 and M8. They correspond to the shift from abstract to figurative and from *païdian* to half *païdian* half *ludus* respectively. We consider these two meetings as conceptual. In that vein, the two designers of the core team underlined that these two meetings were moments of conceptual 'rupture' and key moments in the design process:

> "*On a changer si oui alors en fait on était la première visualisation qu'on a fait était complètement abstraite*" 'we change yes well in fact we were, the first visualization that we done was completely abstract'
> "*je peux dire le moment où on a décidé de passer d'un truc très abstrait à un truc figuratif c'était un moment clé le moment où on a essayé d'introduire un personnage c'était un moment clé*" 'I can say the moment where we decided to go from an abstract thing to a figurative thing, it was a key moment the moment where we try to introduce a character it was a key moment'

In this section, we are interested in the socio-cognitive design processes that are undertaken by more than one designer in the conceptual meetings M7 and M8. We will next introduce the two meetings. For each meeting, we will provide an example of the five socio-cognitive design processes. These processes will be illustrated to depict their steps distributed amongst the designers/participants.

[8] It was partially described in the previous chapter (chapter 7)

2.1 Transition from abstract to figurative visual representations, the M7 meeting

The M7 is a meeting that lasted three hours and forty-five minutes. It focused on a shift from abstract to figurative visual representations.

In the following sections, the actors involved in this meeting and the global context will be described. Then, an example of each socio-cognitive design process will be described.

2.1.1 Context of the meeting M7

The meeting M7 took place with the creative and project director O, the coder M and the freelance graphic artist Jt. The latter just integrated the design team as the conceptual shift is aligned to his professional domain and expertise, *i.e.* graphic art.

In this meeting, O, M and Jt were gathered to discuss about the re-orientation of the prototype. The transition from abstract to figurative involved that the designers restructure the whole construction of the game. In other words, they had to reconstruct the universe of the game, the display of all soundtracks in the scenery, the choice of visual representation for each soundtrack and for the different outputs of a soundtrack, *i.e*. the long output refers to all the notes of an instrument soundtrack and the short output refers to a note/chord of an instrument soundtrack.

The meeting can be divided in two themes. First, the designers discussed issues oriented toward the construction of the scenery and its components at a structural level. The goal of the designers was to define a particular structure of the scenery that includes the construction and implementation of the scenery with different types of visual representations - the soundtracks' feedbacks and the character -. This theme encompasses the excerpts E1, E2, E3, E6 and E7.

Then, the designers focused their discussion toward specific components of the scenery, the visual representations of the music soundtracks. This theme was performed in an iterative manner. First, the designers went over all the soundtracks to distinguish which one would be represented in the scenery and which one by fireflies - the default value -. Then, for the ones chosen to be represented in the scenery, they proposed different solutions. These solutions consist in visual representations of soundtracks depending on their type of sound and in their location in the scenery. This enabled the designers to finally define a distribution of the soundtracks in the scenery (photo 28) with a pool of ideas for the visual representations. This theme includes the excerpts E4, E5 and E8. During in this second theme, the designers accessed soundtracks from a computer and sometimes soundtracks' representation in the prototype.

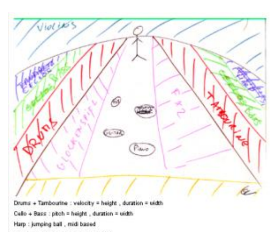


Photo 28. The distribution of the soundtrack in the scenery at the end of the meeting M7

The excerpt E1 is taken at the beginning of the meeting (figure 7). It is separated by a short time from the E2. In the middle of the meeting, the excerpts E3 to E7 are separated by five to ten minutes. The last excerpt E8, focused on the refinement of theme 2, is an hour and a half after E7.

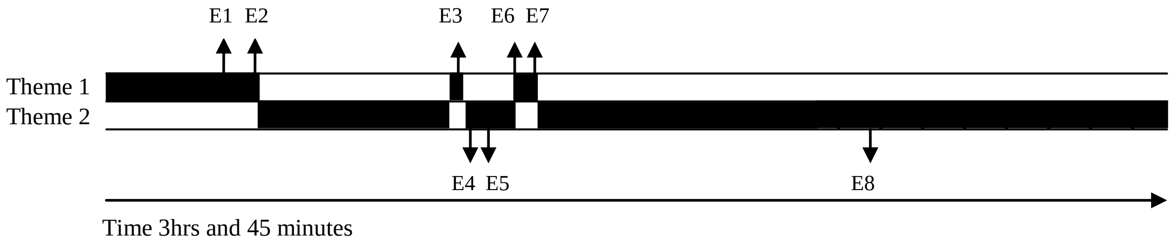


Figure 8. Meeting M7

Directly after the E2, the designers invested the second theme. During this second theme, the designer Jt reinvested three times the theme 1 in E3, E6 and E7.

2.1.2 Design processes in M7

In the meetings M7, we found five design processes. These are co-evolution of problem-solution, problem framing, analogical reasoning, combination and composition (figure 8). These were undertaken by several designers/participant. This implies a distribution of the different steps of a design process amongst the designers/participant.

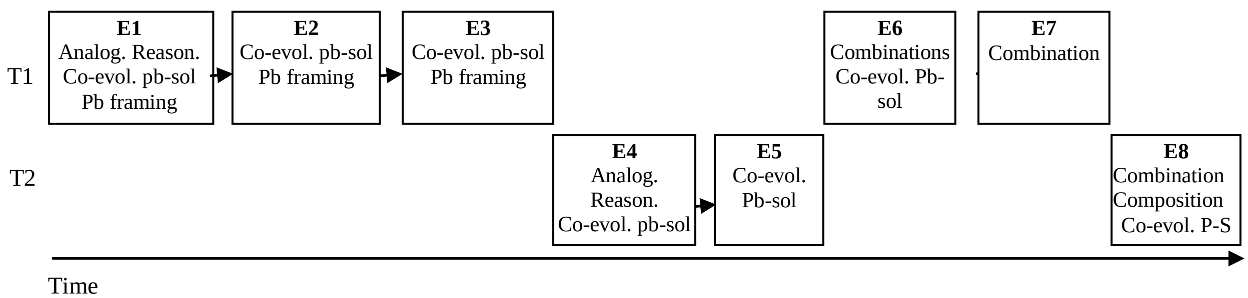
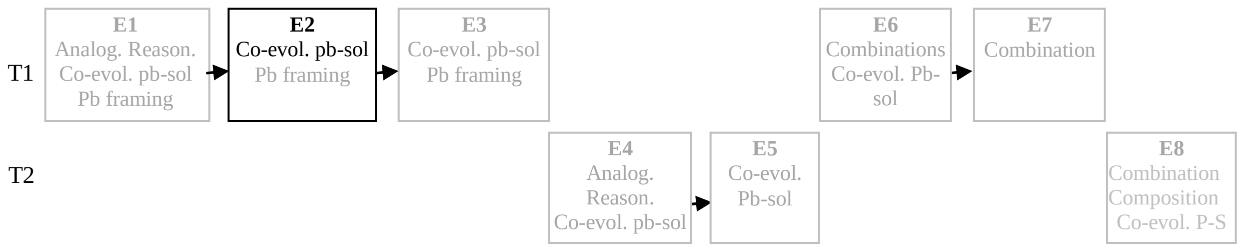


Figure 9. Design processes in meeting M7

In this section, we will illustrate the five design processes. For each of them, we will give an illustration. The co-evolution of problem-solution will be illustrated with the excerpt E2, problem framing with E3, analogical reasoning with E4, combination with E6 and composition with E8.



Co-evolution of problem-solution process. In E2, the stakes of the participants were to define how the visual feedbacks of the soundtracks will appear in the scenery and this, by taking into account the different types of sounds *e.g.* staccatos notes, rounded and indistinct notes, etc.

This excerpt started with the identification of the ‘visual feedbacks appearance’ problem by O. To resolve this problem, different means to make the feedbacks appear in the scenery were proposed; the first mean was generated by M ‘make elements appear by magic’ and two means were generated by Jt ‘make the elements light up’ and ‘change their opacity’. These three solutions were elaborated only by the generator of the solution. Then, O generated a solution ‘a combination of elements, it can’t be only blocks and (inc)’ which was co-elaborated by all designers. After, the designer O generated another problem ‘different visuals for types of sounds’, mainly developed by O, to which he paired the solution ‘short sounds appear and long sounds come from upstream’. The excerpt ended with the generation of a last problem by O ‘the structure of the music composition’.

During this excerpt, the designers were in the meeting room around the table and in one occasion, O used the whiteboard during the development of the ‘different visuals for types of sounds’ problem (photo 29). It ended with O inviting M and Jt to go upstairs in order to have access to the music soundtracks and the prototype.

Photo 29. From left to right O, M and Jt

This excerpt encompasses a problem framing on the ‘visual feedbacks appearance’ problem and a co-evolution of problem-solution process both performed collectively. We will scrutinize the co-evolution of problem-solution process that unfolded throughout the excerpt in more detail and the problem framing will be described in another excerpt.

The excerpt (table 58) starts with the generation of a problem by O "*On a un problème de vitesse si t'arrives suffisamment vite ça marche*" 'we have a speed problem if you arrive fast enough it works' (line 1). To this problem, four solutions were generated; first, M generated a solution "*A moins de faire apparaitre euh ton déroulement dans la magie*" 'Unless you bring up your course by magic' (line 5), second, Jt generated two alternative solutions "*ça peut être une question de de juste de matériaux qui sont déjà là et par exemple ils s'illuminent*" 'it can be a question of only material that is already there and for example it lights up' (line 6a) and "*ils passent d'une opacité de 0 à 1 ils apparaissent*" 'they pass from a 0 opacity to a 1 opacity, they appear' (line 6b). Finally, O generated a last solution "*je pense que c'est une combinaison de choses mais ça peut pas être que des blocks et des (inc)*" 'I think that it is a combination of things but it can't be only blocks and (inc)' (line 8a). Thus, for the problem of visual feedbacks appearance, four solutions started a first movement of problem-solution.
Then, the designer O brought back the solutions into the problem space "*certains sons sont plus lent donc on peut pas se permettre des faire arriver comme ça et certains plus euh plus rapide et y va falloir d'être*" 'some sounds are slower thus we can't make them arrive like this and some are faster and we will need, be' (line 8c). To this new problem, O exemplified this problem with a solution for a type of sound "*Typiquement les petits staccatos y font chachachen y faut effectivement des choses clak clak clak qui portent et puis euh*" 'typically the small staccatos they do chachachen we need effectively things like clak clak clak that carry well' (line 8d). At last, the designer O underlined another problem related to the types of sound that structure the music composition "*ça va nous aider à structurer à structurer comme ça ça va aussi nous aider pour la compo pour nous dire attention y faut qu'on aie des pistes qui soient avec des trucs longs y faut qu'on en aie avec des trucs plus rapides*" 'it will help us to structure like this it will also help us for the musical composition to tell us take care we need soundtracks with long things we need soundtracks with things more rapid' (lines 11e).

No	Loc	Verbatim	Pers	D.a.	Pb/Sol
1	O	On a un problème de vitesse si t'arrives suffisamment vite [ça marche *We have a problem of speed, if you arrive fast enough, it works*	Ply	Gen pb(a)	Pacing speed of representat°
2	M	[ça marche effectivement *Indeed, it works*	Dsg		
3	O	Et c'est ça le problème c'est ça le vrai problème *And this is the problem, it's that the true problem*	Dsg		
4	JT	[ça peut être *It maybe*	Dsg		
5	M	[A moins de faire apparaitre euh ton déroulement dans la magie et faire apparaitre* les choses plus en *amont sur *hands open when go up* *Flat hands go from near to further* des tiles déjà envoyés *unless you make your progress appear by magic and make appear the things upstream on tiles already sent*	Dsg	Gen Sol(a)1	Objects appear on tiles already seen
6a	JT	C'est ce que j'allais dire ça peut être une question de de juste de matériaux qui sont déjà là et par exemple ils £s'illuminent £*closed hand opens* *This is what I was gonna say, it maybe a question of just materials that are already there and for example they bright*	Dsg	Gen Sol(a)2	When activated, the objects illuminate

		up			
6b	JT	ou alors ils passent d'une £opacité de 0 à 1 ils *closed hand opens*£ apparaissent = *or they pass from an opacity of 0 to 1, they appear*	Dsg	Gen Sol(a)3	When activated, the objects turn from 0 to 1 opacity
7	M	=Tu peux faire quelque chose d'autre tu peux dire que il active ça fait tout d'un coup pousser des fleurs *comme par *both hands from down to up and open** magie et quand il relâche elles se fanent instantanément ça peut faire de très belle chose aussi *you can do something else, you can say that when they are activated all of a sudden flowers grow like by magic and when the player release the buttons they wilt instantantly, it could make beautiful thing also*	Dsg	refi	Activation of a track make flower grow and then they wilt
8a	O	Chui d'accord chui d'accord mais là je pense que c'est une combinaison de choses mais ça peut pas être que des blocks et des (inc) t'as raison il va falloir faire des trucs comme ça eum et peut être que alors *I agree, I agree, but here I think that it's a combination of things, but I cannot only be blocks and (inc). You're right, we will have to do things like that eum, and maybe that well*	Dsg	Gen Sol^{+}(a) 4	Blocks and other thing such as appearance of something else
8b	O	c'est pour ça que je dis que ça peut être intéressant qu'on aille regarder la musique déjà pour qu'on travaille à partir de ça *it's why I say that it might be interesting that we look at the music already to work with it*	Dsg	Mana	
8c	O	parce que certains sons sont plus lent§ donc on peut pas *hand goes forward*§ se permettre des faire arriver comme ça et certains plus euh plus rapide et y va falloir d'être= *because some sounds slower thus we can't allow them to come like that and some are faster and we will have*	Dsg	Pb(b)	Pacing speed of different sounds
9	JT	=(inc) *(inc)*			
8d	O	Typiquement les petits staccatos y font §chachachen y faut *mvt hand forward and backward*§ effectivement des choses §clak clak clak qui sortent et puis §*Hand goes forward* euh *typically the staccatos they do chachachen, we need actually some things clak clak clak that go out and then euh*	Dsg	Gen Sol(b)1	Staccatos with high speed representation
10	M	Si (inc) je suis d'accord effectivement peut etre que ça dépend parce qu'après ce que fait l'utilisateur euh le joueur ça va :a= *If (inc), I actually agree maybe it depends, because after what the players do euh the player, it will*	Ply	Arg-	
11a	O	=Mais non parce que normalement la quanti de l'input elle est là c'est-à-dire que typiquement sur les sur les violoncelles tu vois § §*draws a line on white board* *But no, because normally the quanti of the input is there that is to say that typically on the, on the cello you see*	Dsg	Arg+	
11b	O	y joue le truc il est il lâche au milieu de son bidule *the player activates it, he releases it at the middle of it*	Ply	Arg+	

11c	O	tu joues la note jusqu'au bout §donc tu sais que tu as tout §*draws another line at the end of the 1st one* ça§ pour euh et c'est vraiment une question de ça §*underlines the first line* *You play the note until the end thus you know that you have all this for euh and it's really a question of that*	Dsg	Arg+	
11d	O	et c'est vraiment important qu'on le fasse là *and it's really important that we do this now*	Dsg	Mana	
11e	O	parce que ça va nous aider à structurer à structurer comme ça ça va aussi nous aider pour la compo pour nous dire attention y faut qu'on aie des pistes qui soient avec des trucs longs y faut qu'on en aie avec des trucs plus rapides et ainsi de suite quoi (.) *because it will help us to structure, it will also help for the composition in order to say careful we will need soundtracks that are with long things, we will need others with faster things etcetera*	Dsg	Gen Pb(c)	Structure of the musical composition

Table 58. The co-evolution of problem-solution process

The co-evolution of problem-solution is depicted in the following figure (figure 9). We can highlight that for the first problem, the three designers generated at least a solution. Then, the designer O generated a new problem. Then, he paired it to a solution. At the end, the designer O again generated another problem. This last problem is the overall issue of the theme 2 that the designers invested after this excerpt.

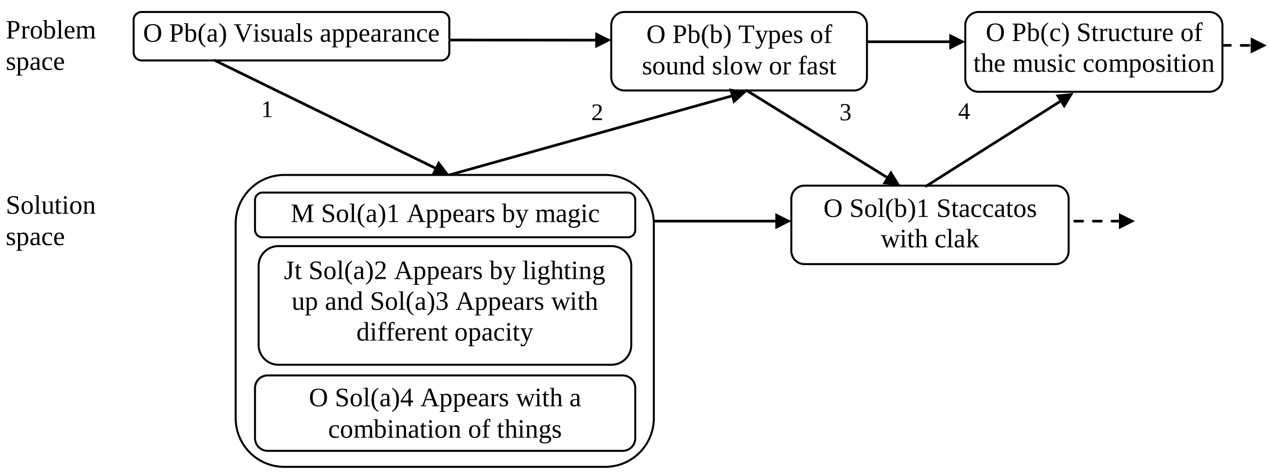
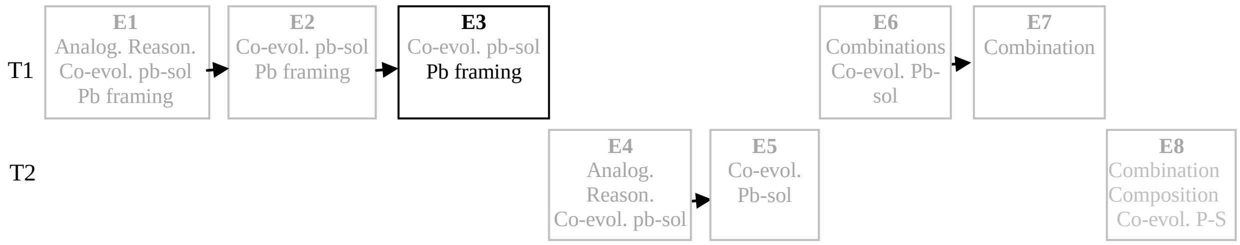


Figure 10. Co-evolution of problem-solution process

This co-evolution of problem-solution involves the three designers. We can underline that all designers contributed to this co-evolution of problem-solution by generating solution/s. However, it is only O that generated problems.



Problem framing process. In E3, the interest of the designers in this excerpt was to delimit the types of possible scenery and of visual feedbacks with their modes of appearance. Indirectly, the designers also established the ordering of the design tasks to be done.

Three problems were brought by Jt. First, he addressed the problem 'type of framing' to which he paired two solutions 'realistic scenery' and 'scenery with blocks'. Then, O generated a solution 'blocks of color'. In reaction to this latter generated solution, Jt evoked another problem the 'Translation of blocks' problem and generated a flow of potential solutions 'concrete blocks', 'flowers', 'waves in water' and 'ice with transparency effects'. These solutions were globally argued by O who generated another solution 'whatever it is at the end in terms of representation, now we think in terms of objects in terms of object's tiles'. This led M to intervene in a more concrete, fine-grained level; M generated a solution 'piano for path's tiles' that was co-elaborated by all designers, but stopped by O who managed the topic under discussion as he considered that the solution was too fine-grained. This excerpt ended with Jt bringing another problem the 'the reference'. This was followed by the generation of another flow of solutions by Jt 'tiles', 'lights' and 'universe of representations of things completely esoteric' and a solution by O 'both the most figurative'.

While the designers were discussing, they were gathered around the computer without interacting with it (photo 30). It is only when M generated his fine-grained solution "*piano for path's tiles*" that O activated the piano soundtrack on the computer.

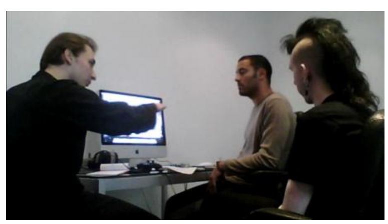


Photo 30. From left to right Jt, O and M

This excerpt contains several socio-cognitive design processes such as three problem framings and a co-evolution of problem-solution. We will shed light on the collective contributions of designers for the problem framing process performed on the first problem generated by Jt 'type of framing'.

The excerpt (table 59) starts with the identification of a problem by Jt "*quel type d'encadrement vous voulez*" 'what type of framing you want' (line 2a). For this problem, an area of the solution space was identified; Jt generated two solution from an area of the solution space that is figurative in nature namely "*un environnement par rapport à un décor réaliste*" 'an environment compared to a realistic setting' (line 2b) and "*un décor t'as une architecture t'as du sol enfin*" 'a scenery where you have an architecture with a floor' (line 2c). Then, O generated a targeted area of the solution space that is more geometric in nature "*y faut qu'on fasse des blocs de couleurs*" 'we have to make blocks of colors' (line 3a). This was followed by the evocation of a design rational underlying O's solution by O "*pour qu'on voit les couleurs les tailles les masses les trucs*" 'to see the colors, the sizes, the masses, the things' (line 3b). Thus, Jt underlined a specific problem from the problem space and identified an area of the solution space that he could explore, *i.e.* figurative representations. Then, O framed the problem by identifying the targeted area of the solutions space, *i.e.* geometrical forms, where Jt should focus his attention on.

No	Loc	Verbatim	Pers	D.A.	Pb/Sol
2a	JT	Après quel euh quel type d'encadrement vous voulez *After what is the type of framing that you want?*	Dsg	Gen Pb(a)	Type of scenery
2b	JT	parce que je me demandais si c'est un environnement par rapport à un décor réaliste *because I was wandering if it's an environment relative to a realistic scenery*	Dsg	Gen Sol(a)1	A realistic scenery
2c	JT	ou complètement euh enfin un décor t'as une architecture t'as du sol enfin *or completely euh well a scenery you have an architecture, you have a floor well*	Dsg	Gen Sol(a)2	A scenery with an architecture with a floor
3a	O	Ça peut probablement à mon avis y faut qu'on fasse des §blocs de couleurs tu vois §*Hands straight parallel* *It may probably, in my opinion we will have to do colored blocks you see?*	Dsg	Gen Sol^{+}(a)3	A scenery with colored blocks with size, mass
3b	O	pour qu'on voit<§ les couleurs les tailles les §*hands parallel with round mvts* masses les trucs> et *in order to see colors, sizes, masses, the things and*	Dsg	Arg+	

Table 59. The problem framing process

The problem framing process is depicted in the following figure (figure 10). We can underline that Jt brought up a specific problem from the problem space and proposed some potential solutions from an area of the solution space. In reaction, O gave an orientation toward another area of the solution space that Jt should explore. Consequently, Jt could have gained information related to the specific visual representations to design that should not consist first of figurative visual representations but geometric visual representations.

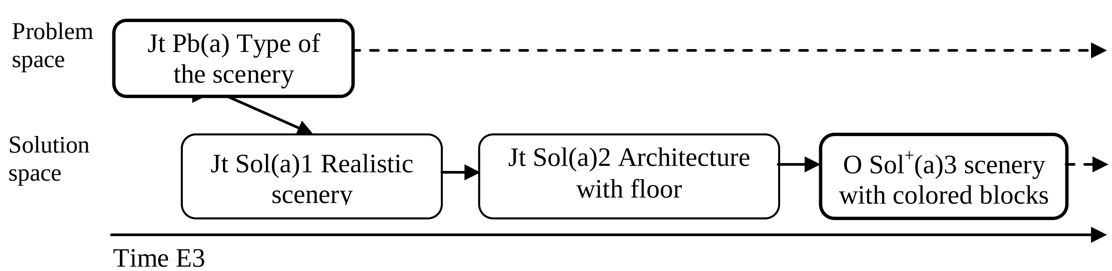
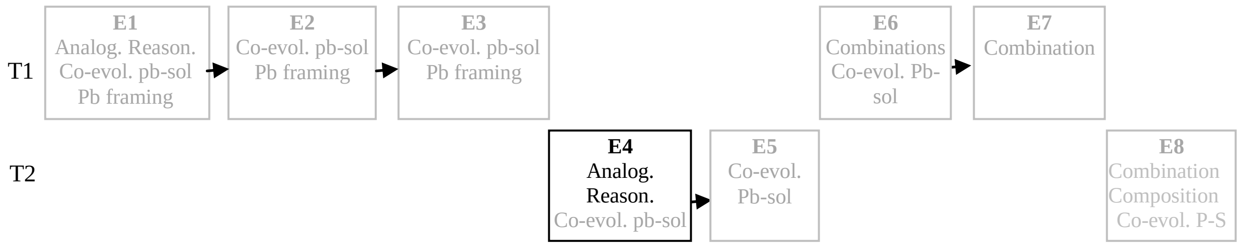


Figure 11. Problem framing process

In this problem framing, its steps are carried out collectively and it involved two designers Jt and O. We can underline that the designers O and Jt contributed to this problem framing with different design activities; generation of problem and solutions. Furthermore, the key steps of this design process were performed by both designers; it is Jt that named the problem and it is O that framed it.



Analogical reasoning process. In E4, the aim was to determine what type of musical files the designers should take into account in order to design a visual representation and what visual representation should be used for the tambourine soundtrack.

First, the designers treated the ‘scenery representations can be based on musical data’ problem. For this problem, M generated a solution ‘based on wave files’ that was argued against by O. This led the discussion to the ‘representation of the tambourine soundtrack’ problem to which M paired with a first solution ‘in the scenery with a fence’. This solution was co-elaborated by all designers. After, M generated an alternative solution ‘by fireflies’ that was co-elaborated by M and O.

During the whole excerpt, the designers apprehended the tambourine soundtrack with its visual representation on the computer, *i.e.* the Midi file, and with the soundtrack playing (photo 31). It is O that had put the midi file on the computer screen and the tambourine soundtrack on. At the beginning, Jt seemed to be looking at the form of the tambourine soundtrack with the midi file displayed on the computer. We believe that O and M knew the midi files of the tambourine soundtrack; these designers used Midi files to generate and design all the visual representations of the soundtracks in the abstract interaction-sound-image prototype.

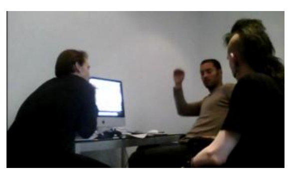


Photo 31. From left to right, Jt, O and M

In that excerpt, we observed that the designers performed an analogical reasoning and a co-evolution of problem-solution. We will shed light on how the designers performed the socio-cognitive design process of analogical reasoning (details on the excerpt see chapter 7, sections 2.3.2 and 3.2.3).

In the analogical reasoning process, the aim of the designers is to produce a visual representation that respects the type of sound, which includes different musical parameters. Some of these musical parameters were provided by midi files and some by the music itself. We could say that the designers probably used midi files and the soundtracks as inspirational sources.

We can underline that M argued and refined his solution ‘in the scenery with a fence’ through an analog solution ‘serpentine’ generated by designer A and used to solve the problem ‘Visual representation of the tambourine soundtrack’ in the abstract interaction-sound-image prototype. Probably, M might have been inspired by the analog solution generated by A.

The analogical reasoning process in this excerpt is illustrated in the following figure (figure 11). First, M generated a solution. He argued and refined it with the use of an analog solution that was previously generated by designer A. This was followed by a simulation and an evaluation of M’s solution with the use of an auditory source; O transferred the information from the auditory source into M’s solution to simulate the morphology of M’s solution. This simulation with a source allowed O to evaluate the solution of M. Then, it is possible that Jt transferred information from the midi files - visual information - into M’s solution to alleviate the negative evaluation highlighted by O.

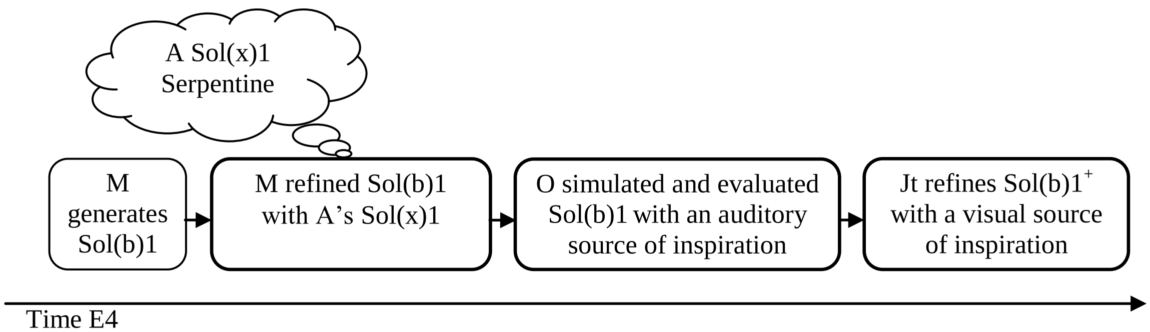
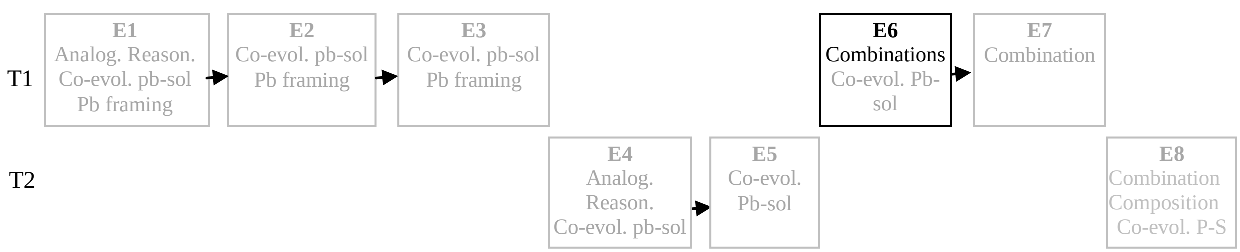


Figure 12. Analogical reasoning process

In this analogical reasoning process, its steps are carried out by the three designers. These designers contributed to this design process through different design activities. They involve generating, refining and simulating a solution. In this case, the analogical reasoning process is performed by M and Jt and an evaluation through the analogical mode is performed by O.



Combination process. In E6, the theme 1 is reinvested. The stakes of the designers in this excerpt were focused on the possible modes of appearance of the soundtracks’ feedback and where these feedbacks should appear.

The problem ‘modes of appearance of the visual feedbacks’ was invested by O who proposed the solution ‘everything is added with a new parallax’ which was elaborated only by him. This was followed by the generation of an alternative solution by Jt ‘layers will be added on the basic scenery with the form of the soundtracks’. This solution was co-elaborated by all designers. This led the designers to focus on the types of soundtrack that should integrate this solution for which Jt and M generated two solutions ‘on staccato and shorts’ and ‘on shorts only’ respectively.

