Phonetic and Phonological Aspects of Civili Vowel Duration: An experimental approach (titre original)

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PHONETIC AND PHONOLOGICAL ASPECTS OF CIVILI VOWEL DURATION: AN EXPERIMENTAL APPROACH

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DISSERTATION PRESENTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE DOCTOR LITTERATUM IN AFRICAN LANGUAGES (PHONETICS & PHONOLOGY) AT STELLENBOSCH UNIVERSITY.

PROMOTER: PROF JUSTUS C. ROUX

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DECLARATION

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

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H.S. Ndinga-Koumba-Binza

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SUMMARY

TITLE:

Phonetic and Phonological Aspects of Civili Vowel Duration: An experimental approach

KEYWORDS:

Vowel Duration – Civili – Vowel Lengthening – Short Vowels – Long Vowels – Civili Orthography – Acoustic Measurements – Natural Duration – Perception Experiment – Perceived Duration – Phonetic (Experimental) Data – Phonological Analyses – Orthographic Implications – Speech Technology

ABSTRACT:

This dissertation is an experimental investigation of vowel duration. It focuses on phonetic and phonological aspects of vowel duration in Civili, an African language spoken in Gabon and some of its neighboring countries. It attempts to bring new insights into the phenomenon of vowel lengthening, and to assess the implications of these insights for standardizing the orthography of this language.

The dissertation contains six chapters. In Chapter 1, the specific aims of and rationale for the study are given and the research problem is demarcated. Furthermore, the potential impact of the study, the methodological approach adopted, and the sociolinguistic situation of Civili are presented.

Chapter 2 introduces the issues surrounding Civili vowel duration as the research problem of the study. The problem is presented as being both descriptive and orthographic in nature. In Chapter 2, the data and analyses of previous studies related to the phenomenon are assessed. This chapter also shows the importance of using both acoustic and perception data when studying vowel duration in Civili.

Chapter 3 focuses on the physical nature of Civili vowel duration. It reports on the acoustic analyses and vowel duration measurements performed on selected words from the corpus. The chapter aims to show that natural duration is one of the acoustic features related to vowels which should be taken into consideration in various phonological analyses.

Chapter 4 focuses on the auditory nature of Civili vowel duration. It introduces a perception experiment conducted with native speakers of Civili during this study. The aim of this experiment was to determine the perceived duration of vowels. This chapter contains the obtained experimental data and analyses thereof.

Chapter 5 provides detail on the input of experimental data into the phonological description of vowel duration in Civili. This chapter also re-explores the phonological analyses from previous studies, as well as from the present study which integrates phonetic (experimental) data and phonological analyses.

Chapter 6 draws the general conclusion of this study on the Civili vowel duration by listing the acoustic, the perceptual, and the phonological findings. This chapter also makes recommendations for the standardization of the Civili orthography as far as its vowel system is concerned. Then, the chapter presents implications for phonological theory and human language technologies. Finally, it provides suggestions for further research, including research on other Gabonese languages.

OPSOMMING

TITEL:

Fonetiese en fonologiese aspekte van vokaalduur in Civili: 'n eksperimentele benadering

SLEUTELWOORDE:

Duur van Vokale – Civili – Vokaalverlenging – Kort Vokale – Lang Vokale – Civili Ortografie – Akoestiese Metings – Natuurlike Duur van Vokale – Persepsie-eksperiment – Persepsie van Duur van Vokale – Fonetiese (Eksperimentele) Data – Fonologiese Analises – Ortografiese Implikasies – Spraaktegnologie

OPSOMMING:

Hierdie proefskrif behels 'n eksperimentele ondersoek na vokaallengte. Dit fokus op fonetiese en fonologiese aspekte van vokaallengte in Civili, 'n Afrikataal wat in Gaboen en sommige omliggende lande gepraat word. Daar word gepoog om nuwe insigte oor die verskynsel van vokaalverlenging te lewer, en om die implikasies van hierdie insigte vir die standaardisering van die ortografie van Civili te bepaal.

Die proefskrif bestaan uit ses hoofstukke. In hoofstuk 1 word die spesifieke doelstellings van en die rasionaal vir die studie gegee en word die navorsingsvraag afgebaken. Verder word die potensiële impak van die studie, die metodologiese benadering wat gevolg is, en die sosiolinguistiese situasie van Civili uiteengesit.