During the excerpt, the designers were in front of the computer discussing. When Jt generated his solution ‘layers will be added on the basic scenery with the form of the soundtracks’, he started to draw his solution on a piece of paper (photo 32). During the co-elaboration of Jt’s solution, O also co-elaborated the drawing of Jt and all the designers, at some point, used it for deictic gestures.

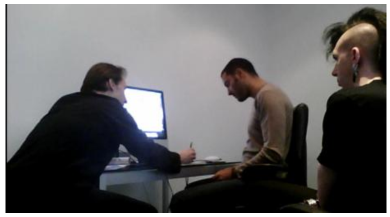


Photo 32. From left to right, Jt, O and M

This excerpt encompasses several combination processes. We will detail the one applied on the solution ‘Layers will be added on the basic scenery with the form of the soundtracks’ to stress the contributions of the designers for that socio-cognitive design process.

In the excerpt (table 60), one solution was generated by Jt “*un chemin de base et une musique qui soit représenté bon admettons que sur le côté y’a des petits buissons et des fleurs et ça ça représente la forme de la musique/ et par-dessus on fait un layer*” ‘a basic path and the music that is represented, say on the side there are small bushes and flowers and that it represents the form of music and above there is a layer’ (lines 2a, 2b). This solution is composed of four elements namely “*basic path*”, “*bushes*”, “*flowers*” and “*layer*”. The “*basic path*” was generated by O in this excerpt as an element of the first solution. Additionally, the “*flowers*” was an element of a solution’s refinement generated by M in the excerpt E2. Finally, to these two combined elements, Jt added “*bushes*” and “*layer*”.

In the refinement of this solution, Jt evoked “*la note courte elle apparait ici*” ‘the note appears here’ (line 5b) and Jt pointed to the middle of the drawing which corresponds to a tile already sent. This element was also generated by M in the excerpt E2.

No	Loc	Verbatim	Persp	D.a.	Pb/Sol
1a	O	<§Tout vient s’additionner> en fait tu as le décor de base le §*Both hands parallel forward multimes* chemin qui est flat pour commencer quoi et puis sur ce décor chaque fois que <§t’ajoute des musiques y’a une parallaxe qui §*Both hands parallel forward multimes* vient s’ajouter> <§par-dessus ou par en dessous ou machin> §*flat hand and the other above and then under* *Everything comes to add up, in fact you have the basic scenery, the path that is flat at first and then on this scenery each time you add a soundtrack there is a parallax that is added above or underneath or whatever*	Dsg	Gen Sol(a)1	Everything is added with new parallaxes
1b	O	mais ça vient en additif <§par rapport à un chemin de §*both hand go foward multimes* base> qui sera ce qu’il est *but it comes additively relative to the basic path that is what it will be*	Dsg	Refo	
2a	Jt	On pourrait très bien avoir un £chemin de base et une *Points to drawing*£	Dsg	Gen Sol(a)2	Path with green at

		musique qui soit représenté bon admettons que sur le côté y'a des £petits buissons et des [fleurs *£draws something on paper* *We could have a basic path and a music that is represented for example on the side there are little bushes and flowers*			each side and on it put layers
3	O	[Voilà c'est ça= *Yes, it's that*	Dsg		
2b	Jt	=Et ça ça représente la forme de la musique/ et par-dessus on fait un layer *And it represent the form of the music and on it we put a layer*	Dsg	Gen Sol(a)2	
2c	Jt	on met des fleurs et quand ça joue ça brille *we put flower and when it plays, it lights up*	Dsg	Refi	
4	O	Par exemple (.) ha non attention parce que §ça si tu m'le *points and goes forward§* lance ah –ha attends attends *for example, oh no watch out because this if you put it,ah ah wait, wait*	Dsg	Arg-	
5a	Jt	Par exemple tu sais les £notes courtes les notes courtes *Presses his thumb£* mettons £qu'ici y'a des ptit fleurs des machins *£points to drawing* *For example you know the short notes, the short notes, for example that here there are little flowers, something*	Dsg	refi	
5b	Jt	quand qu'on fait une note courte est ce que ca s'mettra à briller £tout en même temps ou la note courte elle apparait £ici et= *£points and go forward £points to the middle of drawing* *When we activate a short note, could it begins to shine all at the same time or the short appear here and*	Dsg	refi	

Table 60. The combination process

We can highlight that the generated and refined solution of Jt includes elements that were evoked earlier in solutions generated and/or refined by the designers O and M in the excerpts E2 and E6. In this excerpt, we presented an example where the designer Jt combined several elements previously evoked in order to generate and enhance an alternative solution.

The combination process has multiple phases (figure 12). First, M generated and refined a solution in excerpt E2 "faire apparaitre les choses plus en amont sur des tiles déjà envoyés…il active ça fait tout d'un coup pousser des fleurs comme par magie" 'make things appear as early on already send tiles… he activate and all of a sudden it grows flower magically'. Second, O generated a solution in this excerpt E6 "Tout vient s'additionner en fait tu as le décor de base le chemin qui est flat pour commencer quoi et puis sur ce décor chaque fois que t'ajoute des musiques y'a un parallaxe" 'Everything is added in fact you have the basic scenery that is flat at first and on this scenery each time that you add music there is a parallax'. Third, Jt combined elements of previously generated and/or refined solutions and merged them with two new elements namely 'bushes' and 'layers'. Fourth, Jt refined his solution with an element of a solution that was generated by M in E2.

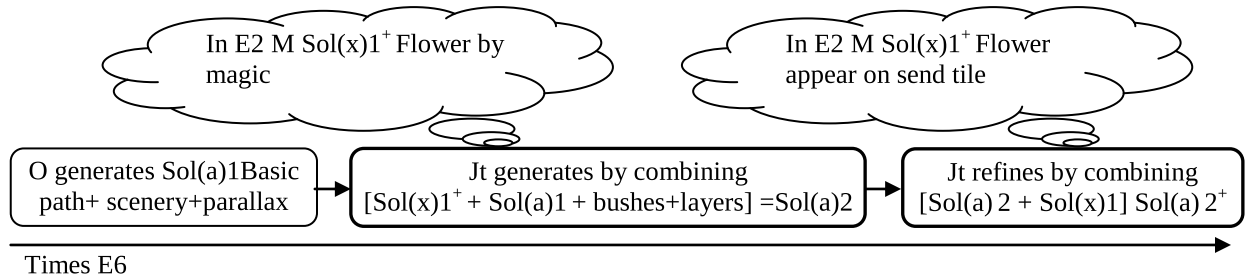
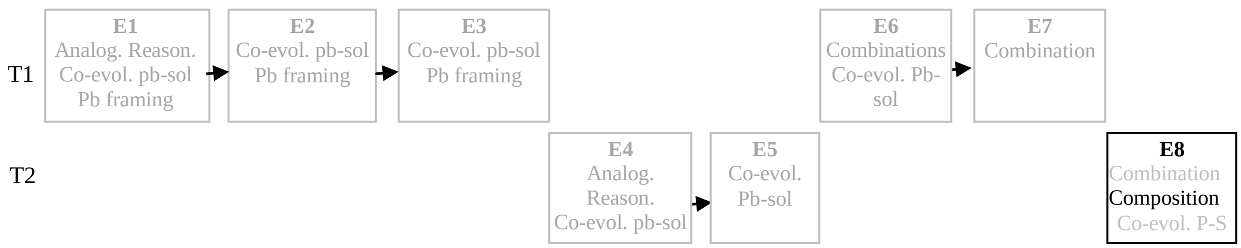


Figure 13. Combination process

This illustration of combination process involves all three designers O, M and Jt. Furthermore, we can see in this case that the nature of the designers' contributions is of different types; all designers generated solutions and M and Jt refined solutions. More precisely, it is the designer Jt that performed the combination design processes.



Composition process. E8 is encompassed in the refinement of the theme 2; the designers were focused on the definition of the visual representation of the trumpet soundtrack as they decided earlier to represent it in the scenery.

The designers focused on a discussion around the 'scenery representations can be based on musical data' problem - data that Jt could work with in order to design the visual representation -. M generated a solution 'use wave files'. In reaction, O generated an alternative solution 'use wave and midi files'. This issue was not elaborated further after the generation of O's solution. Then, their discussion shifted toward the problem 'representation of the trumpet soundtrack' for which M proposed a solution 'use seven objects to produce the representation'. This solution was co-elaborated by all designers and finally was rejected by O. After that, M generated an alternative solution 'represent the trumpet with a fence' that was also co-elaborated by all designers.

During their discussion on the trumpet soundtrack, the designers could listen to and look at the midi file of the trumpet soundtrack before they began to generate their solution (photo 33). Moreover, while they were co-elaborating the generated solutions, a reference to a drawing with deictic gesture was performed by O - the one where the designer O drew progressively to depict the distribution of the soundtracks in the scenery - (*cf*. photo 28, p.149).

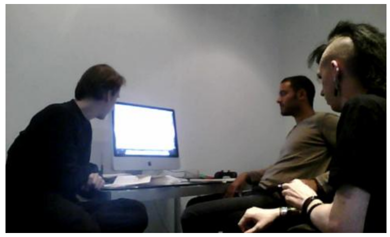


Photo 33. From left to right, Jt, O and M

To achieve their aim, the designers resorted to a composition process and combination. The composition process will be detailed below.

The excerpt E8 (table 61) starts with a generation of a solution by M for the “*Scenery representation can be based on data*” problem “*Oué y faut travailler sur la wave*” ‘yes we need to work with the wave file’ (line 4). This solution was generated twice before. First, the solution was generated by Jt at the beginning of the meeting M7 in the first theme for the “*Animation*” problem (not in the analyzed excerpts). Jt proposed to use wave files in order to do some animations with the software *Maya*, a software that can use wave files to design procedural animation. This solution was accepted by O, but only for elements of visual representation that would represent some specific musical parameters. Second, the solution was generated by M in the E4 in the theme 2 for the problem “*Scenery representation can be based on musical data*” problem of the tambourine soundtrack. M generated this solution for the design of the visual representation of the tambourine soundtrack; designers could take the wave files as a source of inspiration to design the visual representation of the tambourine soundtrack. This solution was rejected by O because he did not know if it would give satisfying results as the designers did not try before to design visual representation based on this source.

In this excerpt, we can underline that M took the solution ‘use wave files to design the visual representation’ solution from the previous targeted problems namely “*Animation*” and “*Scenery representation can be based on musical data*” of the tambourine soundtrack and shifted it to a new problem, the “*Scenery representation can be based on musical data*” of the trumpet soundtrack. In this third case of the generation of this solution, O finally accepted the solution but not without a negotiation; O accepted this solution for this new problem only if this solution would be combined with the use of another type of file “*Mais pas seulement\ j'pense qu'y faut utiliser le midi et la wave la wave t'as pas (inc) et c'est c'qui manque dans le proto*” ‘but not only, I think that we need to use the midi and the wave files, the wave file you don't have (inc) and that is what it is missing in the prototype’ (line 5).

No	Loc	Verbatim	Persp	D.a.	Pb/Sol
1	O	<§*plays de trumpet soundtrack* Ah ça ça va être difficile parce que ça y'a une notion de§ *mvt of wave with his hand*§ *ah this will be difficult because there is a notion of*	Dsg	Ana	
2	Jt	oué y £ ça £*points to an element of the music file* *Yeah this*	Dsg		
3	O	Exactement oué c'est ca (inc) *Exactly yes it's that (inc)*	Dsg		
4	M	Oué y faut travailler sur la wave *Yeah we need to work on the wave fils*	Dsg	Gen Sol(a)1	Use wave file
5	O	Mais pas seulement\ j'pense qu'y faut utiliser le midi et la wave la wave t'as pas (inc) et c'est c'qui manque dans le proto§> §>*Stops music* *But not only, I think that we have to use the midi and the wave files. The wave file, you don't (inc) and it's what is missing in the prototype*	Dsg	Gen Sol(a)2	Combine wave and midi files to design visual representation

Table 61. The composition process

Earlier in the meeting M7, the designer O negotiated and rejected the solution 'use wave files'; in both moments when it was generated, the solution was rejected or partially rejected for its use as a source of inspiration for the creation of the visual representation of animation and the tambourine soundtrack. However, following the composition process, O negotiated the acceptance of this solution that was generated previously for other problems.

We could suggest that composition might be a way to 'force' the acceptance of a solution. It could also help to engage a negotiation over a solution hitherto unaccepted by designer/s.

This example of composition is depicted in the following figure (figure 13). First, Jt generated a solution in the beginning of the meeting that involved the use of wave files in order to represent musical parameters. In the E4, the solution was then re-taken by M who wanted to create the visual representation of the tambourine soundtrack by using the wave files. In reaction, O negotiated and rejected these solutions respectively. Finally, M re-generated the solution for the visual representation of the trumpet soundtrack in the E8. In turn, O negotiated the solution generated by M.

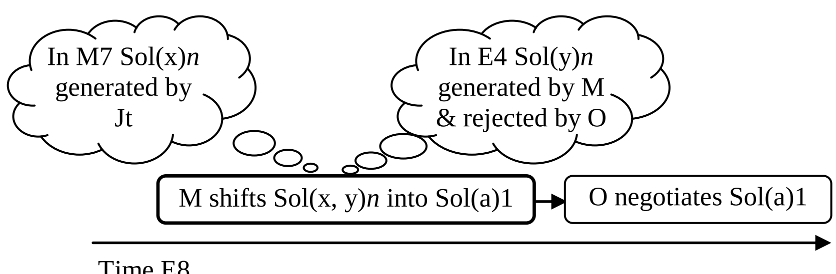


Figure 14. Composition process

The different design activities, *i.e.* generation of solution, shift of location of this generated solution and negotiation, were involved in this composition process. All the designers contributed through at least one of these design activities. Within these contributions, it is the designer M that performed the composition process.

2.1.3 Sources taken into account in design processes

In sum, these socio-cognitive design processes pointed out in the meeting M7 can be related to other excerpts from the meeting or to other moments in M7. In that respect, we can link elements encompassed in each design process to their first moment of evocation. The following figure (figure 14) depicts sources and components (re)taken into account in subsequent design processes.

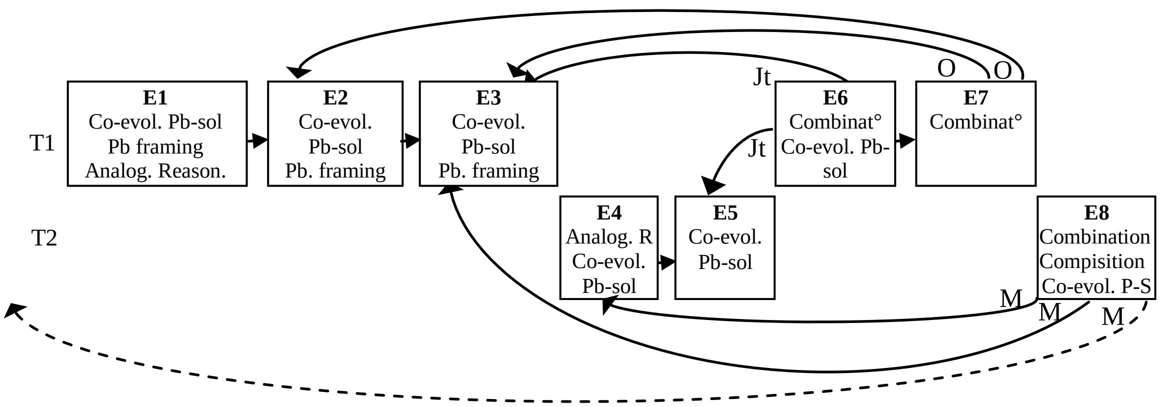


Figure 15. Report of ideas in M7

This figure highlights that generated ideas in the analyzed excerpts (plain lines) and a generated idea in the rest of the meeting M7 (dotted line) are re-invested in subsequent excerpts by the three designers. This highlights that the evolution of themes and socio-design processes can be built on ideas that were previously generated by designers in the meeting.

2.1.4 Collaboration formats in the M7

Collaboration formats can be situated in the excerpts analyzed. This would stress the evolution of collaboration formats in a meeting and within the design processes. The two following figures depict the three collaboration formats in the M7. The first one refers to the theme 1 (figure 15) and the second one refers to the theme 2 (figure 16).

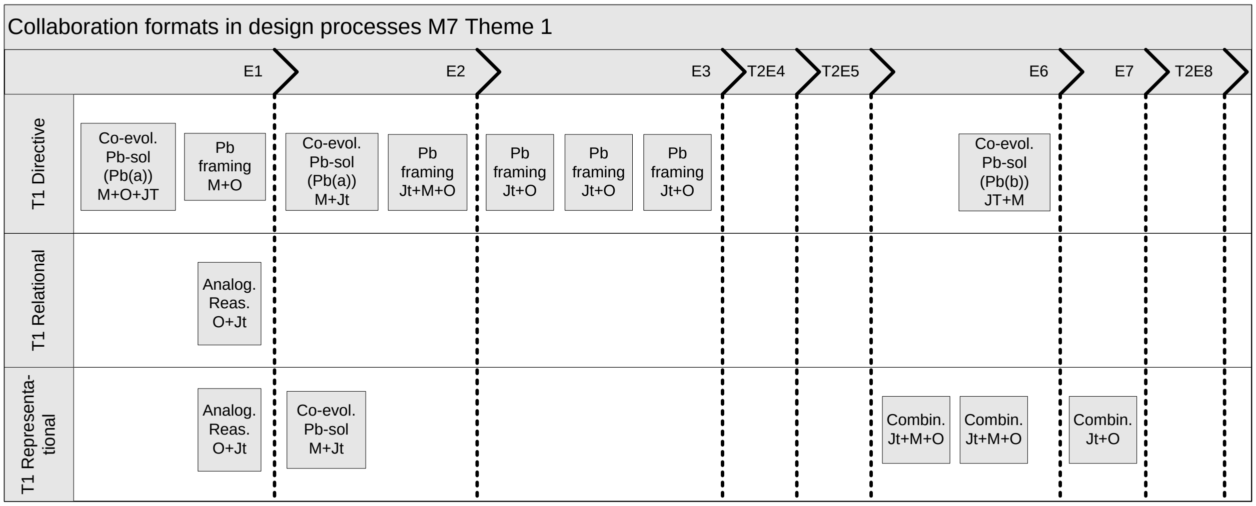


Figure 16. Collaboration formats in M7 in theme 1

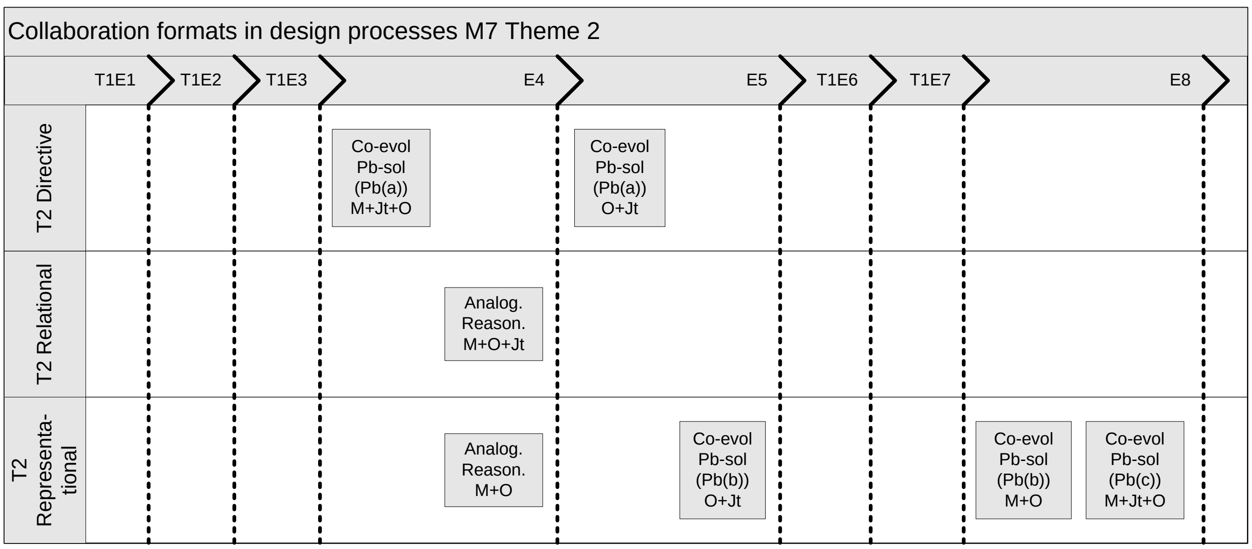


Figure 17. Collaboration formats in M7 in theme 2

These figures highlight that the directive formats are involved in the majority of the excerpts where co-evolution of problem-solution and problem framing are found. It is worth noting that the two last excerpts E7 and E8 do not encompass the directive formats with the two design processes. The representational formats are involved in the majority of the excerpts. They are involved in co-evolution of problem-solution, analogical reasoning and combination. However, the representational formats are not retrieved in problem framing. Contrastingly, the relational formats are only found in analogical reasoning processes.

In terms of contributions, this figure depicts that all designers contribute to design processes. The exception is the problem framing process; it is only the designer O that frames problems.

2.2 Transition from *païdian* to half *païdian* half l*udus*, the succession of M8 meetings

The excerpts of the M8 come from a succession of three meetings. A first meeting occurred a few days before the two observed meetings that we will present. The second and third meetings took place in the studio on the same day. The second meeting that lasted thirty minutes occurred in the afternoon with O and P. It encompasses the excerpts E1 and E2. Then, the third meeting that lasted fourteen minutes occurred in the evening with O and M. It includes E3 and E4.

The three meetings were focused on the integration of different types of scores - performance and style scores - and on the musical experience. The prototype at that moment gave to players the possibility to interact in a free manner. This prototype will give place to a new one that gives the choice to players to either interact in a free manner, *i.e. paidïa*, or to interact with the game by scoring points, *i.e. ludus*. Therefore, the prototype will encompass two possible experiences for the players instead of only one, the *paidïan* experience.

These meetings will be described with the actors that participated and with the global context in which they occurred. Moreover, for each excerpt, problems and solutions will be described, socio-cognitive design processes will be identified and for some, illustrated.

2.2.1 Context of the meetings M8

This succession of meetings encompasses several designers/participants. One designer was present in all three meetings; it is the project and creative director O. This designer undertook the first two meetings with external participants. The first external participant is F an expert game designer and the second one is P another game designer. The last meeting took place with the designers O and M, the coder of the design project.

To ease the comprehension of the following sections and to preserve a chronological temporality, we will present the first meeting with O and F that was reconstructed with the two other meetings (figure 17). Then, we will proceed to the description of the two observed ones. The excerpt E1 and E2 involve the designers O and P and the excerpts E3 and E4 occurred with O and M.

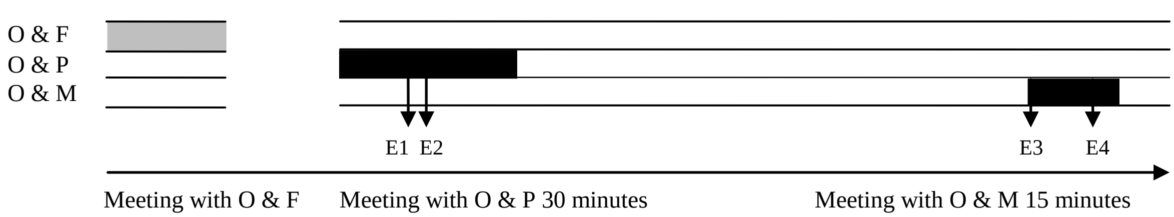


Figure 18. Sequence of meetings in meeting M8

The first meeting is reconstructed with the reported speech of F from the second and third meetings. During this meeting, we assumed that F play-tested the prototype and debriefed with O. We believe that the stake of O was to gather player's feedbacks and possibilities of new solution for the conceptual re-orientations of the prototype.

In this meeting, O and F engaged in discussions around solutions linked to the state of the prototype and to potentially new orientations of the prototype concerning issues of players' gains, musical experience and potential endings of the game. Three problems and two solutions generated by F are presented below. We will then see how these problems and solutions were reconsidered and processed in the two following meetings. F highlighted:

- The 'replayability' problem refers to the reinforcement of the players' willingness to replay the game. F paired this problem with the solution 'win something that will dress your avatar at each replay'. F's problem and solution will be linked to two new orientations, performance (theme 1) and style (theme 2) scores, developed in the two following meetings in E1, E2 and E4.
- The problem 'overwhelming' that he explained as the game offers twelve soundtracks at first, this number of available soundtracks is overwhelming for the players. To this problem, F proposed the solution 'winning instruments at each replay'. In other words, the players start a game with some soundtracks and at the end they win a new soundtrack. This problem and solution were linked to the new orientation of the performance score (theme 1) processed in the second and third meetings in E1 and E4.
- The 'pressure of the music' problem that can be defined as the game is based on a soft experience, but the music exerts a pressure on the experience. No solution was reported by O and it was linked to the musical experience (theme 3) re-developed in the third meeting in E3.

Regarding the second meeting, where the excerpts E1 and E2 were taken, P first play-tested the prototype and then debriefed on his player's experience with O. The two excerpts are taken from the debriefing of P with O. The prototype embedded new functions which are a score scale, a second musical loop and a character. The score and the second musical loop were not play-tested by P; O had to activate them by interacting with the prototype in order to show them to P during the debriefing.

In the meeting, participants engaged in a discussion around alternative solutions linked to the state of the prototype and to potentially new orientations of the prototype concerning issues of players' gain, casual and hardcore gamers' experiential spaces and initiation of musical loops. In the excerpts E1 and E2, O and P discussed and co-elaborated solutions concerning the player's gain with performance and style scores. The excerpt E1 occurred a few minutes before the excerpt E2 in the debriefing of P; they are separate by a sequence where O interacted with the prototype in a way to explain to P the style score. There was no meeting or other play-test between the second and the third meeting.

The third meeting encompassing the excerpts E3 and E4 is a debrief meeting where O reported the contributions of the external participants F and P to M. In this debriefing, O evoked to M three new possible orientations that were either generated by F and/or by P or that O generated himself in reaction to the debriefings of P and F. O and M discussed the new orientations related to the parameters of navigation in the musical loop and the different types of score and they co-elaborated solutions related to these new orientations. The excerpt E3 corresponds to the 'Pressure of the musical' problem evoked by F and the excerpt E4, to the new orientation related to the performance score.

2.2.2 Design processes in M8

In the meetings M8, we found four design processes. These are composition, analogical reasoning, co-evolution of problem-solution and combination (figure 18). However, we did not find a problem framing process.

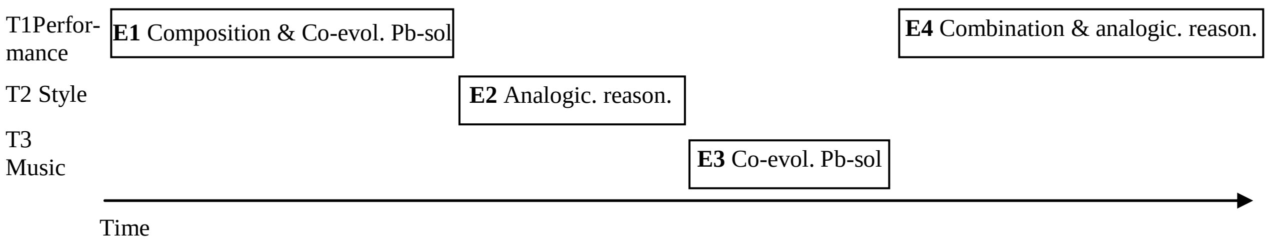
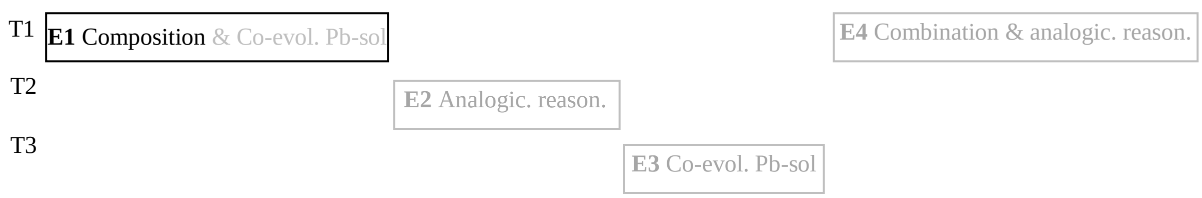


Figure 19. Design processes in M8

In this section, we will illustrate the four design processes. We will give an illustration for each of them. The composition will be illustrated with the excerpt E1, the analogical reasoning process with E2, the co-evolution of problem-solution with E3 and the combination process with E4.



Composition process. In E1, during the debriefing, O's stakes are to first gather P's feedbacks on his experience with the game and then to present a new function implemented in the prototype to seek with P new solutions. The new orientation was focused on performance gains that will be given to players in the experiential space of the hardcore gamers.

In the excerpt, O addressed the problem 'player's gain for the tempo reward'. O started by generating a solution 'winning a character's attribute' and P generated an alternative solution 'winning soundtracks' which were both generated by F in the first meeting for the 'replayability' and the 'overwhelming' problem respectively. Both participants, O and P, co-elaborated the alternative solution.

During this excerpt, the designer and participant were in front of the prototype (photo 34). While P debriefed and co-elaborated his solution with O, this latter designer interacted with the prototype at some occasions.

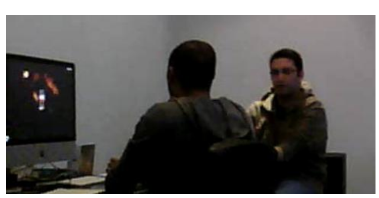


Photo 34. From left to right, O and P

This excerpt encompasses composition and co-evolution of problem-solution processes. We will develop in more detail the composition process.

In this excerpt (table 62), we noticed a change of a solution's location which can be considered as a composition process. We underlined in the first meeting that F generated the solution 'win something that will dress your avatar at each replay' for the 'Replayability' problem. In this first meeting, F play-tested the prototype that only had an experiential space meant for casual gamers. Thus, we could say that F generated this solution for that experiential space.

In the second meeting, O evoked to P that an experiential space for hardcore gamers will be added. Following the evocation of that additional space, O re-generated F's solution for the performance score of the new hardcore gamers' experiential space in order to enhance the replayability. It resulted in the following solution "*t'as un mode de replay orienté gamer c'est-à-dire que tu vas avoir je sais pas le droit de choisir un objet par exemple qui va habiller ton perso*" "*you have a replay mode oriented hardcore gamers that is to say you will have, I don't know, the right to choose an object for example that will dress your character*" (line 1b).

No	Loc	Verbatim	Enun	Persp	D. a.	Pb/Sol
1a	O	t'as un mode de replay orienté gamer *you have a replay mode oriented gamer*	O	Dsg	Inter	
1b	O	c'est-à-dire que tu vas avoir je sais pas le (.)§ droit *activates sound* § de choisir un objet par exemple qui va habiller§ ton *gesture toward the prototype*§ perso *that is to say you will have I don't know the right to chose an object for example that will dress your character*	F	Dsg	Gen Sol(a)1	Winning a character's attribute

Table 62. The composition process

This example highlights a composition process on a solution generated in two different meetings (figure 19). In the first meeting, there is an attribution of a location that encompassed the casual space for the solution generated by F. In the second meeting, O changed the location of F's solution from the casual gamers' experiential space to the hardcore gamers' experiential space.

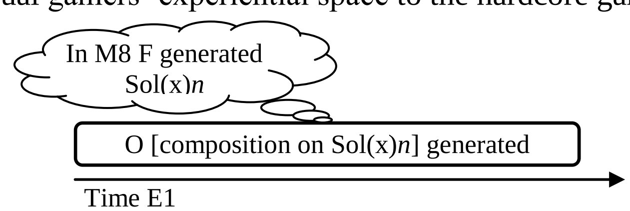


Figure 20. The composition process

This design process is performed with contributions brought by two participants. These contributions are of different nature; the contribution of F is a generation of a solution with a specific location and O contributed by shifting the location of the solution previously generated by F. Thus, the contributions are a generation of a solution and a switch of location. This latter can be considered as the key step of composition. It is the designer O that performed it.

T1	**E1** Composition & Co-evol. Pb-sol			**E4** Combination & analogic. reason.
T2		**E2** Analogic. reason.		
T3			**E3** Co-evol. Pb-sol	

Analogical reasoning process. In E2, during the debriefing of P, O explained and showed to P the style score. Then, the stake of O consisted of eliciting new solutions from P regarding this score. In the excerpt, O and P discussed about the style score, another facet of the 'replayability' problem evoked by F that is a complement of the performance score. O and P both generated a solution of gains to give to the players related to the style score. O generated a first solution 'the character will dance, do acrobatics'. Then, P generated an alternative solution 'win pets'. Both designers co-elaborated the alternative proposal.

In the excerpt, O and P were discussing in front of the prototype (photo 35). In some occasions, O interacted with the prototype while both designers were generating and co-elaborating the two solutions.

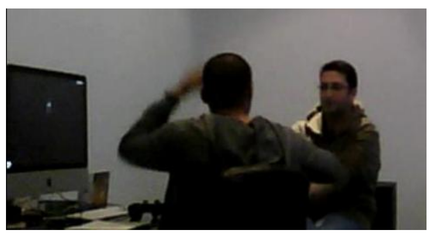


Photo 35. From left to right, Jt, O and M

We observed that this excerpt encompasses an analogical reasoning process. This design process was applied on the alternative solution 'win pets' generated by P. It will now be described in more detail.

In the segment (table 63), the problem of 'Style score' was paired with the solution '*win pets*' by P (line 2). O reacted to this solution by re-attributing this idea to a video game Jumping Maestro in which the designer Jt was involved in the development. After the re-attribution, O described the game and the element that reifies P's solution "*c'est-à-dire qu'ils ont un petit oiseau qui coure sur des :es des poteaux télégraphiques et c'est des cordes en fait et à chaque fois qu'y arrive dessus tu dois sur la musique tu dois gratter la corde et y saute (inc) c'est vachement bien fait si tu l'fais bien y'a d'autres petits oiseaux qui se mettent à te suivre t'as des:s*" 'they do that, that is to say they have a little bird that runs on telegraphic poles and it's a cord in fact and each time the bird arrives on them, you need on the music you need to scratch the cord and the bird jumps and if you do it well, there are other small birds that start to follow you' (line 7b).

Following the description of Jumping Maestro and the reification of P's solution in this video game, O took an element from Jumping Maestro "*si tu l'fais bien y'a d'autres petits oiseaux qui se mettent à te suivre*" 'if you do it well there are other small birds that start to follow you' and transferred it into P's solution which resulted in the refined solution "*c'est-à-dire que tu va/happer un instrument et cet instrument ça sera un pet qui va te suivre un truc qui va venir courir avec toi ou euh*" 'that is to say you will snap an instrument and this instrument will be a pet that will follow you, a thing that will run with you' (line 9b).

No	Loc	Verbatim	Persp	D.a.	Pb/Sol
2	P	=faut que tu gagnes [des bêtes *Have to win pets*	Ply	Gen Sol(a)2	Win pets
3	O	[il relève euh y quoi/ *It stands up, it what*	Dsg		
4	P	des bêtes *pets*			
5	O	non alors ça/ ça/ ce que j'ai envie de faire c'est § peut-être c'est *activates sound*§ alors\= *no well this I would like to do is maybe, it's well*	Dsg		
6	P	=tu fais gagner des bêtes après tu vends des peluche *You make the people win pets and then you sell cuddly toy*	Dsg	Arg+	
7a	O	t'as t'as joué t'as vu Jum-mping Maestro/ de Pasta Games (inc) français c'est un bon jeu musical et c'est sur DS/ et eux y font ça *have you played, have you seen Jumpring Maestro of Pasta Games (inc) French? It's a good musical game and it's with the DS and they do that*	Dsg	Arg+	
7b	O	c'est-à-dire §qu'ils ont un petit oiseau qui coure sur des:es des <§*gestural simulation* poteaux télégraphiques et c'est des cordes en fait et à chaque fois qu'y arrive dessus tu dois sur la musique tu dois gratter la corde et y saute (inc)§ c'est vachement bien fait §si tu l'fais §>*stops gestural simulation*<§*gestural simulation* bien y'a d'autres petits oiseaux qui se mettent à te suivre § [t'as des:s *stops gestural simulation*§> *that is they have a little bird that runs on telegraphic poles and they are ropes in fact and at each time that it arrives on it you have to, on the music, scratch the rope and it jumps (inc). It's really well made. If you do it well, there are other little birds that start to follow, you have*	Ply	Inter	(Analog)
8	P	[mm oué c c ça que je pensais (inc)£ £ *arms wide open and little mvts* *Mm yeah that what I was thinking (inc)*	Dsg	Refo	
9a	O	alors moi ce que je me disais §peut-être probablement ce qu'on <*plays with prototype*§ va faire c'est que ça§ sera parmi parmi les intruments\ *stops playing*§> *well what I was saying to myself is that maybe, probably what we'll do is that it will be amongst the instruments*	Dsg	Refi	
9b	O	c'est-à-dire que § tu va/happer un instrument et cet <§ *plays with prototype* instrument ça sera un pet qui §va te suivre un truc qui va venir <§*hand from computer to him* courir avec toi ou euh§>= §*hand from computer to him* *that is you will snatch an instrument and this instrument will become a pet that will follow you, a thing that will run toward you or euh*	Ply	Refi	

Table 63. The analogical reasoning process

The analogical reasoning process is represented in the following figure (figure 20). First, a solution was generated by P. Then, O evoked a reification of P's solution, Jumping Maestro. It is Jt that showed this game to O in a previous meeting, thus Jt shared his knowledge with O. After, O described this game and the reification of P's solution. Finally, O transferred an element from Jumping Maestro into P's solution. Therefore, O performed analogical reasoning processes in the design activities of refinement of P's solution.

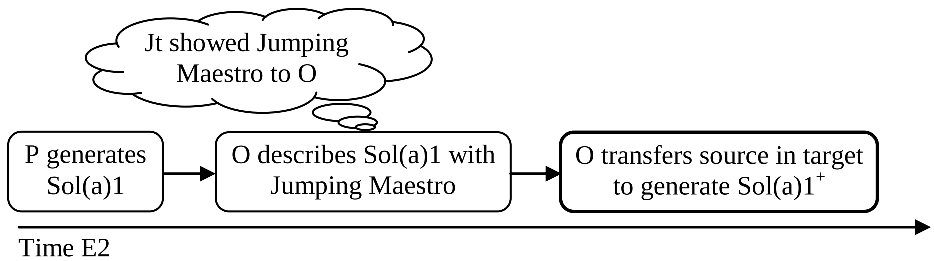
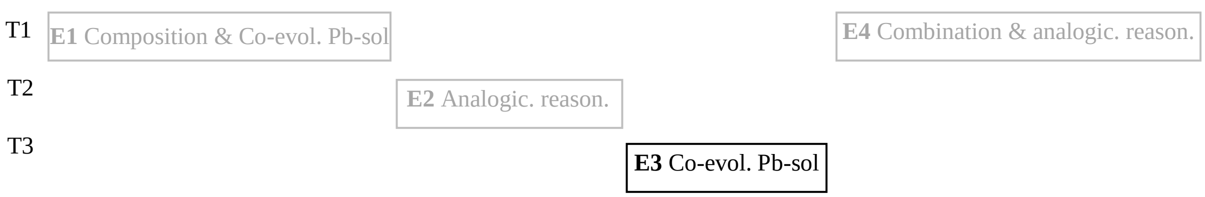


Figure 21. Analogical reasoning process

We can underline contributions of two designers and one participant in this analogical reasoning process. They contributed by generating and refining a solution, and sharing information. The analogical transfer was performed by the designer O.



Co-evolution of problem-solution process. As a reminder, E3 starts the third meeting with O and M. In this excerpt, O only reported to M the player's experience of F, but not the player's experience of P. The reported player's experience of F concerned the 'pressure of the music' problem. The stakes of the designers were to take into account solutions that could re-orient the game toward its former goal which was to create a soft sensorial experience for the players and that these new design solutions would alleviate the reported problem of F. As we described earlier in the reconstruction of the first meeting, F underlined in his debriefing the fact that the music exerts a pressure on the experience (negative evaluation). Therefore, O and M focused their discussion toward solutions that could decrease the pressure of the music in the player's experience.

The problem evoked by F led O to generate a solution '*x* pressed buttons' in order to reduce the pressure. This solution was co-elaborated by both O and M. After, O generated a new problem related to his solution the 'setting' problem. Then, M generated an alternative solution 'gains with pressed buttons on the tempo' that was also co-elaborated by both designers.

In this excerpt, O and M were discussing in the meeting room in the basement. O was standing in front of the white board and M was sitting at the table during the entire excerpt. Moreover, O drew on the white board while he generated his solution '*x* pressed buttons' (photo 36) and used the drawing while he explained and refined it.

Photo 36. From left to right, M and O

We found that this excerpt encompasses a co-evolution of problem-solution process. It will be developed in more detail below.

In this segment (table 64), O reported the player's experience and the problem generated by F "*il m'a relevé un point… le point étant euh tout l'jeu est doux tu vois tout le jeu est sous le tout l'jeu est doux et euh et toute l'expérience est basé sur cette douceur… le problème est qu'on subit complètement la pression de la musique*" 'he found a point…the point is all the game is soft you see all the game is under the, all the game is soft and all the experience is based on this softness the problem is that you are completely under the pressure of the music… the problem is that we are completely subjected to the musical pressure' (line 1c, d and e). To this problem, O paired a solution "*l'idée ça s'rait de dire pour passer la boucle euh:euh d'après il faut qu't'ai fait au moins x pressions de boutons*" 'the idea would be to say, to pass to the following loop, you need to have at least pressed x buttons' (line 5c). After, O refined his solution "*quand on veut pas qu'è se répète on va mettre un chiffre très-très petit ok d'accord\ si on veut au contraire le machin on va l'mettre du haut*" 'when we don't want it to repeat itself we will put a small number ok if we want in contrary the thing we will put it up' (line 23). Then, O considered its implication back into the problem space; he generated a new problem "*ça c'est du règlage*" 'this is setting' (line 23).

No	Loc	Verbatim	Enun	Persp	D. a.	Pb/Sol
1c	O	il m'a relevé un point qui m'a fait vachement réfléchir et auquel je pense il faut une solution\ (inc) pas une solution parfaite pas l'idéal mais euh\ le point étant euh *he brought a point that made me think and that I think we need a solution (inc) not a perfect solution, not the ideal, but the point is*	F	Dsg	Deb	
1d	O	tout l'jeu est doux tu vois tout le jeu est sous le tout l'jeu est doux et euh et toute l'expérience est basé sur cette douceur *all the game is soft you see, all the game is under, all the game is soft and euh all the experience is based on this softeness*	F	Ply	Arg+	
1e	O	le problème est qu'on §subit complètement la *makes a heavy step §* pression de la musique tu vois c'est que la musique à son rythme et tu subis ce rythme pourquoi/ parce qu'on est pas dans un truc de compo et donc on subit la pression de-e du déroulement de la loop et *the problem is that we completely are subjected to the pressure of the music you see. It's that the music has its rhythm and you have to put up with it. Why? Because we are not in a game of composition and thus we have to go through the pressure of the progression of the loop and*	F	Ply	Gen Pb(a)	Pressure of the music

1f	O	/Florent était parti super compo c'est normale c'est c'est le réflexe numéro un de des mecs (inc) après y'a compris que c'était un truc d'arrangement et y'a dit ok j'ai compris mais *Florent started with composition, it's normal, it's the first reflexe of the guys (inc) after he understood that is was a game of arrangements and he said ok I understand but*	O	Dsg	Perso	
1g	O	il était gèné par l'aspect §pression de la musique §*whole body goes down and up multimes* et de devoir la pression du machin et /j'ai réfléchis\\ *he was annoyed by the aspect pressure of the music and by having to the pressure of the thing and I was thinking*	O	Dsg	Deb	
2	M	Oué j'te vois j'te vois venir vas-y *Yeah I see where you want to go, go ahead*	M	Dsg		
3	O	Ok vas-y *Ok say it*	O	Dsg		
4	M	Non non vas-y j'voudrais pas de donner une nouv- une idée qui :i *No no go I wouldn't want to give you an idea that*	M	Dsg		
5a	O	Alors mon idée ben tu vas m'le dire quand même euh l'idée c'est que §on a notre boucle et on a une §*draws the loops like rectangles* deuxième boucle et on a une troisième boucle ok/ *well my idea, well you'll tell me your idea, euh the idea is that we have our loop and we have a second loop and we have a third loop ok?*	O	Dsg	Inter comp	
5b	O	actuellement t'as pas ton mot à dire t'arrive clack<§ *follows the rectangles*§ t'enchaine sur la deuxième boucle t'enchaine sur la troisième boucle> *now you don't have the choice, you arrive clack, you follow on the second loop, you follow on the third loop*	O	Ply	Inter comp	
5c	O	l' idée ca s'rait de dire pour § passer la boucle §*draws a curve from the first loop to the second* euh:euh d'après il faut qu't'ai fait §au moins x *writes a number above curve*§ pressions de boutons *The idea would be to say to pass the loop euh following, you would need to have pressed at least x buttons pressures*	O	Ply	Gen Sol(a)1	x pressed buttons to go to 2nd loop
…		…				
23a	O	Juste la musique est va s'répéter à des endroits alors quand on veut pas qu'è se répète on va mettre§ un *points to the number*§ chiffre très-très petit ok d'accord\\ si on veut au contraire le machin on va l'mettre du haut donc ça c'est du règlage *only the music it will repeat itself at some places. Well when we don't want it to repeat itself, we will put a lower number ok, if we want it to repeat itself, we will put a higher number and thus this is setting*	O	Dsg	Gen Pb(b)	Setting

Table 64. The co-evolution of problem-solution process

The co-evolution of problem-solution process is depicted in the figure below (figure 21). In the first meeting, F contributed by sharing the problem ‘pressure of the music’ he encountered during his player’s experience. With this, in the third meeting, O generated a solution that he paired with F’s problem and then refined. After, O re-invested the problem space by taking into account his refined solution into the problem space which resulted in the generation of a new problem.

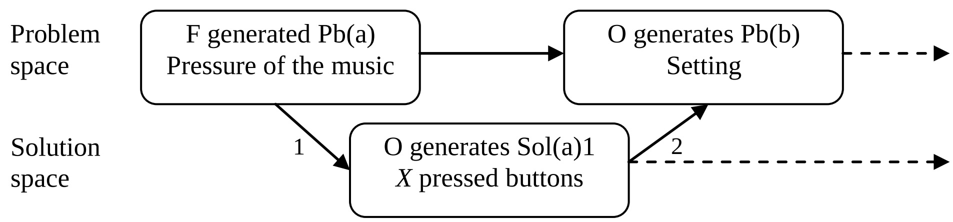


Figure 22. Co-evolution of problem-solution process

We can underline that the co-evolution of problem-solution is performed by F and O; the contributions of both F and O made the problem and the solution spaces co-evolved. Their contributions are generation of problem and generation of solution.

Combination process. E4 consists on the report by O of the contributions of F and P. The stake of the designers is to consider the issue of ‘overwhelming’ brought up by F in the first meeting. In this excerpt, O reported the problem ‘overwhelming’ F exposed. Then, he generated the solution ‘starting with fewer buttons’ that was generated by both F and P. The solution generated by O was co-elaborated by both O and M. Then, O shifted toward another problem ‘endings’ which he paired with two solutions ‘two ending that correspond to the two experience spaces’ and ‘ending with additional scenery elements’. They were all co-elaborated by both O and M.

In this excerpt, O and M were discussing in the meeting room. O was standing in front of the white board without drawing on it and M was sitting at the table facing O (photo 37).

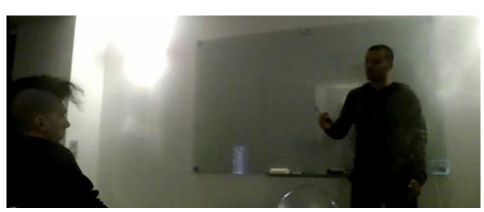


Photo 37 . From left to right, M and O

We observed a combination of two problems paired with one solution. This combination process on two problems will be scrutinized further. As a reminder, we underlined that F in the first meeting generated the ‘Overwhelming’ and the ‘Replayability’ problems. F paired the ‘overwhelming’ problem with the solution ‘win instrument at each replay’. In the second meeting, O reported the ‘replayability’ problem to P and presented a new orientation, the performance score. For that, P generated the solution ‘win new sounds’ which is similar to what F generated for the ‘overwhelming’ problem. We can acknowledge that the similar solution generated by F and P is paired with two distinct problems.

In this excerpt (table 65), F’s and P’s solutions were re-generated by O “*peut-être y faut di:iminuer le nombre de bouton au départ*” ‘maybe we need to decrease the number of buttons at first’ (line 1c). The refinement of O’s solution was especially similar to F’s and P’s solution “*tu fais le voyage une première fois t’as quatre boutons par exemple à la fin t’en gagne un autre tu peux refaire le morceau et t’as un nouvel instrument*” ‘you do you trip a first time you have four buttons for example, at the end you win another one, you can do again the musical loop and you have a new instrument’ (line 3b and 5). After this, O explained that this solution is generated in order to solve two problems “*je tie deux problèmes y a un problème de trop de bouton et lui* [F] *le problème qui l’a relevé et qui est intéressant y dit euhm il faut travailler la replayabilité*” ‘I tie two problems, one is too much buttons and him [F] the problem that he raised and that is interesting he said you need to work on the replayability’ (lines 11c and 11d).

No	Loc	Verbatim	Enun	Persp	D.a.	Pb/Sol
1a	O	Y dit euh:h (.) overwhelming trop de boutons au départ tu vois *He says overwhelming too much buttons at the beginning*	F	Ply	Gen Pb(a)	Overwhelming
1b	O	quand il prend le truc en main trop trop de sons tro:op de machins euh:h euh:h *when he takes the game in hand, too much sounds, too much things, euh euh*	O	Dsg	Reph	
1c	O	ça ça (inc) et peut-être y faut di:iminuer le nombre de bouton au départ *this, this (inc) and maybe we have to lower the number of buttons at the beginning*	O	Dsg	Gen Sol(a)1	Decrease number of buttons at first
2	M	(inc) *(inc)*	M	Dsg		
3a	O	Ce qui tie in ce qui tie in avec un autre une autre réflexion qu’on avait peu:eut être ça la réflexion est pas abouti là-dessus mais l’idée c’est de dire ok *This ties with an other reflection that we had, maybe the reflection is not completed, but the idea is to say ok*	O	Dsg	Refi	
3b	O	tu fais § le voyage une première fois t’as quatre §*puts his hands from L to R* boutons par exemple *you do the game a first time, you have four buttons for example*	O	Ply	Refi	
4	M	ouain *yeah*	M	Dsg		
5	O	A la fin § t’en gagne un autre tu peux <§ refaire le §*hand from L to R* §*hand mvt in*	O	Ply	Refi	

		circle morceau et t'as un nouvel instrument *at the end you win another one, you can replay the loop and you have a new instrument*				
6	M	En:n *in*	M	Dsg		
7	O	Un nouveau et à chaque fois §> §*stops mvt in circle* et ainsi de suite jusqu'à ce que tous le:es *a new one and at each time and so on until all the*	O	Dsg	Refo	
8	M	En:n ouai ça c'est bon ça *In yeah, this is good*	M	Dsg	Arg+	
9	O	Tous les instruments à:à disposition *All the instruments are available*	O	Dsg	Refo	
10	M	Ca te multiplie la longueur du truc *It enhance the lenght of the thing*	M	Ply	Arg+	
11a	O	Ca te pousse à la à la à la replayabilité *It pushes you to replayability*	O	Ply	Arg+	
11b	O	alors mais ça leu alors ça ça c'est c'est ma solution et elle est pas parfaite encore *well, but, this well this is my solution, it is still not perfect*	O	Dsg	mana	
11c	O	et euh lui ce qui proposait ce qui proposait c'était pas ça y pensait pas à ça en fait je veux dire je tie deux problèmes y a un problème de trop de bouton et lui le problème qui l'a relevé et qui est intéressant *and him, what he was proposing is not that, he didn't think of that. In fact, I want to say I tie two problems. There is one problem too much buttons and him the problem he highlighted and that is interesting*	O	dsg	Refi Pb(a)	
11d	O	y dit euhm il faut travailler la replayabilité *he said you need to work on the replayability*	F	dsg	Gen Pb(x)	Replayability

Table 65. The combination process

The combination is described in the following figure (figure 22). In the first meeting, there was the generation of two problems by F 'overwhelming' and 'replayability' and F paired the former problem with a solution, thus he generated two problems and a solution. In the second meeting, P generated a solution 'win new sounds' for the 'replayability' problem. In the third meeting, O proposed the solution that was previously generated by both F and P to pair it with the two combined problems 'overwhelming' and 'replayability'.

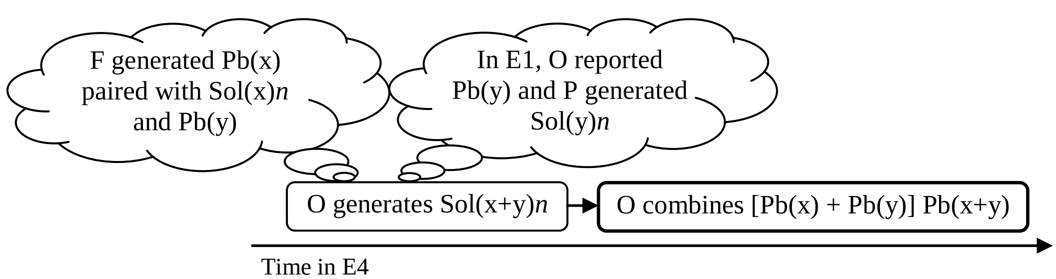


Figure 23. Combination process

This design process is performed with contributions brought by one designer and two participants. These contributions are of different nature ranging from generation of a problem and solutions, and merging of problems. It is the designer O that performed the combination of the two problems.

2.2.3 Sources taken into account in design processes

In sum, the identified design processes in the meeting M8 can be related to previous ideas generated in the sequence of the meeting M8 or from another meeting. In that vein, we can depict the ideas encompassed in each design process to their first moment of evocation. The following figure depicts the sources and components taken back in subsequent design processes (figure 23).

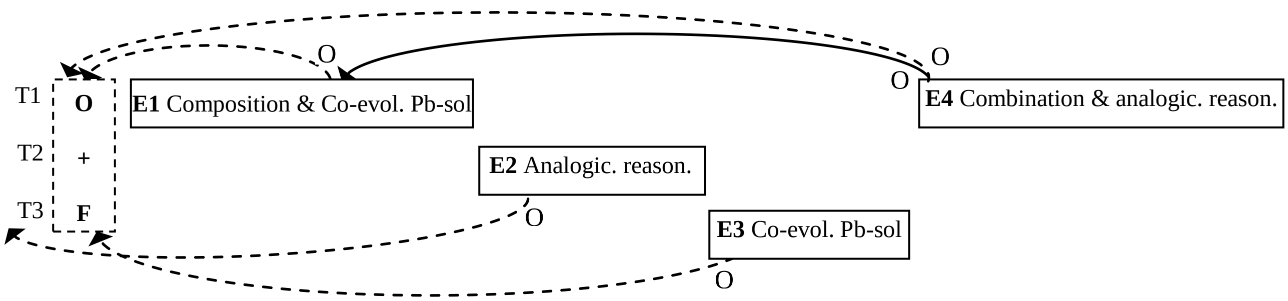


Figure 24. Report of ideas in M8

This figure underlines that previously generated ideas are reinvested in subsequent excerpts. On the one hand, a generated idea (plain line) by a present designer was reinvested in a subsequent design processes. On the other hand, reported speeches of absent designers (dotted lines) are also reinvested in subsequent design processes. One case in E2 concerns information that was shared previously to the M8 sequence of meetings. This highlights that the evolution of themes and design processes can be built and progress on the basis of previously generated ideas.

2.2.4. *Collaboration formats in M8*

Collaboration formats can be replaced in the four analyzed excerpts with their design processes. This would depict the evolution of collaboration formats and design processes in the meeting M8. The following figure illustrates the three collaboration formats in the design processes identified in M8 (figure 24).

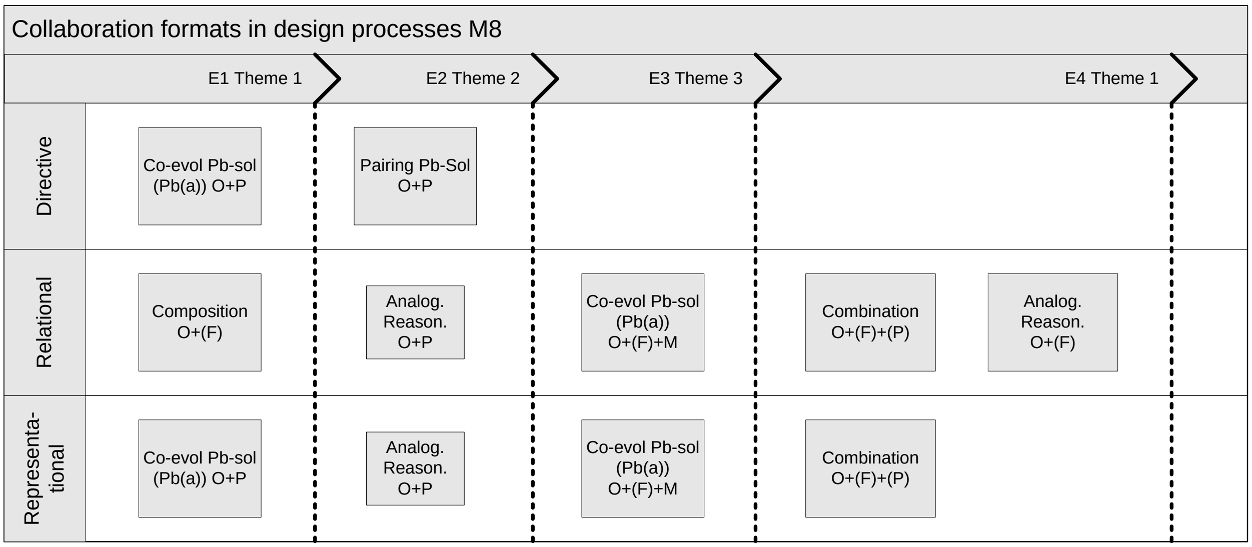


Figure 25. Collaboration formats in M8

This figure stresses that the directive formats is found only in the two first excerpts in co-evolution of problem-solution and in pairing of problem and solutions. Conversely, the relational and representational formats are retrieved in all excerpts; they are found in composition, co-evolution of problem-solution, analogical reasoning and combination.

In terms of contributions, this figure highlights that all designers contribute to design processes within the collaboration formats. The exception is the contributions of O in the relational formats; solutions involved in composition, co-evolution of problem-solution, combination and analogical reasoning processes were reported design ideas. These solutions were reported by O.

3. Conclusion

We have selected two meetings where designers faced a conceptual phase in the global design process: (1) the M7 meeting where the designers had to transform abstract visual representations into figurative ones and (2) the M8 sequence of meetings where designers had to add in the prototype a *ludus* experience for hardcore gamers to the *païdian* one dedicated for casual gamers. The depicted context of M7 and M8 describes well a conceptual phase; the designers (re)-formulated problems and generated the main characteristics of the solutions (Bonnardel, 2009; Edmonds and Candy, 1993). Our decision to choose these moments was motivated by the aim to highlight the temporality of socio-cognitive design processes; we assumed that potential creative moments such as a conceptual phase (Bonnardel, 2006; Bonnardel, 2009) would encompass numerous design processes.

Our results highlighted five design processes in the two conceptual meetings: (1) problem framing, (2) co-evolution of problem-solution, (3) combination, (4) analogical reasoning and (5) composition. We underlined that these design processes were distributed amongst the designers and participants. We could suggest that these design processes are constructed in and through the different contributions of several designers/participant shared in their interactions. Taken separately, each contribution of designers/participants remains a design activity, but taken together within their temporality, they all participate in a bigger structure which is here socio-cognitive design processes.

3.1 Temporality of design processes and collaboration formats in conceptual meetings

Our results stressed specific temporalities of design processes and collaboration formats in two conceptual meetings. These meetings were different in nature. On the one hand, all designers present participated to the re-formulation of problems and the elaboration of the global characteristics of the new concept in the meeting M7. On the other hand, the elaboration of the global characteristics of the new concept was carried on through different meetings in M8. Two of them were conducted with external participants who play-tested and then, were asked to contribute to the elaboration of the new concept's characteristics.

Moreover, the M7 and M8 differ in their themes; one the one hand, M7 encompasses several excerpts in both themes and on the other hand, M8 encompasses mainly one excerpt in each theme. Thus, we propose to discuss them separately.

For the meeting M7, our findings highlighted specific temporalities of design processes and collaboration formats. We stressed that problem framing as well as analogical reasoning processes were taken place at the beginning of the meeting. From that, we could suggest that the meeting started with establishing a convergence toward problems. This could be interpreted as the grounding of a common appreciation of the design problem and how designers should solve it (Stumpf and McDonnell, 2002) before the designers started to solve problems in the meeting.

Additionally, the meeting ended with combinations of ideas that were previously generated within the meeting. From that, we could suggest that after the generation of a pool of ideas, the designers combined them. This result concurs to the claim suggested by Maiden et al. (2004). These authors organized a session within a workshop solely dedicated to the design process of combination following a first phase of divergent thinking. Thus, they encouraged combination of solutions only once many ideas were generated by participants, *i.e.* the phase of divergence.

On the contrary, we found that the co-evolution of problem-solution process was found throughout the meeting. This is consistent with the claim that problem solving results in co-evolution of problem-solution (Cross, 2004; Dorst and Cross, 2001; Maher et al., 1996).

A similar structure was highlighted in the two themes as well; themes started with an analogical reasoning process and ended with combination processes. Furthermore, the co-evolution problem-solution was found throughout the two themes.

In regard to the collaboration formats, our results underlined that both the directive and relational formats are retrieved at the beginning of the meeting and of the two themes. Both collaboration formats involve the two underlined design processes found at the beginning of the meeting, *i.e*. problem framing and analogical reasoning; the directive formats include triggering problem framing and relational formats, relations to reified solutions respectively.

Contrastingly, the representational formats were found throughout the meeting and themes. This is consistent with the definition of design that is provided by Visser (2006a; 2006b). This author views design as a construction of representations which could explain the representational formats throughout the meetings.

These results contrast with a popular technique that is brainstorming used to generate creative ideas. Indeed, we highlighted in the meeting first convergence and then divergence which differs from brainstorming in which divergence is first carried on and then, convergence is undertaken.