Hoofstuk 2 stel die navorsingsvraag van hierdie studie as een wat handel oor kwessies aangaande vokaallengte in Civili. Die probleem word aangebied as een wat beskrywend sowel as ortografies van aard is. In Hoofstuk 2 word die data en analises van vorige studies oor die tersaaklike verskynsel ook geëvalueer. Verder

bespreek hierdie hoofstuk die belang van die gebruik van beide akoestiese en perseptuele data in die studie van vokaallengte in Civili.

Hoofstuk 3 fokus op die fisiese aard van Civili vokaallengte. Dit bespreek die akoestiese analises en vokaallengtemetings wat op geselekteerde woorde uit die korpus uitgevoer is. Die hoofstuk poog om aan te toon dat natuurlike duur een van die akoestiese kenmerke van vokale is wat in ag geneem behoort te word in verskeie fonologiese analises.

Hoofstuk 4 fokus op die ouditiewe aard van Civili vokaallengte. Dit beskryf die eksperiment wat in hierdie studie met moedertaalsprekers van Civili uitgevoer is. Die doel van die eksperiment was om waargeneemde duur van vokale vas te stel. Hierdie hoofstuk bevat die verkreë eksperimentele data en die analises daarvan.

Hoofstuk 5 gee die besonderhede van die insette wat eksperimentele data lewer in die fonologiese beskrywing van vokaallengte in Civili. Hierdie hoofstuk verken ook opnuut die fonologiese analises van vorige studies, asook van die huidige studie wat fonetiese (eksperimentele) data en fonologiese analises integreer.

In Hoofstuk 6 word die algemene gevolgtrekking van hierdie studie oor Civili vokaallengte gemaak deur die akoestiese, die perseptuele, en die fonologiese bevindinge kortliks weer te gee. Die hoofstuk bevat aanbevelings vir die standaardisering van die ortografie van Civili se vokaalsisteem. Die implikasies van die bevindinge vir fonologiese teorie en vir taaltegnologie word aangebied, en voorstelle vir verdere navorsing, insluitende navorsing oor Gaboenese tale, word gemaak.

RESUME

TITRE:

Aspects Phonétiques et Phonologiques de la Durée Vocalique en Civili : Une Approche Expérimentale.

KEYWORDS:

Durée Vocalique – Civili – Allongement Vocalique – Voyelles Brèves – Voyelles Longues – Orthographe du Civili – Mesures Acoustiques – Durée Naturelle – Expérience Perceptuelle – Durée Perçue– Données Phonétiques (Expérimentales) – Analyses Phonologiques– Implications Orthographiques– Technologie de la Parole

RESUME:

Ce travail est une étude expérimentale de la durée vocalique. Il s'articule sur les aspects phonétiques et phonologiques de la durée vocalique en civili, une langue africaine parlée au Gabon et dans quelques pays voisins. Cette étude apporte un nouvel aperçu au sujet du phénomène d'allongement vocalique et évalue les implications de cet aperçu pour la standardisation de l'orthographe de la langue étudiée.

L'étude est construite sur six chapitres. Le chapitre premier présente les objectifs spécifiques de l'étude, leur argumentation et la délimitation de la problématique de recherche. L'impact potentiel de l'étude, l'approche méthodologique adoptée ainsi que la situation socio-linguistique du civili font aussi l'objet d'un traitement adéquat dans le chapitre premier.

Le chapitre 2 aborde les questions entourant la durée vocalique en civili en vue d'une circonscription nette de la problématique. Celle-ci est énoncée dans sa nature comme se posant tout autant sur le plan descriptif que sur le plan orthographique.

Dans le chapitre 2 également, les données et les analyses des études précédentes liées au phénomène d'allongement vocalique sont évaluées. Le chapitre montre ensuite l'importance de l'utilisation aussi bien des données acoustiques que des données perceptuelles dans l'étude de la durée vocalique en civili.

Le chapitre 3 se focalise sur la nature physique de la durée de la voyelle en civili. Il fait un rapport sur les analyses acoustiques et les mesures de durée vocalique effectuées sur des mots sélectionnés à partir d'un corpus spécifique. Le chapitre vise à montrer que la durée naturelle est l'une des caractéristiques acoustiques liées aux voyelles et que celle-ci devrait être aussi prise en compte dans les diverses analyses phonologiques.

Le chapitre 4 est consacré à la nature auditive de la durée vocalique en civili. Il présente une expérience perceptuelle conduite sur des locuteurs natifs de la langue. Le but de cette expérience était de déterminer la durée perçue des voyelles. Ce chapitre contient des données expérimentales obtenues et leur analyse qui s'en est suivie.