For the sequence of meetings M8, three meetings were conducted with different designers and participants. However, the designer O participated in each of these three meetings. Our findings highlighted that the two observed meetings both encompassed reported speeches. Thus, the relational format involving anterior design ideas was found in all excerpts of the sequence of meetings M8. These reported speeches came from the previous meeting/s with participant/s who play-tested the prototype and to whom the new concept was shown.

These reported speeches were involved in several design processes that are co-evolution of problem-solution, analogical reasoning, combination and composition. From that, we could suggest that even absent participants can contribute to several design processes; their generated problems, solutions or player's experience were brought out in subsequent design processes. This underlines a characteristic of design related to the fact that designers do not always elaborate design ideas from scratch (Visser, 2002), but can make relations to previously generated design ideas. Additionally, our results are also consistent with the fact that designers can build on previous ideas generated by others (Maiden et al., 2004; Matthews, 2009; Nijstad et al., 2003; Paulus and Nijstad, 2003) through design processes.

3.2 Distribution of contributions and asymmetries related to problem framing and relations to anterior design ideas

We highlighted for each design process several steps, *e.g.* generating ideas, as well as one or more key steps, *e.g.* combining the generated ideas. Our results highlighted that the steps of a design process are distributed between different designers/participants. We have underlined that the designers/participants contributed to various steps of design processes by generating problem, generating, refining, rejecting and negotiating solution, and sharing information. These design activities took part in the progression of the design processes. Thus, the designers/participants all contributed to different steps and different design processes. In that vein, we could suggest that contributions to socio-cognitive design processes are quite symmetrical.

Additionally, the key step/s of each design process was in majority undertaken by all designers. However, we noticed two exceptions. On the one hand, the design process problem framing is an exception (meeting M7). In this design process, it is only the project director O who framed the problem. This can be related to the directive format triggering problem framing in which we highlighted that it is only the project director O who framed the problem (see chapter 7, section 3.1.2). This might give an explanation to this specific contribution that is brought only by O.

On the other hand, the reported speech of absent participants, *i.e.* relations to anterior design ideas format, is the other exception. In this relational format, we underlined that it is mainly the project director O who reported the ideas of external participants/play-testers. We underlined earlier (see chapter 7, section 3.1.3) that O is responsible for the play-tests. The sequence of meetings M8 involving play-tests in the two first meetings stressed this asymmetry; O gathered problems, solutions and player's experience from participants/play-testers and then, reported them in the subsequent meeting/s. The problems and solutions generated by the external participants, *i.e.* F and P, were subsequently used by O to perform design processes.

We could suggest that design processes can be co-constructed by present and absent designers/participants. Conversely, other design processes such as problem framing and the ones encompassing reported speech seemed to require some specific knowledge, *i.e.* the final state of the product and the ideas generated by participants/play-testers which are held by the specific designer O who is responsible for play-tests.

From all our findings, another question arises: do socio-cognitive design processes lead to more creative outcomes than cognitive design processes performed in a group, but at an individual level that is to say in one head? It is known that diversity promotes creativity. From that, we could make the assumption that in a diverse group a socio-cognitive design process might lead to the most creative outcomes compared to a cognitive design process performed in a 'single head'.

Summary

This chapter aims to identify and describe the temporality of collaborative problem solving. For that, we proceed to a longitudinal analysis. This approach was applied to conceptual design meetings. Furthermore, we also aimed to stress the temporality of collaboration formats.

Our results stressed a wide range of design processes observed during conceptual meetings, *i.e.* problem framing, co-evolution of problem-solution, analogical reasoning, combination, and composition. These design processes were distributed amongst the designers and participants. This underlined that the socio-cognitive design processes are constructed in and through the temporality of interaction.

Our findings also underlined specific temporalities of design processes and collaboration formats. For the meeting M7, our results highlighted that problem framing and analogical reasoning processes are found at the beginning of the meeting and the combination process, at the end of the meeting. This result highlights a difference from the technique of brainstorming; our meeting started with a convergent movement on a problem which differs from brainstorming that starts with a divergent movement. Contrastingly, our results stressed that co-evolution of problem-solution is found through out the meeting.

Regarding the collaboration formats, the directive and the relational formats were found at the beginning of the meeting. This could be explained by the fact that they encompass problem framing and analogical reasoning processes respectively, the two design processes found at the beginning of the meeting. Lastly, we found the representational formats throughout the meeting. This is consistent with the definition of design as construction of representations (Visser, 2006a; Visser, 2006b).

A specific temporality was stressed as well within the sequences of meetings M8. Throughout the two meetings observed, we found the relational format involving anterior design ideas and thus reported speeches. This result is consistent with the fact that designers build on ideas generated by others (Maiden et al., 2004; Matthews, 2009; Nijstad et al., 2003; Paulus and Nijstad, 2003) through design processes.

Furthermore, our results stressed that all designers and participants contributed to the several steps of design processes. However, we highlighted that some key steps were conducted by only one designer that is O. Indeed, in the problem framing process, it is only the designer O who framed problems. Moreover, it is only the designer O who reported the problems, solutions or player’s experience in subsequent meeting/s as he is responsible for play-tests. These results could be explained by the impact of institutional roles and expertise highlighted in the directive and relational formats (chapter 7); the problem framing and reported ideas are involved in the directive and relational formats respectively.

Chapter 9 Creativity from the designers' viewpoint

This chapter introduces the first-person viewpoint, *i.e.* the viewpoint of designers. We will examine how the two designers of the core team judged creativity. First, our goal is to identify the creative solutions from the non-creative ones. Second, our aim is to characterize creative solutions with product's characteristics and design processes. Indeed these characteristics, as reported by the designers themselves, can provide insights on required qualifications to consider a solution as creative.

1. Identifying and characterizing creative solutions: quantitative and thematic analyses

We first conducted a semi-directive interview with the two designers of the core team O and M. These interviews aimed to collect information on the global design process (*cf*. annex 3). Second, the designers O and M completed a questionnaire (*cf*. annex 4). In this questionnaire, nineteen problems and thirty-nine solutions taken from our excerpt corpus were evaluated[9] by the designers. These solutions were evaluated with the novelty and feasibility dimensions on a five points Likert scale. The designers were asked to justify all their ratings. Then, the designers selected solutions that they considered creative if both dimensions were taken into account, *i.e.* the 'free' condition.

To identify creative solutions, we used the (1) Likert scale's ratings from the questionnaire and (2) the solutions selected from the 'free' condition. With these data, we were able to identify the creative solutions in the excerpt corpus with a quantitative analysis applied on the ratings. Thus, it allowed us to answer our research question related to which solutions are judged and identified as creative by the designers.

To characterize the creative solutions, we used (1) the elaboration of the solutions the designers pointed out as creative, novel and original solutions in the interview and (2) the justifications of the designers' ratings in the questionnaire. We used these data to perform a thematic analysis on the identified creative solutions. This thematic analysis allowed us to characterize creative solutions. Thus, we were able to answer our research question 'how creative solutions are characterized?'

We will first highlight the creative solutions evaluated and selected by the designers. Then, we will underline the characteristics of creative solutions/products that were reported by the designers.

[9] The solutions related to implementation issues were discarded.

2. Identification of creative solutions by the two designers of the core team

We will first develop on the solutions rated with the Likert scales and selected in the 'free' condition by the designers O and M as creative solutions. Then, we will present the inter-rater agreement on the ratings and selections of creative solutions.

2.1 Solutions identified as creative

To identify the creative solutions, we used two set of data; the quantitative data from the Likert scales ratings were used to identify rated creative solutions and the 'free' condition data was used to identify selected creative solutions.

With the Likert scales ratings of both designers O and M (annex 14), we proceeded to a third quartile analysis in order to identify the creative solutions. The third quartile analysis was performed on the solutions' score that is to say on the sum of the novelty's and of feasibility's ratings of both designers for each solution, *i.e.* Novelty (O+M) + Feasibility (O+M). The solution's score was on twenty. The third quartile value obtained was seventeen. This quantitative analysis underlined eight (22%) creative solutions that had a total score above seventeen (table 66).

Descriptive statistics	*Novelty*	*Feasibility*	*Score with both dimensions*
Mean	3,57	4,33	15,83
Min	1	1	10
Max	5	5	20
Med	4	5	16
3rd quartile	5	5	17
1st quartile	2	4	14
Variance	2,41	1,06	5,63

Table 66. Descriptive statistics of all rated solutions

In the 'free' condition where designers selected creative solutions with both novelty and feasibility dimensions together amongst the ones presented in the questionnaire (annex 14), the designers O and M selected nine (25%) and eight (22%) creative solutions respectively (table 67). Four of these solutions (11%) were selected by both designers.

Descriptive statistics	*Novelty*	*Feasibility*	*Score with both dimensions*
Mean	4,46	3,79	16,5
Min	1	1	13
Max	5	5	20
Med	5	4	16,5
3rd quartile	5	5	18
1st quartile	4	3	15,75
Variance	1,08	1,41	4,64

Table 67. Descriptive statistics of the selected creative solutions in 'free' condition

It is worth noting that the majority of solutions that were selected in the ‘free’ condition by both designers were solutions that were highly rated on the novelty dimension and lower rated on the feasibility dimension. From that, we could assume that the designers selected solutions more specifically on the basis of the novelty dimension.

2.2 Inter-rater agreement of rated and selected creative solutions

We conducted further quantitative analyses in order to evaluate the inter-rater agreement on the two sets of data, *i.e.* the Likert scale ratings and the selected creative solutions in the ‘free’ condition. In order to do so, we carried out a correlation analysis and kappa of Cohen respectively.

The correlation coefficients were determined on the two dimensions of creativity, the novelty and the feasibility. The correlation coefficients (table 68) for both dimensions showed positively strong correlations (novelty dimension $r = .53$; $ddl = 34$; $p < .01$ and feasibility dimension $r = .52$; $ddl = 34$; $p < .01$). Thus, we could advance that the ratings of the designer M and O were significantly homogeneous in both the direction and the strength.

Dimensions	*Correlation coefficients*
Novelty dimension	0.53
Feasibility dimension	0.52

Table 68 . Correlation coefficient of the ratings for the novelty and feasibility dimensions

For the inter-rater agreement on the selected solutions in the ‘free’ condition, we carried out a Cohen’s kappa coefficient analysis[10]. The Cohen’s kappa coefficient (table 69) showed a fair inter-rater agreement ($P_o = .78$; $P_e = .65$; $K = .36$). Thus, we cannot advance that the designers were agreeing on the creativity of the solution.

		Designer O		
	Categories	Creative	Not creative	Sum
Designer M	Creative	4	4	8
	Not creative	4	24	28
	Sum	8	28	**36**

Table 69. Cohen’s kappa coefficients of the selected solution in ‘free’ condition

In sum, the results underline that globally the Likert scale ratings’ of designers O and M were strongly varying in the same direction for both the dimensions of novelty and feasibility. Thus, we can say that the designers were agreeing on the novelty and feasibility of the solutions which confirms that the sums of the designers’ final score of creativity for each solution can be validly considered (Bonnardel, 2006). However, we underlined that the inter-rater agreement on the selection of creative solutions in the ‘free’ condition was only considered as fair. Therefore, we will not consider for the next sections and chapter the solutions that were selected as creative in the ‘free’ condition.

[10] Cohen’s kappa coefficient is considered Poor = Less than 0.20; Fair = 0.20 to 0.40; Moderate = 0.40 to 0.60; Good = 0.60 to 0.80; and Very good = 0.80 to 1.00

3. Qualitative analysis of the creative, novel and original solutions

Qualitative data came from the interviews and the justifications of the ratings in the questionnaire. In the interviews, one aim was to identify how designers defined and characterize creative, novel and original solutions. In the questionnaire, justifications were asked to characterize the dimensions of novelty and feasibility. It is worth noting that the justifications of the feasibility dimension were not as developed and commented as the ones for the novelty dimension. Therefore, we will focus only on novelty.

We found several products/solutions and design processes characteristics for creative, novel and original solutions (table 70). As creative, novel and original solutions/product and design processes characteristics were in majority the same, we propose to treat them all together. We identified four product characteristics, namely novelty, appropriateness, surprise and ownership. Moreover, we identified four design processes characteristics, namely combination, addition, composition and deepening.

Characteristics		*Occurrences for O*	*Occurrences for M*
Solution/ product characteristics	Novelty	5	10
	Appropriateness	3	1
	Surprise	1	0
	Ownership	4	1
Design processes characteristics	Combination	3	3
	Addition	2	0
	Composition	1	1
	Deepening	3	1

Table 70. Dimensions and design processes for creative, novel and original solutions

In this section, we will first introduce the product characteristics and then, the processes characteristics will be developed.

3.1 Creative solutions characteristics: novelty, appropriateness, surprise and ownership

In the verbatim of the designers, we identified four characteristics that they reported to describe creative solutions. These characteristics are novelty, appropriateness, surprise and ownership. We will define them and provide designers' verbatim to illustrate each of these solution characteristics.

3.1.1 Novelty

The designers reported in their verbatim the characteristic of novelty to describe creative solutions. Novelty could be defined as ideas that do not already exist. For example, the designers stated:

« *ça va devenir quelque chose de nouveau* » 'it will become something new'
« *c'est une solution nouvelle qui n'avait pas été imaginée avant* » 'it's a new solution that had not been imagined before'

What stands out in these verbatim is the ‘novel’ character of a creative solution in comparison to what exist or has been imagined. In that vein, we found that designers could refer to domains when referring to the novelty characteristic:

> «*est ce que c’est nouveau pas tellement pris individuellement parce que il y a des trucs des films qui le font ça. Alors celui-là il est peut-être un peu plus le C tu vois c’est plus interactif*» ‘is it new no really taken individually because there are things, movies which do that. Yet this one, it’s maybe a little bit more than the C you see it’s more interactive’

In this case, we can consider that the designer referred to a domain distinct to video games that is the domain of the film industry. In other cases, designers referred to novelty based on the market. The novelty based on the market can be defined as design ideas that had not already been seen or used in a particular domain; here it would be the video game domain. For example, the novelty based on the market is used for a solution related to controls given to players:

> «*de fait c’est créatif ca n’existait pas avant donc par définition c’est créatif sauf erreur il y a peut être des jeux qui ont existé et qui reprenaient des idées comme ça mais à ma connaissance pas comme on fait j’en connais pas de fait*» ‘actually it’s creative it did not exist before thus by definition it’s creative I believe maybe there are games that existed and that entailed ideas like this but from what I know not like we do, I don’t know any actually’

The designer referred to the domain of video games to confront the design solution to the ones already existing in the domain of video games in order to qualify the solution as creative. This novelty based on the market was reported by the designers for different objects. We provided an example of a solution above. The designers used novelty based on the market also for concepts that they encountered during the global design process:

> « *c’est le concept des shorts et des longs qu’on a plus ou moins inventé enfin inventé on a décidé de construire le jeu comme ça on l’a pas trouvé dans d’autre jeu* » ‘it’s the concept of short and long that we more or less invented well invented, we decided to construct the game like that, it’s something we did not find elsewhere’

In the fifteen occurrences of the novelty/novelty based on the market identified, five were reported by O and ten by M. M is the person in charge of the design solutions implementation, a domain where reuses of design solutions is possible. Thus, we could suggest that M referred more often to this characteristic as he could reuse what has been done in terms of code for solutions implementation.

3.1.2 Appropriateness

Designers reported the appropriateness characteristic in their verbatim. We considered that a designer referred to the appropriateness characteristic when he confronted a solution with the problem it is paired to and it is supposed to solve. In that respect, the designers highlighted a solution or element/s of a solution that is appropriated to the whole or part/s of a design problem. It can be illustrated by the following comment:

« *on agit sur tels éléments de la musique on utilise tels éléments de la musique dans le gameplay et voilà c'était parce qu'on va dans cette zone là qu'on était là l'idée original c'est l'idée fondamentale du jeu et d'agir sur ces elements là de gameplay* » 'we act on elements of the music we use elements of the music in the gameplay and it's because we go toward this zone that we do that, the original idea is the fundamental idea of the game and to act on these gameplay's elements'

In this example, the designer mentioned that the gameplay elements that they integrated and used in the video game were directly linked and appropriated to the fundamental idea. In other words, they were appropriated and suit the aim of the musical video game that is to say to design a *païdian* video game with sensorial experience. The appropriateness characteristic was also applied to problems:

« *si tu considère qu' il y a des jeux qui posent ce genre de question, mais la question tu donnes tout au début ou progressivement, mais appliqué à notre jeu et le fait que ça soit lié à des instruments là ça l'est* [nouveau] *tu vois* » 'if you consider that there are games that ask this kind of question, but the question whether you give everything at the beginning or progressively, but applied to our game and the fact that it's linked to instruments, this is [new] you see'

In this case, the designer underlined the fact that the problem of giving all the controls to players in the solution 'win a soundtrack at each replay' is not creative, but became creative in the context of the game they wanted to reach and to develop; a game where the controls are linked to soundtracks.

In the four occurrences we found, three were reported by O and one by M. We could suggest that the more frequent references of this characteristic by O might be influenced by his responsibility in the design project; he must insure the achievements of the video game's goals as a project director. The achievements of the goals can entail that designers consider all problems with their constraints, solutions paired with these problems and the inter-relations of solutions. Indeed, appropriateness is a way to look at solutions and to assess if they satisfy the problem with its constraints, criteria and goals that have evolved throughout the design project.

3.1.3 Surprise

The designers described creative solutions by reporting the surprise characteristic. This characteristic can be defined as a feeling of unexpectedness when considering a creative product. For example:

« *une idée créative pour moi c'est une idée qui combine deux éléments de manière inattendue* » 'a creative idea in my opinion is an idea that combines two elements in an unexpected way'

From that, we could highlight the fact that the unexpected characteristic might not only apply to products/solutions' characteristics. Surprise may also arise from the result of a design process. In this case, the unexpected characteristic was pointed out in reaction to a combination process. We believe that surprise can arise from an evolutive view of a solution that is to say from how a solution can evolve through design processes and results in a creative one. This product characteristic was reported only once by the designer O.

3.1.4 Ownership

Last, a product characteristic not retrieved in the creativity literature was identified from the designers' verbatim. Designers reported a characteristic of ownership. This characteristic should be regarded as a relation between the designers and their created design ideas. We considered this relation as a kind of authorship or collective authorship with design ideas. This characteristic was found to be reported for different elements such as solutions, concepts or problems. For example, a designer commented the solution 'Short loop pattern' as follows:

> « *ça c'est nouveau c'est propre à nous* » 'this is new, it is our own'

A designer also reported the ownership characteristic to comment two concepts namely 'shorts and longs':

> « *Alors le truc c'est que short et long c'est vraiment une sémantique à nous donc de fait c'est un truc qu'on a inventé pour nous donc c'est obligatoirement très nouveau dans ce sens là* » 'well the thing is that short and long are really our semantics therefore it's a thing that we invented for us thus it's inevitably really new in this sense'

A designer used this characteristic to comment on the solution '*x pressed buttons*' by underlying the problem to which this solution is paired:

> « *C'est complètement un problème à nous* » that's completely our problem'

We believe that ownership is a way to characterize creative solutions by emphasizing the designers' relation to a product that can arise as an emotion of authorship.

In the five occurrences of the ownership characteristics, four were mentioned by O and one by M. We could assume that the authorship of the video game is a relation which is more predominant for the designer O; the idea of the designed video game was proposed by O and O is the one that makes decision over design solutions as he is the project director. Thus, we believe that he could perceive the design problems and solutions with a relation of ownership as he is the main bearer of this global design process.

3.2 Creative design processes characteristics: combination, addition, composition and deepening

From the designers' verbatim, we identified four design processes that were used to describe creative solutions. These design processes are combination, addition, composition and deepening. We will stress each design process characteristic and provide examples from the designers' verbatim.

3.2.1. Combination

We identified the design process of combination in the designers' verbatim. It consists in associating two or more separate design ideas together to form a new entity. This design process characteristic can be illustrated by the following verbatim:

> « *appuyer sur un bouton et avoir un effet visuel c'est pas nouveau mais le fait d'associer un son qui produit telle image et dans un contexte voilà là c'est nouveau*» 'pressing a button and having a visual effect is not new but associating a sound which produces a specific image and that in a context, this is new'

In this example, the designer explained that the solution 'interaction-sound-image' was a solution composed of the concept interaction with the game that will activate sounds which are combined with visual feedbacks. A designer also reported information about elements to be merged:

> « *ça peut être n'importe quoi ça peut être à la fois un élément technique, un élément conceptuel, un élément graphique, un son, ça peut être n'importe quoi, c'est juste agencer deux choses ou deux idées tu vois des idées préexistantes et juste tu vas faire une association à laquelle les gens n'avaient pas pensées avant et ça va devenir quelque chose de nouveau* » 'it can be anything it can be a technical, conceptual or graphical element, a sound, it can be anything, it's just merging two things or ideas you see existing ideas and you will do an association that people did not think about before and it will become something new'

In this verbatim, the elements to be merged are mentioned to be potentially from different nature that is to say technical, conceptual, etc. and could differ in their affiliation to a specific domain that is to say music, graphic art, etc. In that respect, we found that the designers were associating not only solutions together but also concepts, technical features or experiences. For example, designers commented the solution 'tempo reward' that combines two gameplay, *i.e.* experiences:

> « *alors que nous ce qui est original c'est d'intégrer différent gameplay pour plaire à différents joueurs*» 'yet what is original for us is to integrate different gameplay that could suit different players'

In this comment, the combined elements are two types of gameplay, *i.e*. a *ludus* and *païdian* ones. An example that illustrates the combination of two elements of different nature is the following:

> « *c'est l'idée des shorts et des longs et se servir des boutons analogiques pour faire apparaître large* » 'it's the idea of short and longs and using the analogic buttons to make appear large'

This example illustrates a combination of a concept with a technical element. The designer underlined a combination of the concepts 'shorts and longs' that corresponds to the musical composition that is merged with a technical element 'analogical buttons' that is provided by the use of the *Playstation 3* joystick and not by the previous joystick they used.

We highlighted that combination is the result of the association of different elements ranging from basic solutions to more abstract elements, *e.g.* experience as gameplay. We also found that designers reported combination processes applied on problems. This is illustrated in the following comment describing a solution:

> « *Bah oui et non oui dans le sens où c'est une problématique de savoir si tu donnes toutes les méthodes d'action, tous les verbes dès le début c'est une problématique classique de conception de jeu, mais euh mais qui prends une autre couleur parce que tu l'associes à des sons* » 'yes and no in the sense of it's a problem to know if you give all the action methods, all the verbs at the beginning, it's a classical problem of game design, but it takes another color because it's associated with sounds'

The designer highlighted one problem which is related to either give all the interactional possibilities to the players from the beginning or give them progressively. He pointed out that this problem became new when it was associated with one of the three concepts of the video game 'the musical composition'.

Both designers mentioned in equal proportion this design process characteristic.

3.2.2. Addition

Another design process characteristic we found to be involved in the description of creative solutions is the addition. We considered that designers refer to this design process when a new element is brought into the design process. For example, a designer made use of this design process in a metaphorical manner to describe the whole design process of the video game:

> « *c'est pas parce que tu as trois gros piliers que ça fait un beau temple, ça fait un beau temple avec des frises, t'as des bas relief et c'est tout ça accumulé qui fait que tu as un beau temple* » 'it's not because you have three big pillars that it will make a beautiful temple, it makes a beautiful temple with friezes, you got low relief and it's all that acumulated that make a beautiful temple'

> « *il y a plein de petites choses qui mis à bout finissent par faire un truc original* » 'there are a lot of little things that all together end up to do an original thing'

In these comments, we believe that the designer emphasized that it is not the fundamental concepts that help to create a creative product, but all the details that are added to the fundamental concept throughout the global design process.

Two occurrences of this design process characteristic were identified. It is only the designer O that reported the design process of addition. In his comments, O underlined an evolutive perspective involving addition of various elements throughout the whole design process. The global view of the whole design processes may be held by the project director. This could explain the report of this design process characteristic by O as the project director.

3.2.3. Composition

We found the design process of composition in the verbatim of the designers. We referred to composition process when designers mentioned a specific location for a design idea and then changed this design idea to another location. We mentioned that in a video game, design ideas' location can be in the scenery or in an experiential space. An example of composition is reported for the solution 'tempo reward':

> *« l'avatar c'est rien de nouveau, faire une barre de point c'est pas nouveau, mais lier l'un à l'autre, cacher la barre dans l'avatar ça c'est nouveau»* 'a character, it's not new, put a score scale, it's not new, but to link one to the other, to hide the scale into your character, it's new'

The composition process underlined by the designer consists in the integration of an idea 'tempo reward' that is typically implemented in a score scale. In his comment, the designer underlined that they shifted the 'tempo reward' from the score scale to another location that is hidden in a character.

This design process characteristic was reported in equal proportion by both designers.

3.2.4. Deepening

The last but not the least, our results brought up a new design process characteristic not retrieved in the creativity literature. We termed it deepening. We define this design process as the act of taking an existing design idea with the distinctive characteristic of pushing it further to what others have done. Thus, it involves a work to deepen, to take to a higher level of details an idea. For example, a designer stated:

> « *L'idée de matcher le triangle d'interaction-son-image c'est pas nouveau il y a d'autres gens qui l'ont fait avant, ce qui est nouveau c'est le niveau auquel on est aller le porter on est à un niveau au dessus, plus pointu de ce qui a été déjà fait* » 'the idea of matching the triangle interaction-sound-image, it's not new there are other people that did it before, what is new is the level at which we carried it out, we pushed it at a higher, more fine-grained level to what has been already done'

This underlines the fact that the designers enhanced and pushed the concept 'interaction-sound-image' to its further limits. This enhancement is emphasized by the following verbatim in other comments related to the deepening process:

> « *on allait encore au dessus de ça* » 'we went even above that'

> « *on allait un cran au dessus* » 'we went up a notch'

These parts of comments highlight the fact that the designers pushed concepts toward their further limits. Furthermore, a designer explained why they applied this design process to the main problem of the video game designed 'designing a game with interaction-sound-image', *i.e.* to provoke creativity:

> « *mais il y a des jeux qui cherchaient l'interaction qui a une correspondance image son maintenant c'est que nous on voulait creuser dans cette veine là et aller plus loin que les autres avaient fait chercher à provoquer de la nouveauté dans cette direction* » 'but there are game that seek interaction with a correspondance to image-sound, yet it's that we wanted to go toward this direction and go further than the others, seek to provoke novelty in this direction'

We found four occurrences of this design process characteristic; three were reported by the designer O and one by the designer M. The solution that was deepened in the video game was proposed by the designer O. This could explain the fact that O reported more often the deepening process.

4. Conclusion

In conclusion, designers evaluated the solutions creativity with the novelty and feasibility dimensions. They judged approximately a fifth of the solutions as creative through the Likert scale ratings in the questionnaire and the ‘free’ condition. The inter-rater agreement on the Likert scale ratings was significantly homogeneous in both direction and strength. However, the designers had only a fair inter-rater agreement when considering creative solutions in the ‘free’ condition.

During their interview and evaluation of solutions creativity in the questionnaire, designers reported different products/solutions characteristics to describe or justify creative ideas, namely novelty, appropriateness, surprise and ownership. Moreover, they reported design processes characteristics, such as combination, addition, composition and deepening. These characteristics were sometimes reported more often by one of the designers. This could be explained by the reference frame the designers used to comment the creative solutions. We suggested that the reference frame might be linked to the responsibilities of the designers in the design project.

4.1 Creative solutions characteristics: novelty, appropriateness, surprise and ownership

The verbatim of the designers underlined several characteristics of creative solutions. Our results underlined the characteristic of novelty. We defined this characteristic as ideas that do not already exist. The uses of this characteristic highlight the fact that creative solutions can be qualified as novel by their underlying design components such as the solution itself, their concepts or their related problems. This solution characteristic is consistent with the novelty dimension that is included in most of the definitions of creative solution/product (Maher, 2010).

Novel work is defined as original, not predicted and distinct from previous work (Sternberg and Lubart, 1999). Our findings stressed that creative solutions can be considered novel on the basis of ‘previous work’ that can include several domains, but also on the basis of the domain in which the solution lies; novelty based on the market. This latter is defined as design ideas that are not already seen or used in a specific domain; in this case it would be the video game domain. This definition has a subtle difference from the definition of novelty; it is narrowed down to a particular domain in contrast to the novelty definition that can include the previous work of other domains. This precision comes from the verbatim of designers who referred, for some creative solutions, to the specific domain of video games instead of taking into account all possible domains. Henceforth, our results highlighted the novelty based on previous work in different domains suggested by (Sternberg and Lubart, 1999), but also they are aligned with the definition of Maher (2010) that defines novelty on the basis of the same conceptual space, *i.e.* novelty based on the market.

Our results also underlined the appropriateness characteristic of creative solutions. We defined, in the state of the art, creative product as both novel and appropriated (Boden, 2004; Bonnardel, 2006; Gero, 2010; Goldschmidt, 2010; Kristensson et al., 2004; Sternberg and Lubart, 1996 cited par Sternberg and Lubart, 1999; Warr and O'Neill, 2005). These two characteristics considered as dimensions of creative products in the literature are both highlighted by our results. Thus, we could suggest that the designers' reports of the novelty and appropriateness characteristics are consistent with the definition of creative product in the creativity literature.

Furthermore, we also stressed the characteristic of surprise as a feeling of unexpectedness when facing a creative product. This characteristic also applies to design process that can lead to a creative solution and can trigger a surprise. In the definition of Sternberg and Lubart (1999), this surprise characteristic is also emphasized when they characterize novel work as 'not predicted'. It is also used by Boden (2004), Gero (2010), Maher (2010) and Wiggins (2006) to described creative solutions.

Our results highlighted a new characteristic reported by the designers to describe creative solutions that is not retrieved in the creativity literature. We termed it ownership. This characteristic refers to a design idea that has been created by the designers and that the designers think has not been created before in their domain. We regarded it as a relation of authorship between the designers and their design ideas.

Boden (2004) claims that some characteristics can be considered as kind of novelty. We believe that novelty based on the market, surprise and ownership could be considered as kinds of novelty; they provide further information on how solutions could be considered novel. Furthermore, Wiggins (2006) suggests that some characteristics, *e.g.* surprise and value, can be a property of the receiver as an emotion generated by a product. We could assume that the characteristics of surprise and ownership might be of this nature; solutions seem to trigger emotions of unexpectedness and of authorship.

4.2 Design processes characteristics: combination, addition, composition and deepening

We underlined that the designers reported design processes to describe creative solutions. These design processes are combination, addition, composition and deepening.

One of the design processes we found in the designers' verbatim is combination, *i.e.* the association of two or more separate design ideas to form a new entity. We could stress that our results concur to the knowledge already shared in the creativity community; Bonnardel and Marmèche (2005b), Cross (1997), Gero (2010), Jaarsveld and van Leeuwen (2005), Verstijnen, Heylighen, Wagemans and Neuckermans (2001) and Ward et al. (1999) amongst others considered that combination leads to creative outcomes. This is consistent with the results we described above; the designers used the combination process in order to describe creative solutions.

Moreover, the mentioned verbatim underlined the fact that elements to be merged can range from different domains. Accordingly, a designer underlined that combination could be done with elements that come from different nature. This can be related to what has been highlighted in the literature on combination; combinations of discrepant and even opposing elements hold the most potential for creativity (Ward, 2007; Ward et al., 1999).

We also underlined the design process of addition in the comments of the designers to describe creative solutions, *i.e.* new elements are brought into the design process. This design process mentioned in comments is consistent with what has been suggested in the literature on the creative design processes; the addition of new elements can lead to creative outcomes (Jaarsveld and van Leeuwen, 2005). This design process is considered as a manifestation of divergent thinking which is important in creativity (Jaarsveld and van Leeuwen, 2005).

Our results also underlined the composition process, *i.e.* the shift of the location of an object to another one. This result is consistent with a study of Jaarsveld and van Leeuwen (2005). These authors considered composition as a creative design process.

Lastly, our analysis stressed an original design process not found in the creative design literature that is deepening. We described this design process as the act of taking a design idea with the distinctive characteristic of pushing it further than what others have already done; it is taking an idea to a more thorough level of details.

In sum, we have shed light on products/solutions and design processes characteristics reported by designers to describe creative solutions. Some are already developed in the creative design literature and some spurred from our results, such as ownership and deepening. From these results, we could say that creative solutions can be defined on the basis of what has not yet been done generally and in a specific domain - novelty and novelty based on the market respectively - that are suited for a particular problem – appropriateness -, and with which some emotions can arise - surprise and ownership -. Additionally, designers can retro-actively acknowledge what has been done cognitively to create the creative solution - design processes -.

It is worth noting that the designers did not mention any analogical reasoning process in their verbatim although, they did so when they were asked to write the solutions' source/s of inspiration. Furthermore, a minority of the solutions were commented by including users even though some users helped to produce some of these solutions and that finally creative solutions will be evaluated by them.

For the next chapter, we will consider creative solutions on the basis of the Likert scale ratings; these evaluations had good inter-rater agreement unlike the selection in the 'free' condition that only resulted in a fair inter-rater agreement between the two designers of the core team.

Summary

This chapter invests the first-person viewpoint, *i.e.* the viewpoint of designers on the creativity of solutions. Our aim in this chapter consists in the identification and characterization of creative solutions. On the one hand, for the identification, designers of the core team completed a questionnaire that aimed to evaluate solutions creativity with the novelty and feasibility dimensions through five points Likert scales. With the ratings of the Likert scale, we identified through a quantitative analysis creative solutions. Additionally, creative solutions were identified from a ‘free’ condition where designers selected solutions based on the two creativity dimensions together. On the other hand, to characterize creative solutions, we proceed to a thematic analysis on the verbatim of the designers for the creative solutions. The designers’ verbatim were collected during semi-directive interviews and questionnaires.

For the identified creative solutions, the designers described them with products/solutions and design processes characteristics. These characteristics were sometimes reported more often by one of the designers. This could be explained by the reference frames the designers used to comment the creative solutions. We suggested that the reference frames might be linked to the responsibilities of the designers, *e.g.* project director, coder, etc., in the design project.

Regarding the products/solutions characteristics, we found in the designers’ verbatim novelty, surprise, appropriated and ownership. The characteristics novelty/novelty based on the market, surprise and appropriateness are all found in the creative design literature as characteristics of creative solutions. Conversely, the ownership is a characteristic that we highlighted from the designers’ verbatim that is not found in the creative design literature.

In addition, the creative solutions were also described in terms of design processes. Our analysis highlighted design processes such as combination, addition, composition and deepening. The three first ones are retrieved in the creative design literature as leading to creative outcomes. However, the deepening design processes was emphasized in the designers’ verbatim and we believed that it is not developed in the creative design literature.

We believe that the new characteristics that were highlighted in our analysis might have not appeared in our results with an evaluation made by independent judges; ownership is a specific relation of authorship between the designers and their ideas and deepening would have required the independent judges to know the ideas that were deepened. These characteristics of creative solutions might have appeared in our results due to the fact that it was an evaluation of the creativity in a first-person viewpoint, *i.e.* by the designers themselves.

Chapter 10 Specific collaboration formats and socio-cognitive design processes in the generation of creative solutions?

This chapter depicts the crossing of the processes and the products, *i.e.* third-person and the first-person viewpoints respectively. Our goal is to seek whether, if any, specific collaboration formats and socio-cognitive design processes are involved in the generation of creative solutions compared to non-creative solutions as evaluated by the designers themselves. This will highlight the collaboration formats and socio-cognitive design processes that lead to the generation of creative solutions. We assume that specific forms of interaction could lead to creative outcomes as well as specific design processes.

1. Identifying collaboration formats and socio-cognitive design processes in the generation of creative solutions: quantitative analysis

According to the third-person viewpoint, we highlighted three collaboration formats and five socio-cognitive design processes. From to the first-person viewpoint, we distinguished creative solutions from the non-creative ones with Likert scale ratings[11]. On these bases, we performed quantitative analyses to shed light on the collaboration formats and socio-cognitive in the generation of creative solutions in our excerpt corpus. The quantitative analyses consist in relative deviations. This analysis was performed on variables such as collaboration formats and their components, socio-cognitive design processes and their components, and degrees of creativity of solutions. The degrees of creativity of solutions are defined in function of the solution's score, *i.e.* Novelty(O+M)+Feasibility(O+M), as:

- High with a score above the third quartile (>17) with a total of eight solutions;
- Middle with a score between the first and third quartiles ($14< x \leq 17$) with a total of seventeen solutions;
- Low with a score equal or below the first quartile (≤14) with a total of eleven solutions.

This type of analysis enables us to characterize the strength of association between variables at a global level with the Cramer's V^2 and at a local level with relative deviations[12]. These quantitative analyses will enable us to answer our main research question that is 'Are there specific collaboration formats and design processes involved in high degree of solutions creativity compared to lower degrees?' At a secondary level, it will allow us to stress components of collaboration formats and of design processes also involved in high degree of solutions creativity.

[11] As the selected solutions in the 'free' condition had a poor inter-rater agreement, we take into account only the solutions that were identified to be creative from the Likert scale ratings that had a good correlation coefficient (cf. chapter 9, section 2).

[12] At the global level, the strength of association is considered low for $0<V^2<0{,}04$; intermediate for $0{,}04<V^2<0{,}16$ and strong for $V^2>0{,}16$. At the local level, the conventional value 0,20 is used to consider an attration or repulsion. The attraction refers to the positive value (+0,20) and repulsion refers to the negative value (-0,20).

We will first shed light on the collaboration formats that are involved in each degree of creativity. Then, we will focus on the design processes that were found in all degrees of creativity. After, we will develop on the design processes highlighted by the designers, *i.e.* the first-person viewpoint, and the analyst, *i.e.* the third-person viewpoint. Lastly, we will underline associations between collaboration formats and socio-cognitive design processes.

2. Collaboration formats and creativity

In this section, we will first introduce quantitative analyses on the variables degrees of creativity and collaboration formats. Then, we will develop further the relational formats that were found to be associated with high degree of creativity.

2.1 Quantitative results

We highlighted three collaboration formats: directive, relational and representational (see chapter 7). With these, we performed a relative deviations analysis in order to point to the collaboration formats involved in each degree of creativity, *i.e.* high, middle or low (annex 15; table 83). The aim is to highlight collaboration formats in function of degrees of creativity and more specifically the one involved in high degree of creativity. The following table depicts the quantitative analysis's results (table 71).

Degree of creativity	*Directive format*	*Relational format*	*Representational format*
High	-1,01	**+0,46**	+**0,24**
Middle	**+0,87**	+0,05	-0,55
Low	**+0,45**	-0,57	+0,18

Table 71. Relative deviations between degrees of creativity and collaboration formats

We found a low association between collaboration formats and degrees of creativity (Cramer's V^2= 0,02). At the local level, relative deviations highlight that the directive formats have an increasing tendency of association as the degree of creativity decreases. In other words, the directive formats tend to be associated to low degree of creativity of solutions. Conversely, the relational formats have an increasing tendency of association as the degree of creativity raises; the relational formats tend to be tied to high degree of creativity. In contrast, the representational formats have a tendency to be involved with high degree of solutions creativity. However, the representational formats do not seem to be indicative and distinctive of higher or lower degrees of creativity; there is no increasing or decreasing association of the representational formats in function of the degrees of creativity.

We are interested in the collaboration formats specific to high degree of creativity. Therefore, we will shed further light on the relational formats that tend to be involved in high degree of creativity.

2.2 Relational formats as related to creativity

The relational formats encompass (1) relations to anterior design ideas and (2) relations to reified solutions. We will develop further the involvement of these two relational formats in the degrees of creativity.

2.2.1 Relations to anterior design ideas specifically generated by players

This relational format involves reported speeches. We will first shed light on the relations to anterior design ideas in function of the degrees of creativity. Then, we will provide further detail on the enunciator of the reported speeches; we will develop whose speech was reported and if it was complemented with information on the persona[13].

First, we quantified for each solution which one encompassed a relation to an anterior design idea. From this, we can highlight that the relations to anterior design ideas format is involved in all degree of creativity (figure 25). We found a strong association between this relational format and the degrees of creativity of solutions (Cramer's V^2= 0,21).

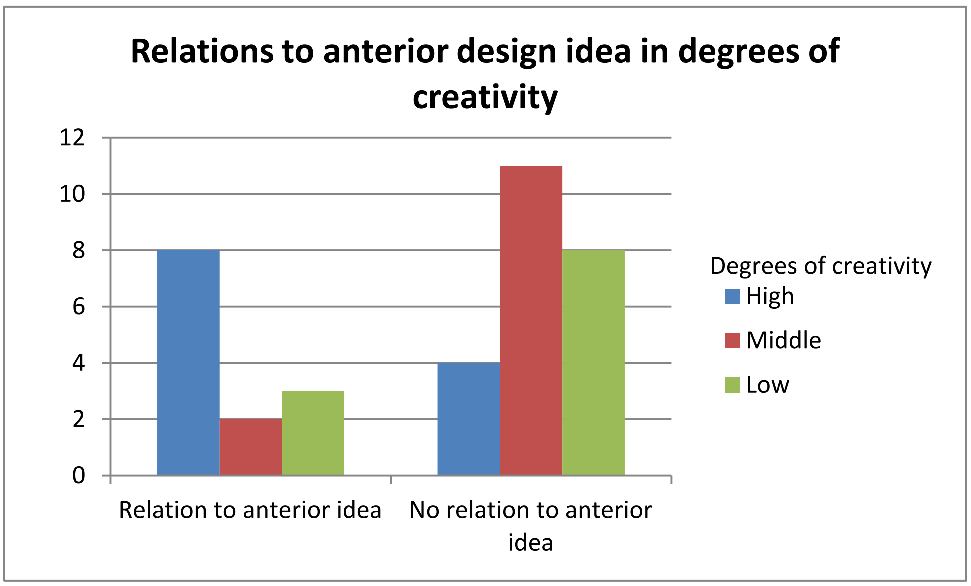


Figure 26. Distribution of relations to anterior design idea in degrees of creativity

The results from the relative deviations enabled us to highlight the involvement or not of this relational format, *i.e.* a reported speech, in function of the degrees of creativity (annex 15; table 84):

- High degree of solutions creativity tends to be associated with relations to anterior design ideas and thus, with reported speech;
- Middle and low degrees of creativity tend to involve no relations to anterior design ideas.

[13] These reported speeches were seen to be complemented by information on the enunciator in the form of persona (*cf.* chapter 7, section 2.2.2)

These anterior design ideas being reported can come from different designer/participant. In that respect, we shed further light on the enunciator of these reported ideas. For that, we categorized the enunciators as (1) designer, *i.e.* participants with an expertise in design and/or designers, (2) player, *i.e.* video game players without an expertise of design or (3) other, *i.e.* participants that are neither designer nor player.

We can underline that designers, players and other participants all generated solutions that have a high and middle degree of creativity (figure 26). However, it is only the reported speech of designers that are encompassed in low degree of creativity.

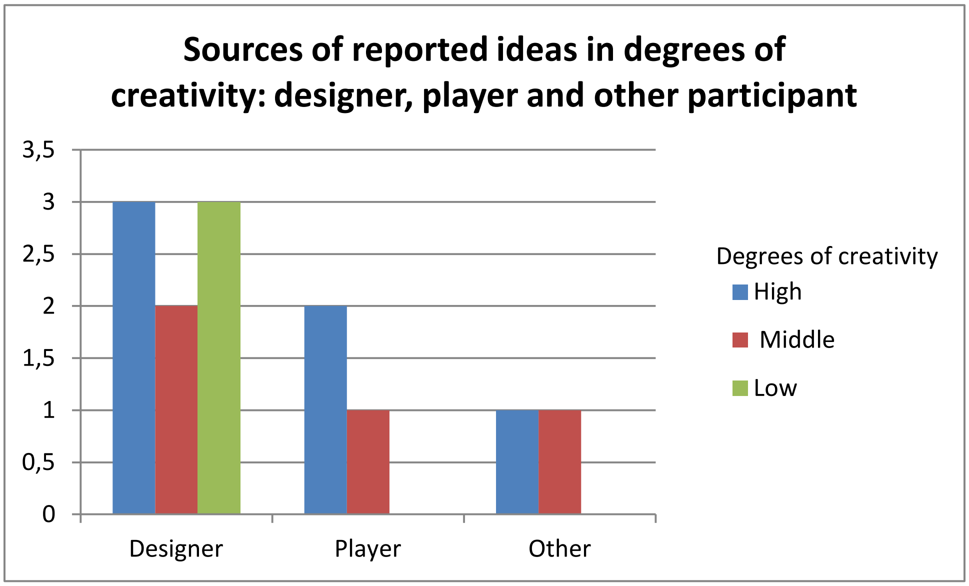


Figure 27. Distribution of enunciators of reported idea in degrees of creativity

At a global level, we found an intermediate association between these participants and the degrees of creativity (Cramer's V^2= 0,10). The local associations highlight that (annex 15; table 85):

- High degree of creativity tends to involve reported speech of players;
- Middle degree of solutions tends to involve relations to solution generated previously by other participants;
- Low degree of creativity tends to be associated with relations to solutions generated previously by designers.

Globally, these reported solutions were coming from participants of different domains such as video games with designers and players, music domain with a scientific community of music and communication domain with a participant from public relations.

We mentioned that the reported speeches were sometimes associated with complementary information on the enunciator in the form of persona (chapter 7, section 2.2.2). We will now highlight this complementary information of persona in function of the degrees of creativity (figure 27).

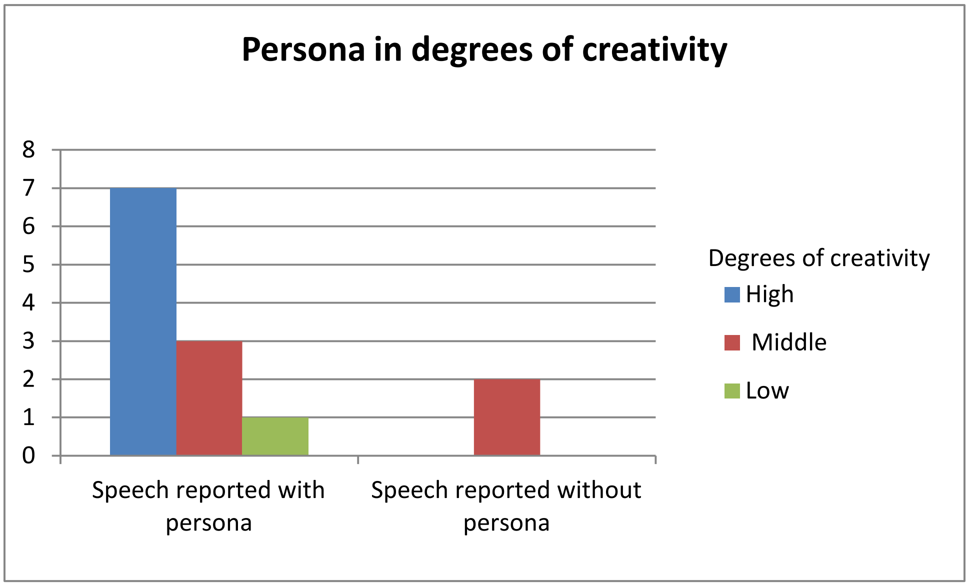


Figure 28. Distribution of information on persona's enunciator in degrees of creativity

We can highlight that all degrees of creativity encompass speeches reported with a persona. On the other hand, it is only the middle degree of creativity that encompasses speeches reported without complementing it by a persona. We found a strong global association between persona in reported speeches and degrees of creativity (Cramer's V^2= 0,29). Locally, the relative deviations highlight that (annex 15; table 86):

- High degree of creativity tends to be tied to speech reported with the enunciator's persona;
- Middle degree of creativity tends to involve speech reported without the enunciator's persona.

The reported personas were both targeted ones, *e.g.* musicians and gamers of musical video games, and non-targeted ones, *e.g.* hardcore gamers and gamers without knowledge of music

2.2.2 Relations to intra-domain reified solutions

The relational formats include relations to reified solutions. We will shed further light on this format. In that vein, we will highlight the involvement of this format in each degree of creativity of solutions and the nature of reified solutions.

We can highlight that the relations to reified solutions format is involved in all degree of creativity (figure 28). We found a global association between this relational format and the degree of creativity that is strong (Cramer's V^2= 0,19).

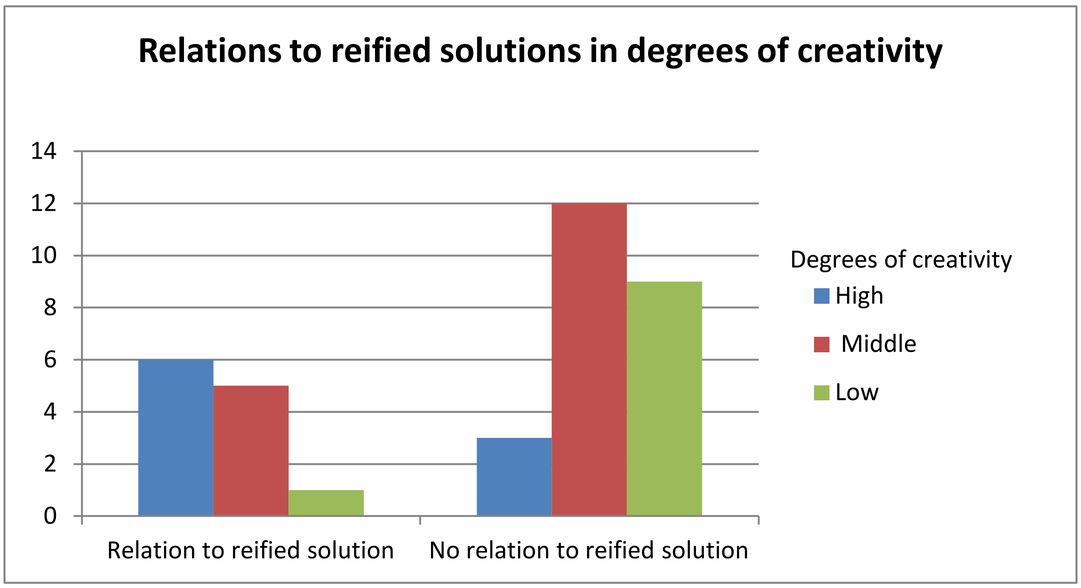


Figure 29. Distribution of the relations to reified solutions in degrees of creativity

At the local level, the relative deviations stress that (annex 15; table 87):

- High degree of solutions creativity tends to involve relations to reified solution/s;
- Middle and low degrees of creativity tend to encompass solutions generated without relations to reified solution.

We categorized reified solutions as intra-domain, *i.e.* for solution in the prototype and in the video game domain, and as inter-domain, *i.e.* for other domains than video games (*cf.* chapter 7, section 3.2). With these categories, we shed light on the types of the reified solutions involved in the degrees of creativity.

The following figure depicts the intra-domain and inter-domain reified solutions in the degrees of creativity of solutions (figure 29). We can stress that intra-domain reified solutions are involved in high and middle degrees of creativity. Contrastingly, inter-domain reified solutions are not retrieved in high degree of creativity. At a global level, we found a strong association between reified solutions and degrees of creativity (Cramer's V^2= 0,47).

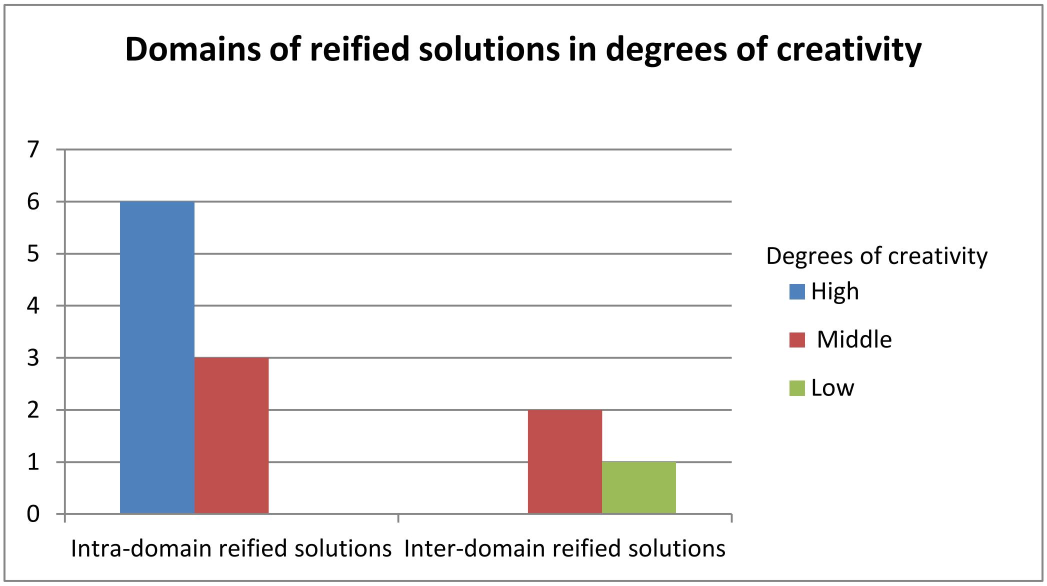


Figure 30. Distribution of reified solution's domain in degrees of creativity

The results of the relative deviations underline that (annex 15; table 88):

- High degree of creativity tends to encompass relations to intra-domain reified solutions;
- Middle and low degrees of creativity tend to contain relations to inter-domain reified solutions.

The reified solutions came from solutions implemented in the prototype and other video games for the intra-domain, and from art and movies for the inter-domain.

3. Design processes and creativity

In this section, we will first highlight design processes that tend to be involved in degrees of creativity. Then, we will shed further light on the analogical reasoning process that tends to be involved in high degree of creativity.

3.1 Quantitative results

We identified five socio-cognitive design processes in a previous chapter, namely problem framing, co-evolution of problem-solution, combination, analogical reasoning and composition (chapters 8). With these, we performed a relation deviations analysis (annex 16; table 89). Our aim is to stress design processes in function of degrees of creativity (table 72).

Degrees of creativity	*Problem framing*	*Co-evolution problem-solution*	*Analogical reasoning*	*Combination*	*Composition*
High	-0,73	-0,78	**+1,58**	-0,73	**+0,64**
Middle	+0,02	**+0,21**	-0,36	**+1,03**	-0,99
Low	**+0,73**	**+0,51**	-1,13	-0,70	**+0,73**

Table 72. Relative deviations between design processes and degrees of creativity

At a global level, there is an intermediate association between design processes and degrees of creativity (Cramer's V^2= 0,10). Locally, relative deviations highlight that:

- Analogical reasoning's association with degree of creativity tends to increase as creativity increases that is to say analogical reasoning tends to be associated with high degree of creativity;
- Composition tends to be associated with high and low degrees of creativity;
- Combination tends to be tied to middle degree of creativity;
- Co-evolution of problem-solution's association with degree of creativity tends to decline as the degree of creativity increases thus, this design process tends to be associated to middle and low degrees of creativity;
- Problem framing's association with degree of creativity tends to decrease as the degree of creativity increases, in other words problem framing tends to be associated with low degree of creativity.

We will develop in more detail the analogical reasoning process in the next section as it is the only design process that tends distinctively to be involved in high degree of creativity. We will not develop the composition process as it is also associated to low degree of creativity and thus, it cannot be considered as indicative of high level of creativity.

3.2 Analogical reasoning as related to creativity

Analogical reasoning process can be performed with intra-domain or inter-domain sources. It is worth to note that we found all analogical reasoning processes within the relations to reified solutions involved in the relational formats. We found the same results (*cf*. section 2.2.2 for the results and annex 16, table 90).

We conducted a relative deviations analysis between the variables of design processes and collaboration formats. We found that the analogical reasoning process tends to be associated with the relational formats (annex 17). Indeed, the relational formats encompass relations to reified solutions.

4. Conclusion

Our main research goal is to seek what are the specific collaboration formats and design processes involved in high degree of creativity compared to lower degrees. The results depicted in this chapter underlined that the relational formats and the analogical reasoning process have a tendency of association with high degree of creativity. We will discuss further the collaboration formats and the design processes with an emphasis on the ones related to creativity.

In this section, we will discuss briefly the collaboration formats first that are not related to creativity and then, we will develop further the one related to creativity. For the design processes, we will use the same structure.

4.1 Collaboration formats not related to creativity: directive and representational formats

Our results highlighted that directive and representational formats do not tend to be tied to high degree of creativity. In this section, we will develop these two collaboration formats.

We defined the directive formats as design activities serving to trigger the evolution and definition of the design process. We highlighted that the directive formats entail different functions such as divergence, *i.e.* eliciting generation of alternative solution, and convergence, *i.e.* trigerring problem framing and agreement crystallization. We stressed that the involvement of the directive formats decreases as degree of solution's creativity increases. This result seems to underline a discrepancy with the creative design literature; divergent and convergent thinking lead to creative outcomes (Cropley, 1999a; Fasko, 1999; Runco, 1999; Runco, 2010).

We underlined that the directive format entails encouragement to contribute to the framing of a problem. This problem framing process is considered to foster creativity (Christiaans, 1992; Dorst and Cross, 2001; Edmonds and Candy, 1993; Runco, 2004). The directive format includes an encouragement to contribute solution alternatives as well. This enhancement of solution generations is considered to increase the creativity performance (Nemeth and Nemeth-Brown, 2003). These two functions of convergence and divergence were found in the directive formats. However, in our analyses, the directive formats seemed to be inversely related to creativity.

Our discrepant result could lie on the extent of creativity considered; is the sources or processes creative or is it only solutions? In the method we used, we only considered the creative solutions, but not the sources nor the processes. This might explain this result that does not concur to a long-term consensus on the involvement of divergent and convergent thinking in creativity.

Regarding the representational formats, we found no increasing associations of these formats in function of degrees of creativity. This could be interpreted with the definition of design we adopted in this dissertation; design is a construction of representations (Visser, 2006a; Visser, 2006b). In that vein, the representational formats can be found throughout a global design process; the representational formats may be more related to the design rather than creativity.

4.2 Collaboration format related to creativity: relational formats

We defined the relational formats as construction of relations between a design idea under discussion with another one - reified or not- within or outside the design project to apprehend the design idea under discussion through another design idea. The relational formats were stressed as distinctly indicative of high degree of creativity for both relations to anterior design ideas and to reified solutions. We will discuss these two separately.

Relations to anterior design ideas

Our results stressed that relations to anterior design ideas tend to be involved in high degree of creativity. These anterior design ideas were generated by participants during participatory design or during debriefings of play-tests. This suggests a particular importance of the participatory and iterative design for creativity.

The reported ideas were coming from surrounding workers and external participants of various kinds such as designers from different domain areas, different kinds of players and individuals that are not from the two former populations, *e.g.* historian, art director, members of family and so on. Diversity of the composition of design group is known to foster creativity (Milliken et al., 2003; Nijstad et al., 2003; Paulus and Brown, 2003). Thus, we could suggest that this relational format related to creativity concurs to and highlights the benefice of diversity for creativity.

Furthermore, the relations to anterior design ideas format brought up new problems, solutions and constraints generated by participants. We mentioned that Jeffries (2011) qualifies a designer who reports ideas/speeches as a translator and a spokesperson between the space of the users and the design team, *i.e.* a facilitator role. This author mentions that this role of facilitator is important for creativity. Our results provide empirical data that supports this statement by stressing relations to anterior design ideas in high degree of creativity. Jeffries (2011) argues that a facilitator creates opportunities to maintain a high level of creativity in the design process and allows the deporting of a part of creativity on the players themselves. However, we do not know how this author categorizes and defines ‘players’.

Our findings could deepen the relation between creativity and the role of facilitator; we highlighted that specifically ideas of players were tied to high level of creativity compared to designers’ and other participants’ ideas that were not. This result brings insightful contribution to the composition of the group in order to promote creativity; the contributions of players through their reported ideas are important for creativity.

The reported ideas were complemented in some cases with information on the enunciator's persona. An interesting point related to persona was brought up to light. Diverse individuals were brought as participants in the design process and their persona were not always considered as a target for the object-to-be-designed. Our results highlighted that reporting a participant's idea with her/his respective persona, targeted or not, was associated with high degree of creativity. Thus, participants' ideas of targeted as well as non-targeted population both were involved in high degree of creativity. From this, we could suggest that designers can beneficiate in terms of creativity to include in their design process various personas even though they are not formerly taken into consideration and targeted. We could suppose that this is another way to enhance diversity of a specific population. From this arise a new question; does the non-targeted population promote higher degree of creativity? In the video game literature, it is suggested that the targeted audience should be involved in play-tests sessions (Zimmerman, 2003). This statement would be confirmed or infirmed with this research question.

From this, we could highlight the importance of the reports of ideas generated by the extended design group; various participants and more precisely various players can contribute to generate a pool of divergent ideas. From this pool, the design team can select the solutions that they consider worth to be further elaborated and implemented in the prototype. In that regard, it spreads the range of the design team; it is not only the design team that brings ideas to the design project, but also other participants, which can lead to high degree of creativity. Consequently, several design orientations brought by the extended design group can be explored and examined.

Relations to reified solutions

Our results stressed that relations to reified solutions tend to be associated to high degree of creativity. The reified solutions were coming from the same domain, *e.g.* video games and functions/elements from the designed video game itself, and from other domains, *e.g.* art and movies. This suggests a particular importance of relating existing materials with discussed ideas for creativity.

Our results also stressed that high degree of creativity tends to be associated with relations to intra-domain reified solutions. This result appears to contrast with the design and creativity literature. Indeed, it is claimed that inter-domain sources/solutions are indicative of innovative reasoning and open up the research space for the generation of new design ideas (Ball and Christensen, 2009; Bonnardel, 2000; Bonnardel, 2006; Bonnardel, 2009; Bonnardel and Marmèche, 2005a; Bonnardel and Zenasni, 2010).

A variable in studies of analogical reasoning could explain this result. Some studies further define the distance of the sources in inter-domain analogies; some researchers consider inter-domain sources that are 'far' or 'close'. In this dissertation, we did apply this distinction neither for inter-domain nor for intra-domain sources. This second level of category could be taken into account for further analysis to refine our results and might explain our different result. Thus, a question related to the distance of the source and target within the same domain can be raised.

4.3 Design processes not related to creativity: problem framing, co-evolution of problem-solution, combination and composition

Our findings underlined that co-evolution of problem-solution, analogical reasoning and composition were retrieved in generation of creative solutions. These results concur with the creative design literature that considers them as leading to creative outcomes (Ball and Christensen, 2009; Bonnardel, 2006; Bonnardel, 2009; Bonnardel and Marmèche, 2005b; Christensen and Schunn, 2007; Cross, 1997; Dorst and Cross, 2001; Jaarsveld and van Leeuwen, 2005; Visser, 2002). However, these design processes were not associated with high degree of creativity.

We found that problem framing and co-evolution of problem-solution tend to be inversely proportional to creativity. These results contrast the design creativity literature that considers them as leading to creativity (Christiaans, 1992; Dorst and Cross, 2001; Edmonds and Candy, 1993; Runco, 2004). For the former one, we could explain this result by the fact that very few problem framing process were identified in our corpus. For the latter one, it could be explained by our method of coding. Co-evolution of problem-solution was not coded as co-evolution of problem-solution when it spread over two or more excerpts; the co-evolution of problem-solution were considered only within an excerpt. Thus, when solutions were co-elaborated throughout several excerpts, *e.g.* when reported solutions were taken back into subsequent design discussion in other excerpt or meeting, we did not considered it as a co-evolution of problem-solution.

4.4 Design process related to creativity: analogical reasoning

In the five design processes underlined, it is only the analogical reasoning that tends to be associated to and distinctively indicative of high degree of creativity. This design process was developed further to highlight the nature of sources involved in each occurrence. The results of relations to reified solutions format were the same for the analogical reasoning process; intra-domain sources have a tendency to be associated with high degree of creativity. Furthermore, we stressed a tendency of association between the analogical reasoning process and the relational formats, both related to creativity.

Another pending question related to sources of analogical reasoning and reified solutions arises; are dissimilar source-target both taken from a ‘close’ intra-domain lead to creative solutions? We mentioned that combination of dissimilar pairs result in more creative outcomes (Ward et al., 1999). This dissimilarity could have an impact on sources transferred into targets as well. Further analysis such as characterizing the dissimilarity of concepts in sources-targets within a close intra-domain, *e.g.* a source from a *ludus* musical video game transferred into a *païdian* musical video game target, should be conducted. This could be complementary to what we mentioned above that is a further analysis on the ‘close’ or ‘far’ distance of a source-target both within a domain (see section 4.2).

Summary

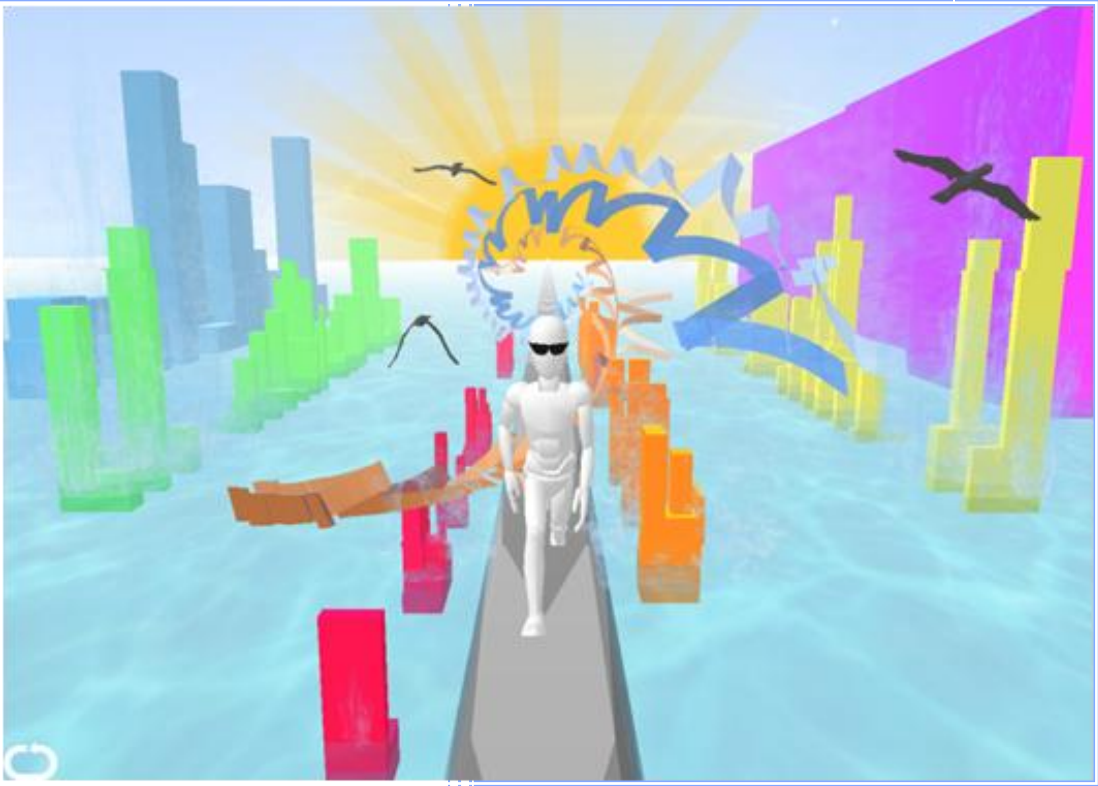
This chapter brings a closure on the crossing of the two analyzed focuses of creativity, *i.e.* the processes and the products. The goal pursued in this chapter resides in the identification of the specific collaboration formats and design processes involved in high degree of creativity. To reach this goal, we crossed the results of the third- and first-person viewpoints that is to say the collaboration formats and design processes with the solutions rated as creative by the designers of the core team.

We found that high degree of creativity tends to involve the relational formats. Moreover, our findings underlined that high degree of creativity involves relations to anterior design ideas. In this relational format, high degree of creativity tends to be tied to anterior design ideas that were generated by players. Furthermore, when reporting participants' ideas, the designers complemented the idea with the enunciator's persona in some occasions. This complementary information tends to be associated with high degree of creativity as well. The other relational format, relations to reified solutions, also tends to be tied with high degree of creativity. It encompasses both intra- and inter-domain reified solutions. We found that intra-domain reified solutions have a tendency to be associated in high degree of creativity. In terms of design processes, our findings underlined a tendency of the analogical reasoning to be involved in high degree of creativity. Like the relations to reified solutions format, we found that intra-domain sources were involved in high degree of creativity in the analogical reasoning process. Lastly, we stressed that the analogical reasoning process has a tendency to be tied with the relational formats.

Our findings stressed the importance of the facilitator role, *i.e.* relating the space of the users with the space of the design team. They also highlighted the importance of reporting divergent ideas generated by diverse participants of an extended design group for the generation of creative solutions and more precisely, the ones of players. In the process, associating members of the extended group with their respective personas seem to play an important role in high degree of creativity; it could help to enhance and underline diversity of specific populations.

From these results, we could answer our main research question; what are the specific collaboration formats and design processes involved in high degree of creativity compared to lower degrees? Our findings underlined both a collaboration format, *i.e.* the relational, and a design process, *i.e.* analogical reasoning, that tend to be specific to high degree of creativity.

PART IV- GENERAL DISCUSSION



Chapter 11 General discussion and research perspectives

This dissertation enabled us to identify and characterize collaborative and design processes involved in the design of a video game and in the generation of creative solutions, *i.e.* high degree of creativity. Furthermore, it allowed us to identify and characterize creative solutions.

In this chapter, we will discuss our main results. We will first focus on the processes and then, on the products. Afterward, we will discuss the results related to the crossing of processes and products. We will end this chapter by stressing the limits of this dissertation and its numerous perspectives.

1. Summary of our approach

Our goal in this dissertation was to shed new light on creativity by studying real designers collaborating in their ecological settings. Our interest was principally focused the collaboration of designers leading to creative outcomes.

In order to reach our research goal, we adopted an original methodology that takes into account two focuses of creativity that are processes and products. These two focuses are then crossed. The processes are studied with corpora of video excerpts and the products with interview and questionnaire conducted with the two designers of the core team.

To study the processes, we adopted a third-person viewpoint, *i.e.* the analyst viewpoint. In this view point, we conducted three levels of analysis encompassing content, interactional and longitudinal approaches. These levels of analysis allowed us to identify and characterize collaboration formats and socio-technical contexts impacting them, socio-cognitive design processes as well as the temporatlity of these collaborative and design processes.

For the products, we conducted quantitative and thematic approaches with a first-person viewpoint, *i.e*. the designers' viewpoint. As a result, we were able to identify creative solutions and characterize them.

Our original methodology ended with the crossing of both processes and products with a quantitative approach. In turn, we were able to point out specific collaborative and design processes involved in the generation of the most creative solutions.

In the following sections, we will summarize our findings highlighted by our original methodology.

2. Contributions our findings

The stakes in this study are to describe and characterize forms of collaboration and design processes in a collaborative design and more precisely in the generation of creative solutions. In this section, we will highlight the contributions of each of our two focuses of creativity, *i.e.* processes and products, and their crossing separately as well as the contributions linked to the game design domain and the adopted research strategy.

2.1 Divergence and convergence with different collaborative and design processes

Regarding the collaborative and design processes, our results highlighted three multi-functional collaboration formats, *i.e.* directive, relational and representational (chapter 7). These brought new insights on how collaborative purposes can be achieved. Moreover, our finding underlined five socio-cognitive design processes, *i.e.* problem framing, co-evolution problem-solution, analogical reasoning, combination and composition (chapter 8). These depicted how collaborative problem solving is unfolding in meetings.

On the one hand, some of these collaborative and design processes were described as bringing divergence in the design process. We stressed results that pointed out one directive format related to divergence, *i.e.* eliciting alternative solution generation. This directive format was underlined to encourage contributions of other designers through uses of delay marks (McDonnell, 2010a; McDonnell, 2010b). In that vein, we highlighted that this directive format brought divergence to the design project as it elicited the enhancement of pools of solutions.

In addition, we stressed another collaboration format related to divergence; the relations to anterior design ideas format highlighted polyphony in interaction (Baker et al., 2009). This relational format stresses reports of divergent ideas generated by various participants, *i.e.* other designers, players and other types of participants, in the design process. It is considered that a diverse group may trigger new ideas from other participants that they would otherwise not have thought of and increase the number of alternative solutions considered (Milliken et al., 2003; Nijstad et al., 2003). In that vein, the polyphonic context can be related to the diversity of the design group; diverse participants contribute to the global design process through their reporting speech. Diversity was also stressed by the various personas that were related to the enunciator's reported idea; targeted and non-targeted personas were associated with reported design ideas. Thus, this relational format emphasized the extent of the research space of the global design process; divergent ideas of various participants are reported and brought up during the discussion of design ideas.

On the other hand, we found a collaboration format and a design process contributing to the convergence in the design project. Indeed, our finding highlighted that the two directive formats triggering problem framing and triggering agreement crystallization, and the design process problem framing were bringing convergence to the global design process. These collaborative and design processes were highlighted to bring convergence on problems and decision making.

We underlined numerous functions for the other collaboration formats. These functions could either be oriented toward divergence or convergence.

2.2 Social dynamic: symmetry and asymmetry in collaborative and design processes

Co-design or collaborative design is defined with certain symmetry in the interactional positions (Burkhardt et al., 2009). We highlighted both collaborative formats and socio-cognitive design processes that have symmetrical as well as asymmetrical components.

On the one hand, our results highlighted that divergence is brought up by all the designers and participants. Indeed, in the directive format involving divergence, *i.e*. eliciting alternative solution generation, all designers and participants were involved in the different positions of the directive format (chapter 7). Thus, we could suggest that all the designers and participants encouraged each others to contribute and generated alternative solutions. This result emphasizes the symmetric character related to divergence.

However, our results stressed that it was particularly the designer O who reported play-testers/participants' idea. This concern a role related to the relational format involving anterior design ideas, *i.e.* the facilitator role (chapter 7). We interpreted this asymmetry with the responsibility of O; he is responsible for play-tests. Thus, O can gather problems, solutions or player's experience of play-testers/participants which bring divergence in the design group.

On the other hand, the directive format trigerring problem framing and triggering agreement crystallization and the relational format involving anterior design ideas were stressed to be impacted by institutional roles and expertise (chapter 7); some positions in the sequence of activities were mainly undertaken by a specific designer that is the project director O.

Some designers have specific institutional roles and expertise. They may hold particular knowledge that is not symmetrically distributed amongst design team. The specific knowledge held by some designers seems to make them more suitable for some design thinking, *i.e.* convergence. This concern the directive formats triggering problem framing and triggering agreement crystallization.

The convergence toward framed problems and crystallized agreements were under the control of the project director. Thus, it highlights an asymmetry of contributions in collaborative design that are related to convergence. This asymmetry could be linked to the responsibility of this designer O; a project director who knows the goals and the expected state of the final prototype.

At least in the directive formats, we could suggest that it is O who controlled and managed the convergence phase, *i.e.* framed problems and decisions making. Contrastingly, we could suggest that all designers and participants contributed to the divergence.

In regard to the design processes, our findings stressed symmetrical contributions of several designers and participants, *i.e.* absent or present. We also found that the designers and participants contributed to the different steps of the socio-cognitive design processes that we underlined. These findings highlight symmetrical contributions of designers and participants in socio-cognitive design processes (chapter 8).

However, the problem framing process and key steps of design processes encompassing reported speech, *i.e.* only O reported ideas of play-testers and performed design processes on these reported speeches, were underlined to encompass asymmetries. These asymmetries could be related to the directive format triggering problem framing and the relational format involving relations to anterior ideas respectively that we characterized as both encompassing asymmetrical contributions (chapter 7).

Thus, our findings highlighted that the project director controlled phases of convergence related problem framing and decision making. This asymmetry is also underlined for the relations between participants/play-testers and the design group; the pooling and sharing of divergent problems, solutions and player's experience generated by potential play-testers/participants. Our findings also stressed that divergence in the directive formats and the building on others' ideas through design processes are undertaken by all designers and participants and thus, are undertaken symmetrically.

2.3 Temporal dynamic in meetings: convergence first then divergence

For the temporality of collaborative and design processes (chapter 8), our results underlined that problem framing and analogical reasoning and the directive and relational formats are both retrieved at the beginning of a meeting and design themes. This highlights a convergence on the problem at the beginning of a meeting. This results stressing a phase of convergence on problems at the beginning of a conceptual meeting differs from the brainstorming technique; in brainstorming, divergence and then convergence are aimed (Nickerson, 1999).

Futhermore, the temporality also stressed the combination process at the end of a meeting. Differently, our results underlined that a clustered sequence of meetings involving play-tests principally promotes the relational formats with the reports of play-testers' ideas in subsequent meetings in the sequence. This latter and the combination process found at the end of a meeting is in line with the basic ideas of brainstorming related to building on and combining ideas of other participants (Maiden et al., 2004; Matthews, 2009; Nijstad et al., 2003).

The empirical contributions related to collaborative and design processes that we brought up in this dissertation can serve to guide practice[14] of designers striving to bolster their creativity. Related to a more applied technique such as brainstorming, our findings could suggest that rules as well as design process should be taken into account. In this technique, rules consist of promoting a large amount of solutions amongst others, *i.e.* critical judgment and logical consideration should be suspended (Matthews, 2009; Nijstad et al., 2003). It could be suggested that first a convergent phase, *i.e.* problem framing, could be beneficial as we found that a conceptual meeting started with several problem framing processes.

[14] Our goal is not to depict a prescriptive model, but only to point to several aspects that seemed to support creativity in the observed design process.

2.4 Player's experience in collaboration formats: relational and representational formats

We mentioned that the player's experience is a core issue in game design. This concept was underlined in two collaboration formats that are the representational and relational formats (chapter 7).

The representational formats encompass alternations of player's and designer's perspectives. Our results highlighted that the designers brought throughout the global design process the player's perspective within the representational formats. We underlined that this player's perspectives covered generic knowledge of players, profiles of players, players' experience or simulations of player's experience. These could be provided by designers from their knowledge on different types of players.

We have also underlined that player's experience was brought in the design process through the report of play-testers/participants' experience with the musical video game prototype. Thus, experiences of different players were shared in the design group through the relational formats involving anterior design ideas. In this case, the several spheres of the player's experience were not provided by the designers' knowleged, but by players themselves.

The players were surrounding workers and external participants, *i.e.* designers from different design domains, different types of players and participants from a different domain of the video game. These various play-testers brought new problems, solutions, constraints and player's experience. Thus, we could suggest that they all contributed to the global design process through their reported speech encompassing a core element of game design that is player's experience.

2.5 Two original characteristics to define creative products: ownership and deepening

This dissertation identified and characterized creative solutions/products in the analyses of products with a first-person viewpoint (chapter 9); the designers of the core team evaluated the creativity of solutions. Moreover, they described creative solutions to justify their evaluation. From that, we underlined two types of creative solutions' characteristics that are products and design processes characteristics.

We stressed several characteristics of creative products such as novelty, appropriate and surprise that are found in the creativity literature. Indeed, these characteristics of creative products can be retrieved in the definition of creativity; creativity is the capacity to produce ideas under an observable form or to realize a production that is both novel, *i.e.* original and unexpected, and adapted to the situation in which it occurs (Bonnardel, 2006; Bonnardel, 2009; Bonnardel and Zenasni, 2010; Sternberg and Lubart, 1996 quoted in Sternberg and Lubart, 1999).

We also underlined that the designers reported design processes to describe creative solutions. These design processes are considered to lead to creative outcomes; combination (Bonnardel and Marmèche, 2005b; Cross, 1997; Gero, 2010; Jaarsveld and van Leeuwen, 2005; Verstijnen, Heylighen, Wagemans and Neuckermans, 2001; Ward et al., 1999), addition and composition (Jaarsveld and van Leeuwen, 2005). Thus, the design processes mentioned by the designers are consistent with the creativity literature.

For both the creative products' and processes' characteristics, we identified two original characteristics of creative solutions. We found that designers described creative solutions with a product/solution characteristic, *i.e.* ownership. This characteristic was defined as a relation of authorship or collective authorship between the designers and their generated design ideas. The designers also used an original characteristic of design process to describe creative solutions, *i.e.* deepening. We defined this design process as the act of taking an existing design idea with the distinctive characteristic of pushing it further to what others have done, deepening it and to take it a higher level of details.

2.6 Relational formats and analogical reasoning process as related to creative products

The crossing of processes and degrees of products creativity emphasized specific collaborative and design processes in high degree of creativity (chapter 10). Indeed, relational formats as well as analogical reasoning were found to have a tendency of association with high degree of creativity. Thus, we considered them as distinctly indicative of creativity. These findings lead to several contributions.

We stressed that solutions related to reified solutions and analogical sources tend to be associated to high degree of creativity. These reified solutions or sources for analogical reasoning processes related to creativity are consistent with the creativity literature; analogical reasoning is considered to lead to creativity (Ball and Christensen, 2009; Bonnardel, 2006; Bonnardel, 2009; Bonnardel and Marmèche, 2005b; Christensen and Schunn, 2007; Cross, 1997; Visser, 2002). However, we evoked that the use of intra-domain reified solutions/analogical sources found in high level of creativity is contrasting with the literature and would need further analysis (see perspectives, section 4.1).

We also stressed that the reports of design ideas generated by external participants were highlighted to trigger high degree of creativity. This finding implies several contributions for creative design.

Reporting ideas from various participants can be considered as important in order to pool ideas and promote creativity by enhancing divergence. These ideas were gathered during participatory design and the steps of test and/or analysis in the iterative design. We could suggest that from our findings, participatory design and iterative design could foster creativity by providing a means to gather divergent ideas from participants and thus, expand the research space. However, the gathering of divergent ideas needs to be shared by the design team. This sharing of information was highlighted by a facilitator role undertaken by the project director O; O related discussed ideas in the design group to previously generated ones by play-testers/participants.

We related the reports of participants' speeches to a role mentioned by Jeffries (2011) that is to say a facilitator role. Our results are consistent with this role mentioned to be implicated in creativity (Jeffries, 2011). Furthermore, we highlighted that this facilitator role was particularly associated with high degree of creativity when players and participants with their respective personas are being reported in the design group.

On the one hand, our results emphasize the value of players' reported ideas in the generation of creative solutions. We could suggest that players can promote creativity through their reported speeches. Furhtermore, they can participate to enhance diversity of the extended design group. On the other hand, our results emphasize as well another types of diversity; it could be not only the diversity of a group that is important for creativity (Milliken et al., 2003; Nijstad et al., 2003; Paulus and Brown, 2003), but also diversity of specific populations, *i.e.* various personas in each population brought into the extended design group.

From these findings, we could highlight the importance of the extent of the design group; other participants from outside the design team and more precisely various players can contribute to generate a pool of divergent design ideas. Additionally, various types of personas should be integrated in the extended design group. This composition of the extended design group could help to unleash creativity potential during a global design process by enhancing diversity.

It could be safe to mention that our results highlighted not only the importance of knowledge transfer within a structured organization, *i.e.* the design team. They also underlined the importance of knowledge's exchanges coming from beyond the boundary of the structured group through the involvement of users, external designers and participants in activities of use, test, information and co-design. This shed light on an importance of the extent of the design group.

We underlined that the reports of speech in the relational format have an asymmetrical character; only O reported design ideas of play-testers/participants. Nevertheless, this relational format is associated with high degree of creativity. From this result, we could suggest that creativity might be not hindered by asymmetry in collaborative design.

In sum, we can emphasize the value of the original research strategy we adopted. It highlighted several contributions that could promote creativity in a collaborative design. We will turn next on the methodological contributions.

2.7 Methodological contributions

In individual and group creativity, a considerable number of studies use one of the four focuses, *i.e.* persons, places, products or processes. In this dissertation, we develop an original methodology. This original methodology aimed to shed light on the two focuses processes and products and then cross them.

The original creative solutions/products characteristic *ownership* and design process characteristic *deepening*, which are not retrieved in the creativity literature, highlight the potential benefice of evaluating creativity with the designers themselves (chapter 9); it can highlight subtleties of solutions. Furthermore, it provides empirical data to support the claim of Boden (2004). This author emphasizes that quantitative data as well as qualitative should be used to measure creative and also to highlight subtleties of solutions. Furthermore, our results highlighted that using only a scale metric might not be suffisant to evaluate creativity and describe creative products. Indeed, the qualitative data shed light on new contributions related to the characteristics of creative solutions.

Our adopted methodology ended up with the crossing of underlined collaborative and design processes with the most/less creative products (chapter 10). By analyzing both processes and products, we brought new contributions on the one hand related to collaboration formats and socio-cognitive design processes and on the other hand, related to the characterization of creative solutions. When crossed, these two focuses of creativity allowed us to point out how creative solutions are generated in terms of collaborative and design processes. Thus, we found specific collaboration format and design processes involved in the generation of the most creative solutions.

3. Limits of this dissertation

This dissertation mainly aimed to describe and characterize the collaboration formats and socio-cognitive design processes in a collaborative design of a video game. More precisely, it aimed to highlight the ones involved in high degree of solutions creativity. Some limits can be highlighted in relation to the methods or to the conduct of this dissertation.

In order to relate collaborative and design processes to high degree of creativity, we only asked the designers to evaluate the creativity of the solutions, but not the creativity of the sources used to co-elaborate the creative solutions. If the sources would have been taken into account, it could have highlighted other conclusions. This can be related to another limit. We structured our analyses on design periods or problem-solution pairings. This could bypass significant information on the development and evolution of a creative solution.

At a more technical level, we faced some difficulties. The capture of the designers' activities with video-recording device proved to be highly difficult in an ecological setting where designers evolved in complex space, *i.e.* where the object-to-be-designed is situated in one place and design tools, external representations and information are scattered in the entire design studio. This resulted in difficulties to keep the frontal and actions views. Although the second system used, the multiplexer, prove to be a good way to alleviate these difficulties, it engendered another difficulty namely the access to the data itself.

In a general perspective, we tried to cover as much diversity as possible in our corpus; different participants, different uses of external representations, different types of solution and different moments in the design process. This diversity could alleviate the idiosyncratic nature of specific meeting in some proportion. Nevertheless, our results should be confronted in other contexts. In that sense, we should conduct analysis of other types of design, *i.e.* other domains of design with different external representations and design methods, in order to appreciate the generic nature of our results. Nevertheless, some formats could need to be adapted to the type of design studied. This brings us to the perspectives of this dissertation.

4. Perspectives

The results found in this dissertation raised several questions related to collaborative and design processes and their involvement in high degree of creativity. We will discuss perspectives related to collaborative and design processes, game design and player's experience, technologies-mediated contexts and other design domains.

4.1 Deepening our results on collaborative and design processes

Our findings prompted several questions. In this section, we will discuss the pending questions related to both the collaboration formats and the design processes we underlined.

We have highlighted the temporality of the three identified collaboration formats and design processes. However, we did not provided a temporality of their formats, *e.g.* triggering problem framing, triggering agreement crystallization, eliciting alternative solution generation for the directive formats. This could give a more fine-grained view on the evolution and on the dynamics of each collaboration format. Thus, we could highlight specific sequences that lead to high level of creativity, but also associations of specific formats. This would deepen the view that we provided in this dissertation.

Furthermore, we could refine the collaboration formats that we highlighted in this dissertation. First, we could assume that they are other directive formats that support divergence and convergence in collaborative design. Thus, further analysis should be conducted. Second, we could analyze further the roles of external representations and modalities in collaborative design and more precisely in high degree of creativity. It is worth to note that we have not analyzed if creative solutions were associated to specific uses of external representations as the representational formats were retrieved throughout the global design process. These external representations and the roles they support could be analyzed through a relative deviation analysis.

In the same line, our surprising result related to the implication of intra-domain reified solutions and analogical reasoning in high degree of creativity should be further analyzed. Indeed, this result contrasts several studies on analogical reasoning and creativity. We underlined potential analysis to be conducted such as an analysis based on the characteristics of the intra-domain sources or reified solutions. The use of 'far' and 'close' indicators could be used as additional indicators for intra-domain and inter-domain reified solutions or sources for conducting further analysis. This would consider for the intra-domain sources the axis of 'far' and 'close' found for inter-domain sources in some studies.

Another axis could be added; the dissimilarities of sources and targets could be analyzed as well. This could highlight if dissimilar pairs of source-target result in more creative outcomes in analogical reasoning as it is the case in the combination process (Ward et al., 1999). Furthermore, it could stress if source-target within a close domain result in creative outcomes as well.

The relational format involving anterior design ideas found to be associated with high degree of creativity could be further analyzed as well. This could be done by analyzing further the personas associated with reported ideas. This additional information could shed light on the involvement of targeted and non-targeted personas in high degree of creativity. Thus, it could bring new light on the diversity of the group composition.

In addition, the design processes could be deepened. Aligned with the numerous body of literature on nominal *versus* real groups, we could shed new light on the creative potential of design processes. We highlighted numerous socio-cognitive design processes in conceptual meetings and one design process in high degree of creativity. In the collaborative context and the distributed character that we have highlighted, we could compare the creative potential of design processes distributed amongst participants *versus* design processes performed by one subject, and that in a collaborative context.

Design processes are taught to design students, but if socio-cognitive design processes foster more creativity than design processes performed in one head, collaboration should be complementing the taught design processes and should be more emphasized.

4.2 Game design and player's experience

We underlined in the state of the art that player's experience is a core issue in video game design. The player's experience was highlighted in the representational formats involving alternations of player's and designer's perspectives. However, our findings did not stress any association between this representational format and high degree of creativity; the representational formats were found throughout the global design process. Our result on the representational formats and degrees of creativity might have prevented us to investigate further this essential issue in video game design.

Nevertheless, some specific spheres of the player's experience, *e.g.* emotion, fun, etc., could be related to high degree of creativity. In that vein, an additional analysis could be performed to further analyze the player's experience; a relative deviations analysis with the categorization of the spheres of the player's experience in function of degrees of creativity could highlight whether specific sphere/s of the player's experience tend to be associated with high degree of creativity.

4.3 Applying our original approach in technology-mediated contexts

A considerable number of collaborative and design activities are meditated by technologies to connect different stakeholders and/or to support design. In this dissertation, we studied collaborative design activities that were carried on in a face-to-face context without supporting design and creativity technologies.

Computational studies propose several technologies to support creative design. Our original methodology could be conducted in mediated and non-mediated situations. Potentially, based on the resulting findings, evaluations of creativity-supported technologies could be performed and recommendations could be given.

From the results that we highlighted in this dissertation, some potential directions could be suggested. The creativity-supported technologies often propose a wide range of functions from supporting generation of new ideas, the different perspectives taken to supporting evaluation. A considerable number of studies highlight the importance of providing both intra- and inter-domain sources in the supporting technologies which is in line with our results. However, few studies, if any, stress the benefice of having a support-system able to relate previously generated ideas to the ones under discussion. From our result, this function could have some benefince in terms of creativity. Nonetheless, this function would need to be evaluated.

4.4 Applying our original approach in other domains of design

We underlined several contributions highlighted by our methodology that takes into account both the processes and products. The contributions stressed by our original approach could be confronted with other domains of collaborative design and compared to other methodologies.

As few, if any, studies shed light on collaboration in group creativity (Gero, 2010), we could apply our original approach to collaborative activities in other domains of design. This would stress if the highlighted collaborative and design processes and the ones related to creativity are found in other domains of design. Furthermore, it could even highlight other collaborative and design processes as well as stressing others that could be related to high level of creativity.

Additionally, we could conduct further analysis to see whether the directive and relational format are controlled by a specific member of the design group. This could be done through analyses of other collective in game design, in other domains of design as well as in particularly creative domains.

It is worth to note that the specific population associated with high degree of creativity could be different for other types of design, *e.g.* architecture. The same type of analysis carried on in this dissertation could be conducted in other domains of design to confirm if the users (players are the users of video games) are the specific population that foster creativity.

Finally and more related to our approach, we could take our method of creativity evaluation and conduct it with independent judges. This would provide data that can be compared to the ones provided by the designers themselves. From this comparison, we could confirm or not the great benefice of conducting quantitative as well as qualitative creativity evaluations with designers themselves instead of with independent judges.

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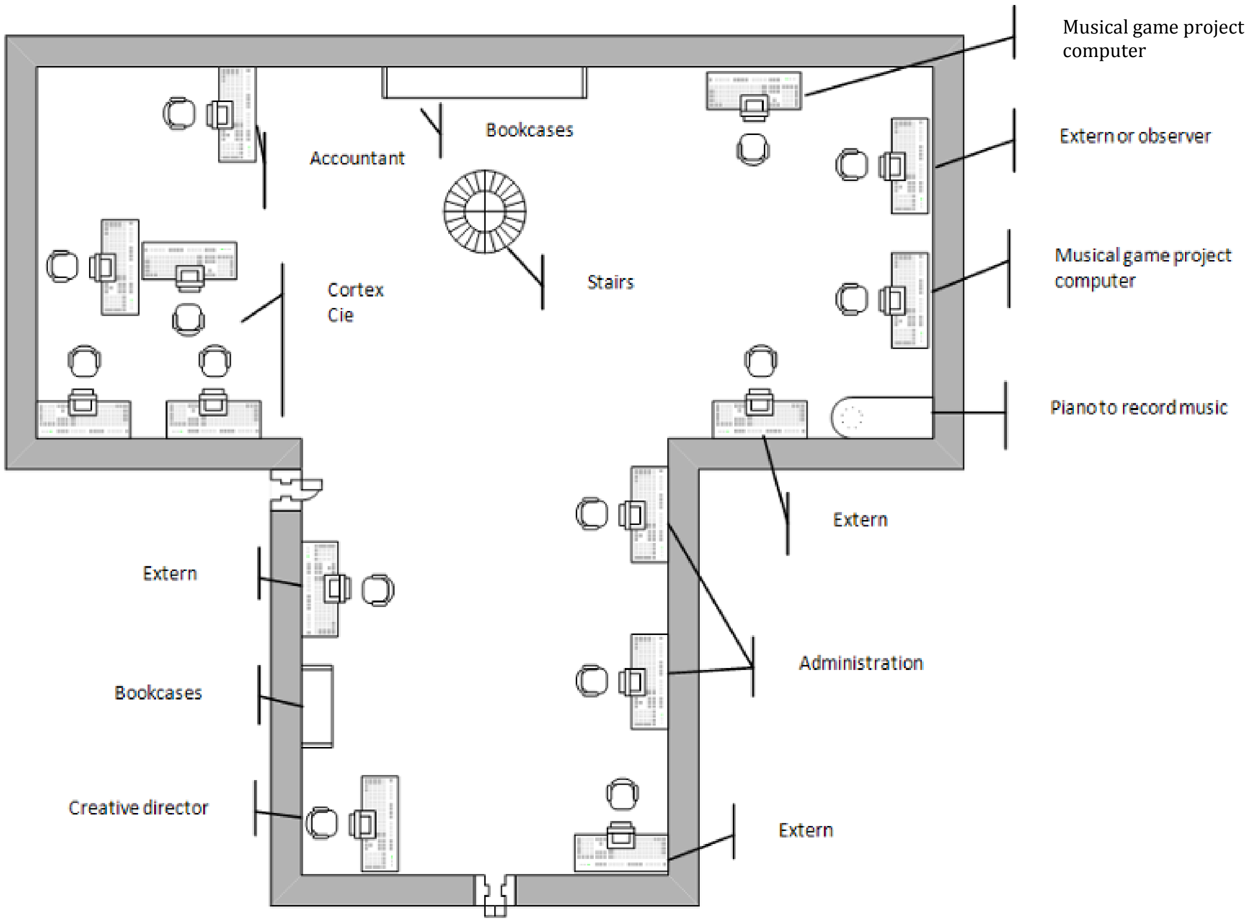
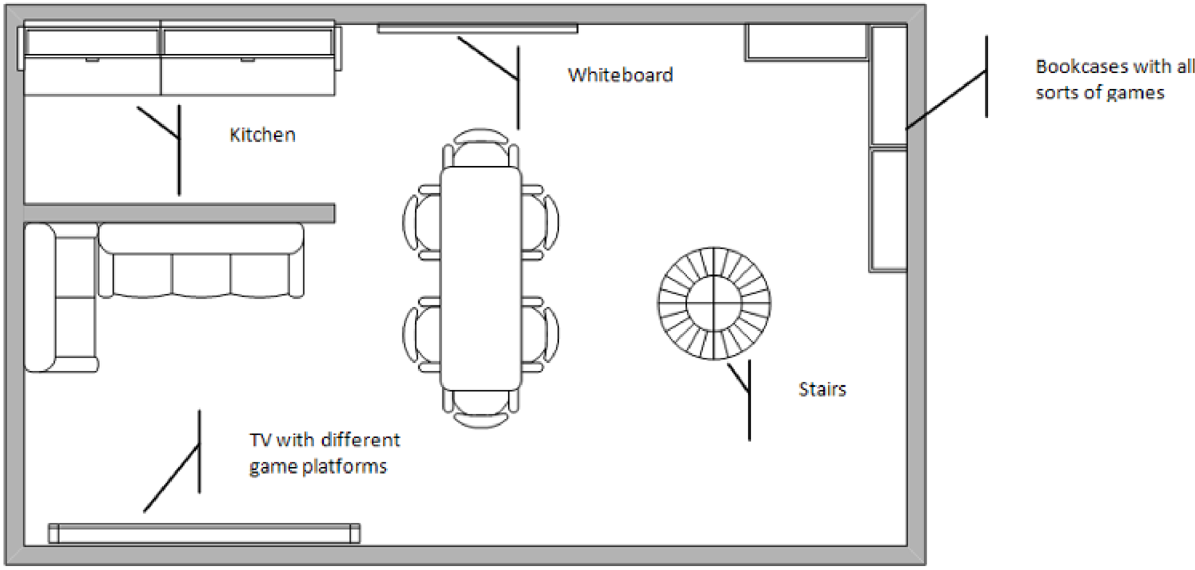
Annexes

Annex 1. The game studio

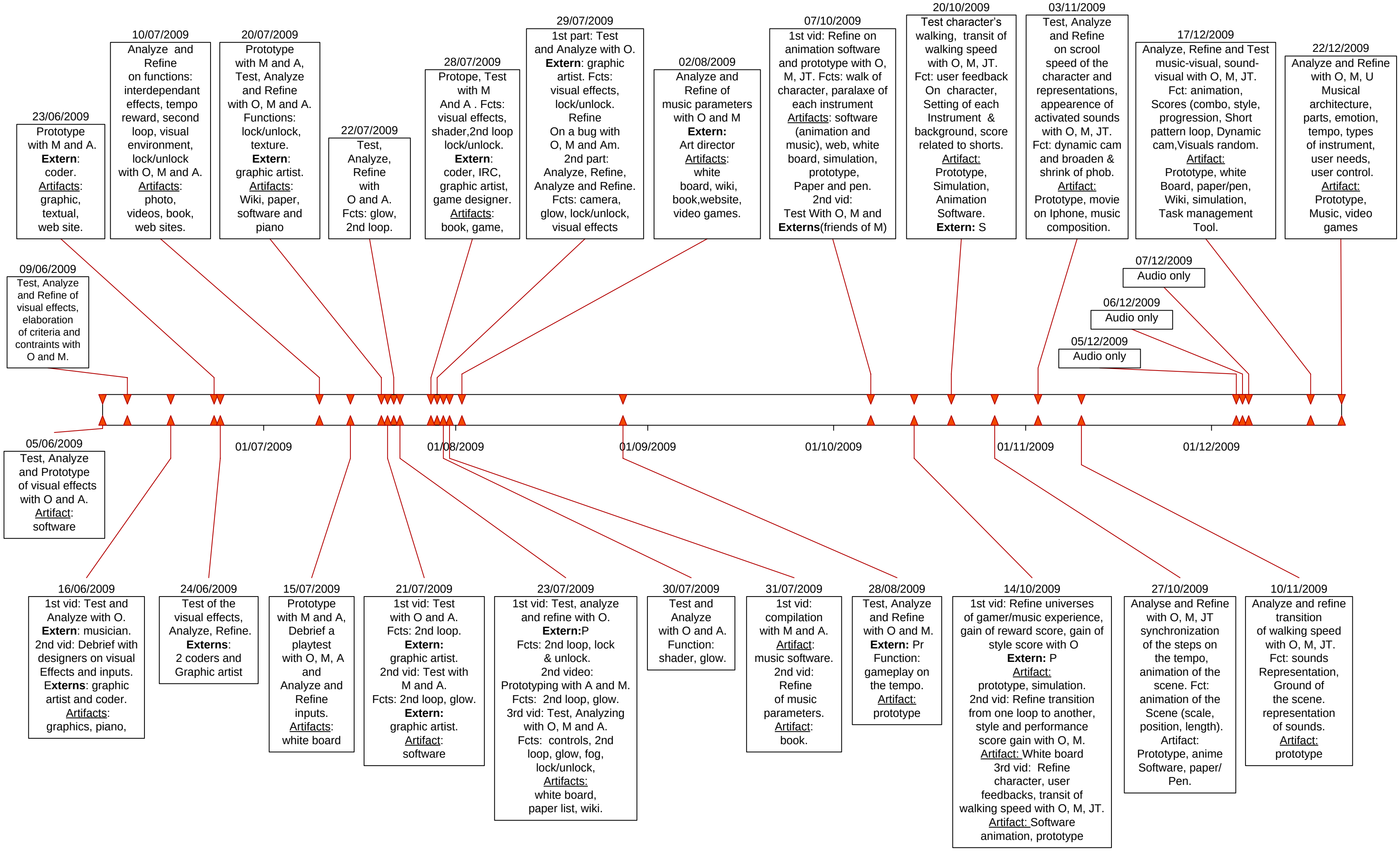


First floor. At the top left a game design company, middle: bookcase with art books, coding books, game design books and some games and top right: the space where musical video game is developed.
Bottom left other books and the desk of the creative and project director O.
Some desks are occupied by externs: other game designers, developers and coders working for O in other projects.



Basement. From left to right, the kitchen, living room with TV and game consoles, table in front a white board and bookcases with books and types of games, *e.g.* card games, board games, video games and so on.

Annex 2. Forty-three meetings video-recorded



09/06/2009
Test, Analyze and Refine of visual effects, elaboration of criteria and contraints with O and M.
23/06/2009
Prototype with M and A. **Extern**: coder. Artifacts: graphic, textual, web site.
10/07/2009
Analyze and Refine on functions: interdependant effects, tempo reward, second loop, visual environment, lock/unlock with O, M and A. Artifacts: photo, videos, book, web sites.
20/07/2009
Prototype with M and A, Test, Analyze and Refine with O, M and A. Functions: lock/unlock, texture. **Extern**: graphic artist. Artifacts: Wiki, paper, software and piano
22/07/2009
Test, Analyze, Refine with O and A. Fcts: glow, 2nd loop.
28/07/2009
Protope, Test with M And A . Fcts: visual effects, shader,2nd loop lock/unlock. **Extern**: coder, IRC, graphic artist, game designer. Artifacts: book, game,
29/07/2009
1st part: Test and Analyze with O. **Extern**: graphic artist. Fcts: visual effects, lock/unlock. Refine On a bug with O, M and Am. 2nd part: Analyze, Refine, Analyze and Refine. Fcts: camera, glow, lock/unlock, visual effects
02/08/2009
Analyze and Refine of music parameters with O and M **Extern:** Art director Artifacts: white board, wiki, book,website, video games.
07/10/2009
1st vid: Refine on animation software and prototype with O, M, JT. Fcts: walk of character, paralaxe of each instrument Artifacts: software (animation and music), web, white board, simulation, prototype, Paper and pen. 2nd vid: Test With O, M and **Externs**(friends of M)
20/10/2009
Test character's walking, transit of walking speed with O, M, JT. Fct: user feedback On character, Setting of each Instrument & background, score related to shorts. Artifact: Prototype, Simulation, Animation Software. **Extern:** S
03/11/2009
Test, Analyze and Refine on scrool speed of the character and representations, appearence of activated sounds with O, M, JT. Fct: dynamic cam and broaden & shrink of phob. Artifact: Prototype, movie on Iphone, music composition.
17/12/2009
Analyze, Refine and Test music-visual, sound-visual with O, M, JT. Fct: animation, Scores (combo, style, progression, Short pattern loop, Dynamic cam,Visuals random. Artifact: Prototype, white Board, paper/pen, Wiki, simulation, Task management Tool.
22/12/2009
Analyze and Refine with O, M, U Musical architecture, parts, emotion, tempo, types of instrument, user needs, user control. Artifact: Prototype, Music, video games
07/12/2009
Audio only
06/12/2009
Audio only
05/12/2009
Audio only
01/07/2009
01/08/2009
01/09/2009
01/10/2009
01/11/2009
01/12/2009
05/06/2009
Test, Analyze and Prototype of visual effects with O and A. Artifact: software
16/06/2009
1st vid: Test and Analyze with O. **Extern**: musician. 2nd vid: Debrief with designers on visual Effects and inputs. **Externs**: graphic artist and coder. Artifacts: graphics, piano,
24/06/2009
Test of the visual effects, Analyze, Refine. **Externs**: 2 coders and Graphic artist
15/07/2009
Prototype with M and A, Debrief a playtest with O, M, A and Analyze and Refine inputs. Artifacts: white board
21/07/2009
1st vid: Test with O and A. Fcts: 2nd loop. **Extern:** graphic artist. 2nd vid: Test with M and A. Fcts: 2nd loop, glow. **Extern:** graphic artist. Artifact: software
23/07/2009
1st vid: Test, analyze and refine with O. **Extern:**P Fcts: 2nd loop, lock & unlock. 2nd video: Prototyping with A and M. Fcts: 2nd loop, glow. 3rd vid: Test, Analyzing with O, M and A. Fcts: controls, 2nd loop, glow, fog, lock/unlock, Artifacts: white board, paper list, wiki.
30/07/2009
Test and Analyze with O and A. Function: shader, glow.
31/07/2009
1st vid: compilation with M and A. Artifact: music software. 2nd vid: Refine of music parameters. Artifact: book.
28/08/2009
Test, Analyze and Refine with O and M. **Extern:** Pr Function: gameplay on the tempo. Artifact: prototype
14/10/2009
1st vid: Refine universes of gamer/music experience, gain of reward score, gain of style score with O **Extern:** P Artifact: prototype, simulation. 2nd vid: Refine transition from one loop to another, style and performance score gain with O, M. Artifact: White board 3rd vid: Refine character, user feedbacks, transit of walking speed with O, M, JT. Artifact: Software animation, prototype
27/10/2009
Analyse and Refine with O, M, JT synchronization of the steps on the tempo, animation of the scene. Fct: animation of the Scene (scale, position, length). Artifact: Prototype, anime Software, paper/ Pen.
10/11/2009
Analyze and refine transition of walking speed with O, M, JT. Fct: sounds Representation, Ground of the scene. representation of sounds. Artifact: prototype

Annex 3. Questions of the semi-directive interview

1. Quel est/a été le but de ce projet de conception qui a duré environ un an ?

2. Quelles ont été tes sources d'inspiration ?

3. Quelles ont été tes motivations ?

4. Est-ce que tu peux d'écrire les étapes qui t'ont mené vers l'idée finale de jeu musical ?

5. Est-ce qu'il y a eu des moments de rupture conceptuelle (moment où le projet a pris une toute autre orientation que celle qui était prévue) durant le processus de conception ?

- Comment ont-ils impacté le projet de conception ?

6. Quelles sont, selon toi, les idées proposées durant la conception de ce jeu vidéo musical qui soient

- les plus importantes ?
- les plus nouvelles ?
- les plus originales ?
- celles qui ont créé un effet de surprise ?
- les plus inhabituelles ?
- les plus créatives ?

Préciser pourquoi et comment elles ont impacté le processus de conception du jeu musical

7. Qu'est-ce qu'une idée créative ?

Annex 4. Example of the questionnaire

Problème Extrait M2E1- 24 juin
Les représentations visuelles des « shorts »

Solution A
Représentation visuelle d'un « short » qui soit cohérente avec la représentation de son homologue « long »

Solution B
Représentation visuelle qui fait rupture avec la représentation visuelle de son homologue « long » c'est-à-dire en se dirigeant dans le sens opposé du « long »

Pour chaque dimension, dites où sur l'échelle se situe chaque solution présentée ci-dessus

Nouveauté : 1 2 3 4 5
Pas du tout nouveau — Très nouveau
Expliquez :

Faisabilité : 1 2 3 4 5
Peu faisable — Très faisable
Expliquez :

Les sources d'inspiration de chaque solution, si applicable :

Annex 5. The excerpt corpus

No	*Date*	*Ext. representations*	*Participants*	*Topics and interests*
M1E1	June 9th	Prototype, gesture, graphic+ gesture	-O Dir crea -M coder	*Location of representations* Evocation of inter-domain source (movie) and intra-domain (Rez: interaction-audio-visual)
M1E2	June 9th	Prototype, gesture	-O Dir crea -M coder	*Representation of each note* New idea: spatialisation Evocation of inter-domain (novel and TV anime) and intra-domain (REZ: forms, colors)
M2E1	June 24th	Prototype, gesture	-O Dir crea -M coder -A coder apprentice -S graphic designer	*Shorts representations* Evocation of inter-domain (MIDI)
M3E1	July 10th	nothing	-O Dir crea -M coder -A coder apprentice	*Play-tests, persona+interaction between elements* Evocation of intra-domain (REZ: interact° between elements)
M3E2	Juily 10th	Video, book, web, gesture	-O Dir crea -M coder	*Scene* Evocation of inter-domain (movie and photo) New idea (from extern) with inter-domain (lightcraft)
M4E1	July 23th	Prototype, gesture, simulation (proto)	-O Dir crea -P game designer	*Presentation of proto to extern* New idea: change of music/visual when gamer plays well
M4E2	July 23th	Prototype, gesture	-O Dir crea -P game designer	*Presentation of proto to extern* Evocation of intra-domain (REZ and Flower: not a game; intra-domain for goal)
M5E1	July 31th	Book, simulation (play)	-O Dir crea -M coder -A coder apprentice	*Music parameters* New idea: taking attack of notes from the way a playing Evocation of inter-domain (workers with sequencer)
M6E1	August 28th	Prototype	-O Dir crea -M coder	*Score scale* New idea: gameplay
M7E1	October 7th	Gesture	-O Dir crea -M coder -JT graphic designer	*Figurative environment* Evaluation with other game Metaphor of other type of game Evocation of inter-domain (REZ: interaction between elements)
M7E4	October 7th	Prototype, music software, gestural simulation, paper/pen	-O Dir crea -M coder -JT graphic designer	*Visual representations* Evocation of inter-domain (Wave files)
M8E1	October 14th	Prototype, gesture	-O Dir crea - P game designer	*Progression score* New idea: score gain matching the idea proposed by extern Evocation of intra-domain (REZ: play mode)
M8E2	October 14th	Prototype, gesture	-O Dir crea -P game designer	*Style score* New idea: style gain Evocation of intra-domain (game and REZ: play mode)
M8E3	October 14th	White board, gesture simulation	-O Dir crea -M coder	*Music experience* -New idea: min. interaction is needed to go further -Persona -enunciation
M8E4	October 14th		-O Dir crea -M coder	*Gains* -enunciation of 2 designers with combination -inspiration source (intra)
M9E1	December 17th	White board, gesture	-O Dir crea -M coder	*Representativeness of feedback*

M9E2	December 17th	Prototype, gesture	-O Dir crea -M coder -JT graphic designer	*New type of interaction* New idea (from extern): short pattern loop Analogy: F° in the game
M10E1	December 22th	Gesture, music software	-O Dir crea -M coder -U Music designer	*Music architecture* New orientation (before inspiration of Air: music tripante)

Table 73.Excerpt corpus

The additional excerpts for the meeting corpus are in bold. The other excerpts come from the excerpt corpus.

Meetings	*Participants*	*No*	*External representations*
M7 October 7th	-O Dir crea -M coder -JT graphic designer	E1	Gesture
		E2	**Gesture, white board**
		E3	**Gesture, paper/pen, music software**
		E4	Prototype, music software, gestural simulation, paper/pen
		E5	**Music software, gesture**
		E6	**Gesture, paper/pen**
		E7	**Prototype, gesture**
		E8	**Music software, gesture**
M8 October 14th	-O Dir crea -P game designer	E1	Prototype, gesture
		E2	Prototype, gesture
	-O Dir crea - M coder	E3	White board, gesture simulation
		E4	

Table 74. Meeting corpus

The directive format to trigger problem framing can be illustrated by the excerpt M7E3. This excerpt is taken from a meeting between the creative and project director O, the coder M and the freelance graphic artist Jt (photo 38). This latter designer just integrated the design team to work on the new orientation of the prototype –figurative visual representations– that is related to his expertise in graphic art. In this meeting, O, M and Jt were gathered to discuss about the new orientation of the prototype. The abstract interaction-sound-image prototype, used in this meeting, will be replaced by a figurative interaction-sound-image prototype. In order to do the transition, the designers will have to translate the abstract visual representations and the scenery into figurative ones.

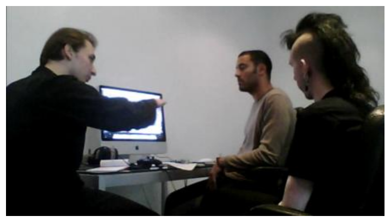


Photo 38. The excerpt M7E3 with from left to right Jt, O and M

In this excerpt, the designers' interest was to define types of scenery, types of visual feedbacks and means of appearance of these feedbacks. The excerpt started with Jt who named a first feature of the problem space to which he proposed a flow of potential solutions from an area of the solution space. This was followed by a solution generated by the designer O that set boundaries in the solution space. Then, a second feature of the problem space was evoked by Jt who again generated a flow of potential solutions. These solutions were globally argued by O who then he evoked other boundaries in the solution space. This led M to intervene in a more concrete, fine-grained level by generating a new solution. This fine-grained solution co-elaboration was however stopped by O as this solution was not at the appropriated level of abstraction. This excerpt ended with Jt bringing a last feature of the problem space. This was followed by the generation of a third flow of potential solutions of an area in the solution space. Then, a delimitation of the solution space was targeted by O. The segment presented below concerns the second out of the three features of the problem space that was brought up by Jt.

In this segment of excerpt (table 75), the designer Jt started by naming a feature of the problem space in the sequence A "*Ben par rapport à comment on les traduit*" 'well regarding of how we translate them'. With this named problem, Jt generated a flow of possible solutions in the sequence B "*si on les traduit en blocs euh de béton, si on les traduit en fleur ou en onde dans l'eau/ ce genre de chose… on peut avoir un autre élément enfin un autre univers où c'est plus de l'eau c'est de la glace avec des effets de transparence*" 'if we translate them in concrete blocks, if we translate them in flowers, or with water waves, this kind of thing…we can have another element well another universe where it is not water anymore, it is ice with transparency effects'. The solutions were first figurative objects and then figurative universes. Thus, Jt proposed an area of the solution space that consists of figurative visual representations and universes.

In reaction, O specified the boundaries of the solution space in the sequence C “*mais tout ce que je dis c’est que quoi que ce soit au final en termes de représentation maintenant on raisonne en termes d’objets en termes de tiles d’objets donc si tu penses que mettre des objets en dessous c’est intéressant vas-y pas de problème tu fais un chemin*” ‘but all I say is that anything it is at the end in terms of representation, now we reflect in terms of objects yet if you think that putting objects beneath is interesting, go ahead no problem, you do a path’. The framed problem by O set the boundaries of the targeted area in the solution space that encompasses dealing with tiles objects (geometrical) in opposition to figurative visual representations proposed by Jt.

No	Loc	Seq	Verbatim	Pers	D.a.	Pb/Sol
4a	JT	A	Ben par rapport à comment on les traduit *Well in relation to how we translate them*	Dsg	Pb(b)	Visual representation
4b	JT	B	si on les traduit en blocs euh de béton *if we translate them in blocks of concrete*	Dsg	Gen Sol(b)1	Concrete blocks
4c	JT	B	si on les traduit en fleur *if we translate them in*	Dsg	Gen Sol(b)2	Flowers
4d	JT	B	ou en onde dans l’eau/ ce genre de chose *or with waves in water this kind of thing*	Dsg	Gen Sol(b)3	Water waves
5	O		En onde dans l’eau/ *With waves in water*	Dsg		
6	JT		Ben par exemple euh= *For example euh*	Dsg		
7	O		=Oui non mais = *Yes, no, but*			
8a	JT		=Ben par exemple le son qu’on avait avant euh typiquement ca pourrait être des ondes dans l’eau et on pourrait bien voir <£qu’il £*Flat hands and then one stays flat and the other, straight, goes under and makes mvts of vertical waves* marche sur l’eau donc on a une transparence en dessous y’a un élément genre des poissons des trucs des dauphins (inc)£> euh et £*stops hands mvt* *Well for example, the sound that we had before euh typically it could be waves in water and we could see well that the character walks on water, thus we have a transparency beneath, there’s an element like maybe fishes, things, dolphins (inc) euh and*	Dsg	Refi	
8b	JT	B	on peut avoir un autre élément enfin un autre univers où c’est plus de l’eau <£c’est de la £*one flat hand and the other, flat, oscillates under* glace avec des effets de [transparence> *we could have another element well another universe where it’s not water anymore, it’s ice with transparency effects*	Dsg	Gen Sol(b)4	Ice with transparency effects
9a	O		[Tout à fait tout à fait tout à fait mais j’chui d’accord t’as complète-ment raison et c’est une bonne idée visuelle *Definitely, definitely, but I agree, you are completely right and it’s a good visual idea*	Dsg	Arg+	
9b	O	C	mais tout ce que je dis c’est que quoi que ce soit au	Dsg	Mana	

			finale en termes de représentation maintenant on raisonne en termes d'objets en termes *but all I'm saying is that whatever it is at the end in terms of representations, now we think in terms of objects, in terms*			
9c	O	C	de tiles d'objets donc si tu penses que mettre <§des objets en §*flat parallel hands with the one under sliding forward* dessous c'est intéressant vas y pas de problème tu fais un chemin>= *objects tiles therefore if you think that putting objects beneath is interesting, go ahead, no problem, you do a path*	Dsg	Gen Sol^{+}(b) 5	Object tiles

Table 75. Directive format to trigger problem framing in the excerpt M7E3

In this example, the directive format to trigger problem framing unfolds like this:

- The sequence A Names a problem: Jt names the problem 'translation of the visual representation of soundtracks';
- The sequence B Generates a flow of solutions: Jt generates four figurative solutions for visual representations namely 'concrete blocks', 'flowers', 'water waves' and 'ice with transparency effects';
- The sequence C Frames the problem: O frames the problem by specifying that the visual representation should not be figurative but object tiles at first.

We will illustrate the first variant of relations to an anterior design idea with the excerpt M3E2. This excerpt presents a segment of a meeting between the creative director and director of the project O and the coder M (photo 39). The meeting was focused on the evaluation of new functions in the prototype and of a new orientation for the evolution of the prototype, the proposition to integrate figurative visual representations.

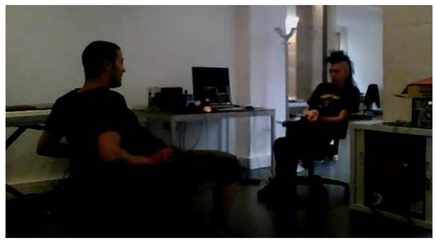


Photo 39 . The excerpt M3E2 with from left to right O and M

In this excerpt, the stake of the designers was to co-elaborate a new orientation related to the visual environment of the prototype. The excerpt unfolded as follows. M proposed a new orientation that is transforming the abstract visual representations into figurative ones. Then, both designers co-elaborated M's new orientation by generating each a solution. The designer M generated a first solution and both M and O col-elaborated it. Then, O generated an alternative solution that was also generated by As in a previous play-test. We will focus on O's alternative solution in order to illustrate the relations to anterior design ideas with the report of a solution.

The segment (table 76) begins with the designer O announcing a re-attribution of a new solution with a polyphony marker "*y'a un autre truc j'crois que c'est Anne-Sophie qui a crevé le tuyau en parlant à Amaury*" 'there is another thing I think that it is Anne-Sophie that generated it while she was speaking to Amaury' (sequence A). In complement, O underlined that As had the same idea that he had in mind "*elle a eu la même réaction que moi donc euh en fait moi j'y pense depuis longtemps*" 'she had the same reaction than mine thus in fact me I think of it for a long time'. This could be viewed as a distribution of authorship to two individuals; O and AS are the authors of the solution. Then, O evoked the solution "*et je pense qu'on devrait pousser dans cette direction euh au light graph*" 'and I think that we should go toward this direction light graph' (sequence B). After a brief description of what was involved in the generated solution, O refined the solution "*et le light graph c'est des mecs qui font en fait du d'la calligraphie eum visuelle avec euh de la lumière*" 'and light graph it's guys that do visual calligraphy with light' (sequence C).

No	Loc	Seq	Verbatim	Enun	Persp	D.a.	Pb/Sol
10a	O	A	[(inc) maintenant moi y'a un autre truc j'crois que c'est Anne-Sophie qui a crevé le tuyau en parlant à Amaury l'autre jour mais euh mais elle a eu la même réaction que moi donc euh en fait moi j'y pense depuis longtemps ça me fait penser et je pense qu'on devrait pousser dans cette direction euh (*inc) now, I, there another thing I think that it's Anne-Sophie that said it while talking to Amaury the other day, but she had the same reaction that I had well euh in fact me, I think of it since a long time, it makes me think of and I think we should go toward this direction euh*	O	Dsg		
10b	O	B	au light graph tu connais ca/ *light graph, do you know that?*	AS		Gen Sol(a)2	light graph for the visuals
11	M		Non\ *no*	M	Dsg		
12a	O		Tu connais pas\ alors y faut que je trouve un bon truc parce que l'autre jour on a cherché sur google on trouvé des trucs pourris avec Amaury qu'on arrivera à quelque chose *You don't know, well I need to find a good thing because the other day we checked on google, we found some crappy stuff Amaury and me, we will arrive at something*	O	Dsg		
12b	O	C	et le light graph c'est des mecs qui font en fait du d'la calligraphie eum visuelle avec euh de la lumière\ donc est ce que vous connaissez Hasein Basoudi/§ Hasein Basoudi §*shows in a book* *And light graph is guys that do calligraphy eum visual with lights well do you know Hasein Basoudi, Hasein Basoudi*	O	Dsg	Refi	

Table 76. The relations to anterior design ideas with the report of a solution in the excerpt M3E2

In this illustration, the relations to anterior design ideas can be described as :

- The sequence A Relates a solution to a designer *x*: O relates the solution to As who also generated it;
- The sequence B Generates a solution: O generates the solution 'light graph for the visuals';
- The sequence C Refines a solution: O refines the solution 'light graph for the visuals'.

This example illustrates that one designer can re-attribute a solution to the first person who selected and generated the ideas/words. However, it was done without giving all the authorship to this person, but by distributing the authorship between the first person who expressed this idea and the designer who detained it without having shared it before. This first distribution of authorship could be a way to bring more weight on the generated solution; the fact that two different individuals had the same design idea might be considered as convergence toward that solution and that this solution is worth to be considered.

An example is depicted in order to illustrate the notion of re-attribution and of re-appropriation. This will be illustrated with the excerpt M8E4. This excerpt comes from a meeting between the creative director and director of the project O and the coder M (photo 40). It is a debriefing meeting where O reported to M the contributions of external designers F and P.


Photo 40. The excerpt M8E4 with from left to right M and O

The stake of the designers in this excerpt is to examine a new problem generated by F. The excerpt started with O reporting the problem generated by F to which O paired a solution. Then, O reported the solution that F paired with his generated problem. After that, O generated an alternative solution. The following section focuses on the reported problem that was generated by F and the solution that O generated.

It is worth to note, in order to ease the comprehension, that two meetings took place just before M8E4. In the first meeting several problems and solutions were generated by F:

- The 'Overwhelming' problem: the game offers twelve sound tracks at the beginning and this number of available sound tracks is overwhelming. It was paired with the solution "*c'est mieux d'en avoir un ou deux* [button associated to a sound] *au début les faire gagner à chaque fois qui rejoue*" 'win a sound track at each replay'
- The 'Replayability' problem: the players' willingness to replay the game to which F paired the solution "*tu termines de jouer et à la fin tu gagnes quelque chose qui vient habiller ton avatar*" 'win something that will dress your avatar at each replay'

In the second meeting, the 'Replayability' problem was evoked by O and a solution was paired to it by P.

- "*ou* [gagner] *des nouveaux sons/*" '*new sound tracks*'.

The segment (table 77) starts with O reporting a problem evoked by F "*Y dit euh:h (.) overwhelming trop de boutons au départ*" 'he says overwhelming, too much buttons at the beginning' (line 1a). Then, O generated and refined a solution to pair to this 'Overwhelming' problem "*peut-être y faut di:iminuer le nombre de bouton au départ… tu fais le voyage une première fois t'as quatre boutons par exemple à la fin t'en gagne un autre tu peux refaire le morceau et t'as un nouvel instrument*" 'maybe we need to diminish the number of buttons at the beginning… you do you navigation a first time you have four buttons for example, at the end you win another one, you can do again the musical loop and you have a new instrument' (lines 1c, 3b and 5). At the end of this segment, O qualified the generated solution as his own "*alors mais ça leu alors ça ça c'est c'est ma solution*" 'yet but this this is my solution' (line 11b).

No	Loc	Seq	Verbatim	Enun	Persp	D.A.	Pb/Sol
1a	O	A,B	Y dit euh:h (.) overwhelming trop de boutons au départ tu vois *He says overwhelming too much buttons at the beginning*	F	Ply	Gen Pb(a)	Overwhel-ming
1b	O		quand il prend le truc en main trop trop de son tro:op de machins euh:h euh:h *when he takes the game in hand, too much sounds, too much things, euh euh*	O	Dsg	Reph Pb(a)	
1c	O	C	ça ça (inc) et peut-être y faut di:iminuer le nombre de bouton au départ *this, this (inc) and maybe we have to lower the number of buttons at the beginning*	O	Dsg	Gen Sol(a)1	Diminish the number of button at first
2	M		(inc) *(inc)*	M	Dsg		
3a	O		Ce qui tie in ce qui tie in avec un autre une autre réflexion qu'on avait peu:eut être ça la réflexion est pas abouti là-dessus mais l'idée c'est de dire ok *This ties with an other reflection that we had, maybe the reflection is not completed, but the idea is to say ok*	O	Dsg	Refi	
3b	O		tu fais §le voyage une première fois t'as quatre §*puts his hands from L to R* boutons par exemple *you do the game a first time, you have four buttons for example*	O	Ply	Refi	
4	M		ouain *yeah*	M	Dsg		
5	O		A la fin § t'en gagne un autre tu peux <§ refaire §*hand from L to R* §*mvts in circle* le morceau et t'as un nouvel instrument *at the end you win another one, you can replay the loop and you have a new instrument*	O	Ply	Refi	
6	M		En:n *in*	M	Dsg		
7	O		Un nouveau et à chaque fois §> et ainsi de suite §*stop mvt in circle* jusqu'à ce que tous le:es *a new one and at each time and so on until all the*	O	Dsg	Reph	
8	M		En:n ouai ça c'est bon ça *In yeah, this is good*	M	Dsg	Arg+	
9	O		Tous les instruments à:à disposition *All the instruments are available*	O	Dsg	Reph	
10	M		Ca te multiplie la longueur du truc *It enhances the lenght of the thing*	M	Ply	Arg+	
11a	O		Ca te pousse à la à la à la replayabilité *It pushes you to replayability*	O	Ply	Arg+	
11b	O		alors mais ça leu alors ça ça c'est c'est ma solution et elle est pas parfaite encore *well, but, this well this is my solution, it is still not perfect*	O	Dsg	mana	

Table 77. The relations to anterior ideas with the report of a problem from the player's experience of F in the excerpt M8E4

In this illustration, the relations to anterior design ideas can be described as:

- The sequence A Relates a player's experience to a designer *x*: O relates a problem to F who generated it;
- The sequence B Generates the problem: O generates the problem 'overwhelming';
- The sequence C Generates a solution: O generates the solution 'diminish the number of button at first'.

At the beginning of this example, we can see a re-attribution; O used polyphony markers before he re-attributed a problem and the authorship to F "*Y dit*" 'he says'. We can also underline a re-appropriation. The designer O generated the solution 'diminish the number of button at first' that he announced as his own "*alors mais ça leu alors ça ça c'est c'est ma solution*" 'thus but this thus it's my solution'. However, the solution O generated is quite similar to the solution F paired with the 'overwhelming' problem 'win a sound track at each replay' and to the solution P generated for the 'replayability' problem for the performance score '[win] new sound tracks'. Therefore, we could say that the designer O re-appropriated this solution as it is not him but F and P that are the authors of this solution.

This example introduce two notions *re-attribution* and *re-appropriation* that can be both involved in the construction of relations to anterior design ideas format. We can suggest that the designer O was re-attributing the speech to its author when he only reported the speech of an absent participant. Conversely, when O reported the speech of absent participants that was modified in some way, then O re-appropriated to himself the resulting solution.

Annex 10. Example of the representational format with alternation of player's and designer's perspectives

We will exemplify the alternation of player's and designer's perspectives format with the excerpt M6E1 that comes from a meeting between the creative director and director of the project O, the coder M and an expert coder Pr who is working in the studio on another project ran by O (photo 41). It is worth to note that Pr is a hardcore gamer of musical video games. We think that it is the reason why O asked Pr to take a look at the new state of the prototype. The meeting is an update of the implementation done by the coder M in order to keep O informed of the evolution of the prototype.


Photo 41. The excerpt M6E1 with O

In this excerpt, the stake of the designers is to evaluate the new orientation implemented in the prototype, *i.e.* the integration of a score scale for the hardcore gamers. The excerpt started with M who showed to O the new orientation/solution he implemented in the prototype. As O interacted with the prototype, M explained to O all the new implementations and their meanings and at some occasions, O asked questions. The new orientation/solution was co-elaborated by both designers. At the end of the excerpt, the new orientation/solution implemented in the prototype was shown to another coder Pr that also asked some questions. The following portion of the excerpt M6E1 involves the presentation of the new orientation and the first interaction of O with the prototype.

The example (table 78) starts with the designer M who installed the prototype in which he implemented a new orientation/solution that we could consider as a generation of a solution with the designer's perspective (line 0). After a period of interaction with the prototype, O argued the implemented orientation/solution with the player's perspective "*ah c'est cool*" 'ha it's cool' (line 1b). At the end, the designer M refined the explication of the implemented orientation/solution with the designer's perspective "*Alors quand tu matches j'te fais plus un et quand tu foire j'te divise par deux*" 'well when it matches I do plus one and when it does match I divide by two' (line 2).

No	Loc	Seq	Verbatim (exc 9)	Persp	D.A.	Pb/Sol
0		A	**installs the new prototype*	Dsg	Gen Sol(a)	Integrate a character for the feedback for score
1a	O		Ah/ ça à l'air intéressant\ (.) typiquement cette aprèm quand j'y jouais ça\ *Ah it looks interesting typically this afternoon when I was playing it*	Ply		
1b	O	B	§(..) ah c'est cool\ <§ *starts to play* *Ah it's cool*	Ply	Arg+	
2	M	C	Alors quand tu matches j'te fais plus un et	Dsg	Refi	

			quand tu foire j'te divise par deux *Well when you activate in the rhythm I give you plus one and when you fail, I divide per two*			

Table 78. The first variant of the alternations of player's and designer's perspectives format in the excerpt M6E1

In this example, the alternations of player's and designer's perspectives can be summarized as :

- The sequence A Generates a solution with a designer's perspective: M generates a solution by implementing it in the prototype that we consider as a designer's perspective;
- The sequence B Argue the solution with a player's perspective: O argues the solution while interacting with it in the prototype in a player's perspective;
- The sequence C Refines the solution with a designer's perspective: M refines the solution with a designer's perspective.

This example shows that the designers involved in the alternations of player's and designer's perspectives format can bring appreciation, new information, explanations or principles related to a generated or implemented solution. In this sequence, a first evaluation of the designer O in the player's perspective underlined the player's experience and the appreciation of O with the new implemented orientation/solution. Then, the designer M adopted the designer's perspective in order to give to O more information and construct a mutual understanding about the new orientation/solution and its implications.

Annex 11. Example of the representational format with alternation of player's and designer's perspectives

We will present the second variant of this format in order to bring complementary information about this format, *i.e.* the components of the perspectives. This excerpt takes place in a meeting between the creative director and director of the project O and the external game designer P (photo 42). It is a debriefing meeting where P reported to O the player's experience of his play-test and proposed new orientations for the prototype.

Photo 42. The excerpt M4E2 with from left to right M and P

In this excerpt, the stake of the participants is to consider the characteristics of the prototype in regard to classic features of video games. The implicit question 'what is a video game' was uncovered by this stake. This excerpt can be described as first P generating a solution which led O explaining the aim of the game to argue against P's solution. Then, P generated an alternative solution by taking into account the main characteristics of the current state of the prototype. In reaction, both participants confronted the current state of the prototype with the classical features of video games. This led the designer O to generate a last solution. The following example is focused on the solution generated by P that led to a confrontation of classic features of video games with the features integrated in the prototype and to the generation of an alternative solution by O.

The example (table 79) begins with the generation of a solution by P with the designer's perspective "*tu peux faire un support de logiciel*" 'you can do a software support' (line 16b). Then, the solution was argued with the player's perspective by O in the "*Non mais je crois je crois que la raison pour laquelle y pensent que c'est pas un jeu c'est parce que ça répond pas à l'idée classique (inc) mais c'est pas juste l'idée c'est vraiment comme on a dit t'a l'heure y s'attendent à ce qu'y ai un score un objectif clairement qui dit y faut faire tel machin*" 'no but I believe that the reason why they [hardcore gamers] think that it's not a game is because it does correspond to the classical idea (inc) but it's not just the idea it's really like we said before they expect a score a clearly stated goal' (line 37c) and then O generated a constraint with the designer's perspective "*peut être qu'y* [objectif] *y sera mais y sera en négatif tu vois*" 'maybe there will be one [goal] that will be in negative" (line 37d). After, O generated an alternative solution with the designer's perspective "*pas faire en sorte que la musique s'arrête*" 'it will be make sure that the music doesn't stop' (37e).

No	Loc	Seq	Verbatim	Enun	Persp	D.A.	Pb/Sol
16b	P	A	tu peux faire un support de logiciel *you could do a software support*	P	Dsg	Gen Sol(b)1	make a software
16c	P		qui peut être sympa *that would be nice*	P	Ply	Arg+	
17	O		Et alors et si j'oublie-e pourquoi c'est pas un jeu *And well and if I forget why it's not a game*	O	Dsg	Inter	
18	O		ta mère qu'est-ce qu'a l'aurait dit/ *your mother, what would she say?*	O	Ply	Inter	
19	P		Ben elle va dire parce que y'a y'a rien à faire *Well she would say because there is nothing to do*	*P'*	Ply	Arg+	
20	O		Ben si y'a à faire= *Well yes there is something to do*	O	Ply	Arg-	
21	P		= non mais y'a rien à faire de cla-classique d'un jeu\ *No, but there is nothing to do that is classic from games*	P	Dsg	Arg+	
22	O		Ben elle en sait rien [(inc) *Well she does not (inc)*	*P'*	Ply		
23	P		[(inc) non mais elle sait c'que c'est un jeu vidéo\ (*inc) no but she knows what is a video game*	*P'*	Ply		
24	O		Ben moi j'pense alors pour quelqu'un qui ne sait pas ou qui ne joue pas= *Well me, I think that for someone that does know or that does play*	O	Ply	Arg-	
25	P		=à moins que ce soit un outil ou une application tu vois ça sera pas un jeu au sens stricto senso *Unless that it would be a tool or an application, you see it won't be a game in a strict sense*	P	Dsg	Refi	
26	O		Ben oui mais dis moi pourquoi ça te gène/ (inc) s'extraire avec la notion de jeu et je pense que tous les critères qu'elle a si tu les descends avec les paramètres si tu dis qui faut un personnage je te dis ok dans tetris y'a pas de personnage *Well yes, but tell me why it is bothering you (inc) extract youself from the notion of a game and I think that all the criteria that she has, if you check them with parameters, if you say it needs a character, I say well in Tetris, there is no character*	O	Dsg	Arg-	
27	P		Mais je pense que la perception qu'elle va avoir la perception première (inc) *But I think that the impression that she would have the first impression*	P	Ply		
28	O		J'pense que en tout cas ce que j'vérifie en [ce moment *I think anyway, what I verify now*	O	Dsg	Inter	
29	P		[ce serait bien que *I would be good that*	P			
30	O		C'est que ce que je vérifie aujourd'hui c'est que *It's what I verify today, it's*	O	Dsg	Refi	
31a	O		ça c'est raisonnement des gamers c'est-à-dire que	O	Ply	Refi	

			les gamers aujourd'hui y disent que c'est pas un jeu *that, it's the reasoning of hardgamers that is hardgamers say that it's not a game*				
31b	P		Tu l'as fait testé/ *Did you test it ?*	P	Dsg		
32	O		Oui je l'ai fait testé à tous les public et tu vois que ceux qui ont une réaction type c'est pas du jeu c'est eux *Yes I did test it with different profiles and you see that the one the had this reaction it's not a game is them*	O	Dsg	Arg-	
33	O		c'est un peu comme Rez quand Rez est sorti à l'époque les gens disait c'est pas du jeu comme quand Flower est sorti Flower y'en a qui disent que c'est pas du jeu mais c'est du jeu ça rentre pas dans les cases habituelles de ce qu'est un jeu pour eux c'est pas du jeu *It's like Rez, when Rez went out at this time players were saying it's not a game just like when Flower went out. Some say that Flower is not a game, but it's a game, it doesn't fit with the typical criteria of a game for them, it's not a game*	O	Dsg	Arg-	(analogy)
34	P		Oué parce que parce que y demande (inc) ton interface elle est uniquement matériel *Yeah because they ask (inc) you interface is only material*	P	Dsg	Arg+	
35	O		Oué mais t'as là on est avec un proto *Yeah but you have, here we work with a prototype*	O	Dsg	Arg-	
36	P		C'est pour ça qu'aujourd'hui justement le fait qu'y a pas d'interface elle est pas celle d'un jeu *That's why today the fact that you don't have an interface, it's not one of a game*	P	Dsg	Arg+	
37a	O		Suis pas sure je crois pas que ça soit = *I'm not sure, I don't believe that it's*	O	Dsg		
37b	P		=mais c'est pas (inc) *But it's not (inc)*	P			
37c	O	B	Non mais je crois je crois que la raison pour laquelle y pensent que c'est pas un jeu c'est parce que ça répond pas à l'idée classique (inc) mais c'est pas juste l'idée c'est vraiment comme on a dit t'a l'heure y s'attendent à ce qu'y ai un score un objectif clairement qui dit y faut faire tel machin *No but I believe, I believe that the reason for which they think that it's not a game is because it does't respect their classicial idea (inc), but it's not only the idea, it's really like we said before, they ask for score, a goal clearly defined that says you have to do that*	O	Ply	Arg-	
37d	O	C	peut être qu'y y sera mais y sera en négatif tu vois *maybe i twill be there, but it will be in a negative form you see?*	O	Dsg	Gen Const	
37e	O	D	comme dans-ans Pong c'est de pas perdre la balle	O	Dsg	Gen	Put goal

			euh ben là ça sera de pas faire en sorte que la musique s'arrête *like in Pong it's to not loss the ball euh well it will be to not make the music stops*			Sol(b)2	in a negative way

Table 79. The alternations of player's and designer's perspectives format in the excerpt M4E2

In this example, the alternations of player's and designer's perspectives can be sum up as :

- The sequence A Generates a solution with a designer's perspective: P generates the solution 'support for a software' by with the designer's perspective;
- The sequence B Argue the solution with a player's perspective: O argues the solution with the player's perspective;
- The sequence C Generates a constraint with a designer's perspective: O generates the constraint 'the goal will be in a negative form'with the designer's perspective;
- The sequence D Generates an alternative solution with a designer's perspective: O generates the solution 'make sure that the music doesn't stop' with a designer's perspective.

This example was brought up in order to highlight the richness of both perspectives. It stresses that the player's perspective can be engaged by numerous means. We can see that the designer P used the player's perspective to evaluate his solution through a projected player's experience "*qui peut être sympa*" 'that can be cool' (line 16c). Moreover, O asked P to hypothesize the player's experience of a potential player "*ta mère qu'est-ce qu'a l'aurait dit/*" 'your mother, what would she say' (line 18). At last, O resorted to his knowledge of a population of players, *i.e.* the hardcore gamers, to bring up the typical player's experience of this population "*comme on a dit t'a l'heure y s'attendent à ce qu'y ai un score un objectif clairement qui dit y faut faire tel machin*" 'it's really like we said before they expect a score a clearly stated goal' (line 37c). These examples show how the designers and participants can use the player's perspective in various ways by resorting to specific, hypothetical players or a population of players.

The same applies to the designer's perspective. We can highlight that the designer's perspective can be taken to evoke the classic rules of the domain "*non mais y'a rien à faire de cla-classique d'un jeu*" 'no but there is nothing classic of a game' (line 21). We can highlight that the classic rules of the domain were also brought into play with the evocation of other video games; the designer O mentioned a video game Tétris that counter-argued the requirement of a classic rule of the domain "*si tu dis qui faut un personnage je te dis ok dans tétris y'a pas de personnage*" 'if you say that it needs a character I will say ok in tetris there is no character' (line 26). Alternatively, the designer's perspective was also taken to evoke characteristics of the prototype itself; the designer's perspective was taken to focus on the prototype's aspects that supported the generated solution "*C'est pour ça qu'aujourd'hui justement le fait qu'y a pas d'interface elle est pas celle d'un jeu*" 'this is why today the fact that there is no interface it's not an interface of a game' (line 36). These illustrations show how the designers can unfold the designer's perspective by putting forward the domain's knowledge and rules, and multiple facets of the design product.

This sub-category shows that the designers may use alternatively and in a complementary manner different perspectives. Accordingly, we presented examples that highlighted the richness of the player's and designer's perspectives taken by the designers/participants.

Annex 12. Example of institutional role and expertise in directive format to trigger agreement crystallization

An example, the excerpt M2E1, will be depicted in order to illustrate how different designers with different institutional roles and expertise can be involved in the triggering agreement crystallization format. The excerpt M2E1 is taken from a meeting between the creative and project director O and the coder M (photo 43). In this meeting, the designer M showed the prototype’s evolution to O. This prototype was one of the first ones to integrate visual components, thus it is in the beginning of a transition from ‘interaction-sound’ to ‘interaction-sound-image’ prototypes. It is worth to note that at this moment, the design team only consisted of these two designers with an apprentice coder A.

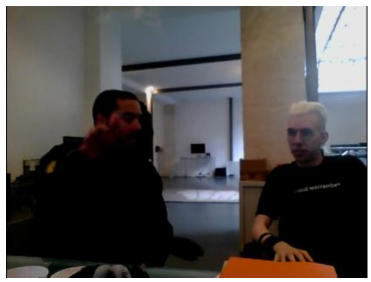


Photo 43. The excerpt M2E1 with from left to right, O and M

In this excerpt, the interest of the designers is to find a visual representation for each soundtrack that could be aesthetic (beautiful) with minimal staging. Also, these visual representations should be comprehensible for the players. The excerpt started with the generation of a first solution by O that was co-elaborated by both O and M. Then, a new problem was invested. For this problem, M followed by O generated each a solution that was co-elaborated by both designers. The portion of the segment below concerns the generation of the alternative solution by O for the second problem.

The segment (table 80) begins with the generation of a solution by O "*juste des boules justes des boules de couleurs*" 'only balls only colored balls'(line 1d). After the co-elaboration of the solution, O allocated a task to M "*ça serait bien que tu me le* [information de balance] *mettes*" 'it would be great that you integrate it [mix information]' (line 4). Then in the sequence C, M agreed to the task that O allocated to him "*ça marche*" 'all right' (line 5).

No	Loc	Seq	Verbatim (ext 2)	Persp	D.a.	Pb/Sol
1d	O	A	oui je voudrais qu'on y arrive avec juste des boules justes des boules de couleurs *yes I would like that we do it with only balls, only colored balls*	Dsg	Gen Sol(a)1	Integrate only colored balls
1e	O		vas-y Cédric chante pour moi *go ahead Cedric sing for me*	Dsg		
1f	O		tu vois ce que je veux dire si si t'avais rien qu'en jouant sur les directions <§ que ça l'arrive d'en haut §*hand left to right, up to down, right to left and down to up* ou de droite de gauche> *you see what I mean, if you would have only by playing on directions, that it arrives from above or from the right, the left*	Dsg	Refi	
1g	O		machin tu peux avoir des trucs super joli avec un §caméléon de couleurs ca peut rendre super bien §*hand open toward proto* *You could have beautiful things with a panel of colors, it could make it beautiful*	Dsg	Arg+	
1h	O		Tu vois imagines que là alors déjà peut être que imagine que au mix § que on balance§ §*points to instrument* §*snaps fingers* *You see, imagines that here well maybe, image that at the mix that we balance*	Dsg		
2	O		Est ce que tu m'as mis les informations §de balance / *hand opened and rotates L to R, R to L*§	Dsg	Inter	
3	M		euh (inc) pas non j'ai pas mis *euh (inc) no I didn't put it*	Dsg	Inter	
4	O	B	ça serait bien que tu me le mettes *it would be nice that you put it*	Dsg	mana	
5	M	C	ça marche *ok*	Dsg	agree	

Table 80. The sub-category task allocation to elicit agreement crystallization in the excerpt M2E1

In this example, the alternations of player's and designer's perspectives can be sum up as :

- The sequence A Generates a solution by an expert designer: O generates a solution of game design which corresponds to one of his expertise;
- The sequence B Allocates a task by the project director: O allocates a task to M as the project director;
- The sequence C Agrees to the allocated task by the implementer: M who is the main implementer of the design project agrees to the allocated task.

At this period of the design process, the only responsible for and expert of game design is the designer O who is also responsible for the conduct of the design project. The solution in the sequence A consisted in a game design solution for the new ‘interaction-sound-image prototype’ which was generated by O. In this case, O applied his responsibility and expertise of game designer and assumed his institutional role and expertise toward the game design. Then, O allocated a task to M (sequence B). In this sequence, the designer O took the institutional role and expertise of the director of the design project. Then, the designer M agreed to perform the task that O allocated to him which is directly link to his institutional role and expertise of expert of and responsible for the coding in the design project.

Annex 13. Example of institutional role experience in directive format to trigger problem framing

The directive format to trigger problem framing can be illustrated by the excerpt M7E3. This excerpt is taken from a meeting between the creative and project director O, the coder M and the freelance graphic artist Jt (photo 44). This latter designer just integrated the design team to work on the new orientation of the prototype –figurative visual representations– that is related to his expertise in graphic art. In this meeting, O, M and Jt were gathered to discuss about the new orientation of the prototype. The abstract interaction-sound-image prototype, used in this meeting, will be replaced by a figurative interaction-sound-image prototype. In order to do the transition, the designers will have to translate the abstract visual representations and the scenery into figurative ones.

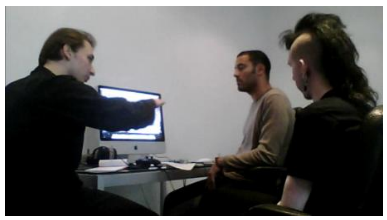


Photo 44. The excerpt M7E3 with from left to right Jt, O and M

In this excerpt, the designers' interest was to define types of scenery, types of visual feedbacks and means of appearance of these feedbacks. The excerpt started with Jt who named a first feature of the problem space to which he proposed a flow of potential solutions from an area of the solution space. This was followed by a solution generated by the designer O that set boundaries in the solution space. Then, a second feature of the problem space was evoked by Jt who again generated a flow of potential solutions. These solutions were globally argued by O who then he evoked other boundaries in the solution space. This led M to intervene in a more concrete, fine-grained level by generating a new solution. This fine-grained solution co-elaboration was however stopped by O as this solution was not at the appropriated level of abstraction. This excerpt ended with Jt bringing a last feature of the problem space. This was followed by the generation of a third flow of potential solutions of an area in the solution space. Then, a delimitation of the solution space was targeted by O. The segment presented below concerns the second out of the three features of the problem space that was brought up by Jt.

In this segment of excerpt (table 81), the designer Jt started by naming a feature of the problem space in the sequence A "*par rapport à la référence*" 'relative to the reference' (line 24a). With this named problem, Jt generated a flow of possible solutions in the sequence B "*est qu'on fait apparaitre des tiles… est qu'on fait apparaitre des lumières… est qu'on a un univers de représentations de choses complètement ésotériques complètement*" 'do we make tiles appear… do we make light appear… do we have a unverse of representations completely esoteric' (lines 24b to 24d). The solutions were first figurative objects as feedbacks of the soundtrack and a universe theme. Thus, Jt proposed an area of the solution space that consists of figurative visual representations and a type of universe.

In reaction, O specified the boundaries of the solution space in the sequence C “*les deux les deux*” ‘both both’ (line 25a). The framed problem by O set the boundaries of the targeted area in the solution space that encompasses dealing with visual representations preferable figurative within a type of universe.

No	Loc	Seq	Verbatim	Pers	D.a.	Pb/Sol
24a	JT	A	Moi je cherchais par rapport à la référence *Me, I wandered about the relation to the reference*	Dsg	Gen Pb(c)	Reference of scenery and representation
24b	JT	B	est qu’on fait apparaitre des tiles/ *do we make tiles appear?*	Dsg	Gen Sol(c)1	
24c	JT	B	est qu’on fait apparaitre des lumières/ *do we make lights appear?*	Dsg	Gen Sol(c)2	
24d	JT	B	est qu’on a un univers de représentations de choses [complètement ésotériques complètement *do we have a universe made of things’ representations completely esoteric?*	Dsg	Gen Sol(c)3	
25a	O	C	[les deux les deux *Both both*	Dsg	Gen $Sol^{+}(c)4$	Construct a universe with tiles and lights
25b	O	C	Au maximum figuratif\\ *At the maximum figurative*	Dsg	Gen const	
25c	O		mais ça peut être figuratif fantastique j’en sais rien (inc) euh et sur les trucs ou on va pas s’en sortir dans le figuratif on fera des trucs abstraits /et c’est pour ça qu’on a les lucioles de base donc je sais d’entrée de jeu que des trucs ça va être l’enfer et donc ces trucs là on va s’en débarrasser sur les lucioles mais le plus on arrive à faire du figuratif le mieux c’est (inc) ça fait un truc ça donne un côté un peu magique *but it can be fantastic figurative I don’t know (inc) euh and for the thing that will be unmanageable with the figurative, we’ll do abstract things and this is why we have the fireflies at the basis well I know for a fact that for some things it’s gonna be hell and well for these things, we will solve them with fireflies, but the more we do figurative, the more is (inc), it makes a thing, it gives an impression of magic*	Dsg	Refi	
25d	O		ça colle comment y font§> *stops the piano track* § *it fits, how they do that?*	Ply	Argu+	

Table 81. Directive format to trigger problem framing in the excerpt M7E3

In this example, the directive format to trigger problem framing unfolds like this:

- The sequence A Names a problem is performed by a designer responsible for and expert of a domain: Jt names the problem ‘the reference’ which is directly linked to his responsibility and expertise, the graphic design;
- The sequence B Generates a flow of solutions by a designer responsible for and expert of a domain: Jt generates four figurative solutions for visual representations namely ‘tiles’,

‘lights’ and ‘esoteric universe’ that are also in the realm of his responsibility and expertise, the graphic design;

- The sequence C Frames the problem by a project director: O frames the problem by specifying the targeted solution area with both visual representations of soundtrack and a universe has to be designed with a preference to figurative references as he holds the expected state of the prototype as the project director.

Annex 14. The ratings of creativity

Pb	Sol	Novel		Feasability		Solution's score	Selected 'free' condition	
		M	O	M	O		M	O
1	A	3	1	5	5	14		
1	B	2	1	5	5	13		
1	C	4	N/A	5	N/A	N/A	X	
2	A	2	1	5	2	10		
2	B	2	2	5	4	13		
2	C	4	4	3	2	13	X	
3	A	5	5	5	5	**20**		
3	B	5	5	5	5	**20**		
4	A	5	5	4	5	**19**		X
4	B	5	5	4	1	15		
5	A	5	N/A	2	N/A	N/A		
5	B	5	5	4	2	16	X	
6	A	5	5	4	3	17		
6	B	4	5	5	3	17		X
6	C	5	5	4	2	16	X	X
7(1)	A	3	2	5	4	15		
7(1)	B	5	5	5	3	**18**		X
7(2)	A	2	1	5	5	13		
7(2)	B	4	1	5	5	15		
8	A	5	5	5	5	**20**	X	X
8	B	5	2	5	5	17		
9	A	3	1	5	5	14		
10	A	5	5	4	1	15	X	X
11	A	3	5	5	5	**18**		
11	B	4	5	4	5	**18**	X	
12(1)	A	3	1	4	5	13		
12(1)	B	3	5	5	4	17		X
12(2)	A	2	5	5	5	17		
12(2)	B	2	5	5	5	17		
13	A	4	5	4	4	17		
13	B	4	5	4	4	17		
13	C	5	N/A	4	N/A	N/A		
14	A	4	5	5	5	**19**		
14	B	3	1	5	5	14		
15	A	4	1	4	5	14		
15	B	2	1	5	5	13	X	
17	A	5	5	3	3	16	X	X

18	A	4	1	5	5	15		
18	B	4	1	5	5	15		
		Min =2	Min =1	Min =2	Min =1	Mean =15,83	Tot =9	Tot =8
		Max =5	Max =5	Max =5	Max =5	Med =16		
						3rd Q =17		
						1st Q =14		
						Min =10		
						Max =20		

Table 82. Ratings of the designers for each solution

Annex 15. Degrees of creativity and collaboration formats

Degrees of creativity	*Directive format*	*Relational format*	*Representational format*
High	4	13	20
Middle	5	6	8
Low	6	7	15

Table 83. Contingency table of degrees of creativity and collaboration formats

Degrees of creativity	*Relation to anterior idea*	*No relation to anterior idea*
High	**+1,76**	-1,32
Middle	-1,24	**+0,93**
Low	-0,49	**+0,37**

Table 84. The relative deviations between degrees of creativity and relations to anterior idea

Degrees of creativity	*Idea from designers*	*Idea from players*	*Idea from other*
High	-0,36	**+0,52**	+0,08
Middle	-0,29	+0,08	**+0,49**
Low	**+0,85**	-0,83	-0,68

Table 85. The relative deviations between degrees of creativity and enunciator of the reported anterior idea

Degrees of creativity	*Speech reported with a persona*	*Speech reported without a persona*
High	**+0,44**	-1,04
Middle	-0,60	**+1,40**
Low	+0,17	-0,39

Table 86. The relative deviations between degrees of creativity and reported speech with/without a persona

Degrees of creativity	*Relation to reified solution*	*No relation to reified solution*
High	**+1,73**	-1,22
Middle	-0,28	**+0,20**
Low	-1,28	**+0,90**

Table 87. The relative deviations between degrees of creativity and relations to reified solutions

Degrees of creativity	*Intra-domain reified solutions*	*Inter-domain reified solutions*
High	**+0,71**	-1,22
Middle	-0,39	**+0,67**
Low	-0,87	**+1,50**

Table 88. The relative deviations between degrees of creativity and domains of reified solutions

Annex 16. Relative deviations of design process and degrees of creativity

Degrees of creativity	*Problem framing*	*Co-evolution of pb-sol*	*Analogical reasoning*	*Combination*	*Composition*
High	0	6	6	0	1
Middle	1	16	5	2	0
Low	1	9	1	0	1

Table 89. Contingency table of the design processes and degrees of creativity

Degrees of creativity	*Intra-domain solutions*	*Inter-domain solutions*
High	**+0,71**	-1,22
Middle	-0,39	**+0,67**
Low	-0,87	**+1,50**

Table 90. The relative deviations between degrees of creativity and sources in analogical reasoning

Annex 17. Relative deviations of collaboration formats and design processes

Collaboration formats	*Problem framing*	*Co-evolution of pb-sol*	*Analogical reasoning*	*Combination*	*Composition*
Directive	**+0,72**	+0,14	-0,98	-0,70	**+2,14**
Relational	+0,01	-0,71	**+1,45**	+0,01	-0,99
Representational	-0,42	**+0,50**	-0,61	**+0,39**	-0,42

Table 91. The relative deviations between collaboration formats and design processes in all degrees of creativity