Le chapitre 5 présente l'apport des données expérimentales dans la description phonologique de la durée vocalique du civili. Ce chapitre re-explore aussi les analyses phonologiques des études précédentes ainsi que celle de la présente étude qui intègre données (expérimentales) phonétiques et analyses phonologiques.

Le chapitre 6 tire la conclusion générale de cette étude sur la durée vocalique en civili en transcrivant les conclusions acoustiques, perceptuelles que phonologiques. Ce chapitre établit aussi des recommandations pour la standardisation de l'orthographe du civili en ce qui concerne son système vocalique. Puis, il met en relief les implications de cette étude pour la théorie phonologique et les technologies du langage humain. Enfin, ce chapitre fournit des suggestions pour des recherches futures, y compris la recherche sur d'autres langues gabonaises.

DEDICATION

I offer this dissertation to Him in whose name, with whose strength, energy and inspiration, and for whose glory it has been done, ***JESUS*-CHRIST**;

to those who know how to build me up,

Anne & Augustin TIWINOT

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Catherine & Jacob BIGOUNDOU

Cornelia Delina & Justus Christiaan ROUX

Nicole & Martin ESSONO NDOUTOUMOU

Joséphine & François MAKOSSO TCHIAMA;

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"Veuillez trouver en ce travail l'expression même de l'amour que je vous dois".

Action de grâce

L'Eternel me fait grâce,
sans tenir compte de ma race
Il me donne l'intelligence,
me remplit de sagesse et science.

Tant pour comprendre et connaître
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Il enrichit mon entourage :
je ne manque pas de parents
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Mais ces dons ont un dessein,
celui de reconnaître enfin
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PREFACE

Introduction

The research and experimental work contained in this dissertation were performed in the Stellenbosch University Centre for Language and Speech Technology (SU-CLaST) from January 2002 to October 2007, both in Stellenbosch, South Africa, and in Mayumba, Gabon. This was done under the supervision of the promoter of this study.

For the sake of the theoretical orientation of this study, six months' coursework was done under the guidance of the promoter (January-June 2002). This training, which included a computer-based self-study course supplied by SU-CLaST (then Research Unit for Experimental Phonology at the University of Stellenbosch) in the Department of African Languages, covered the following areas:

- Linear and non-linear phonological theories
- The nature of the phonetics-phonology interface debate, with case studies
- Introduction to speech production and speech perception
- Introduction to PRAAT functions
- Principles and practice of linguistic fieldwork
- Applied phonetics and basics of human language technologies

The main motivation for doing research on Civili has been the wish to know more about the language to which the author was introduced at the age of 11, as well as to have the language documented in order to make it possible for other researchers and educationists to carry out research and didactic work in the language.

In the first comprehensive study of this nature in the language as it is spoken in Mayumba, Gabon, the author focused on considering the sound system of Civili and its distribution in the phonology. It was necessary to consider the sound system at different levels, particularly in the domain of experimental phonology.

Now this study represents original work by the author and has not otherwise been submitted in any form to another university. Where use was made of the work of others, it has been duly acknowledged in the text.

Publications

Some of the materials contained in this dissertation have been used in the following publications by the author (H.S. Ndinga-Koumba-Binza):

Accepted:

- "Gabonese language landscape: Survey and perspectives". Accepted for publication in the *South African Journal of African Languages*.

2007:

- "Alphabet et écriture: approche historique et cas des langues gabonaises". *Ecriture et Standardisation des Langues Gabonaises*, edited by Jacques Hubert & P.A. Mavoungou. Stellenbosch: SUN Press.
- "Unités-langues et standardisation dans les langues gabonaises". *Ecriture et Standardisation des Langues Gabonaises*, edited by Jacques Hubert & P.A. Mavoungou. Stellenbosch: SUN Press.
- "Annexe: Propositions pour l'orthographe du Civili". *Ecriture et Standardisation des Langues Gabonaises*, edited by Jacques Hubert & P.A. Mavoungou. Stellenbosch: SUN Press.

2006:

- "Lexique Pove-Français/Français-Pove, Mickala Manfoumbi: Seconde Note de Lecture". *Lexikos* **16**: 293-308.
- "English in French-speaking African countries: The case of Gabon". *The Study and Use of English in Africa*, edited by Arua, A.E., M.M. Bagwasi, T. Sebina & B. Seboni. London: Cambridge Scholars Press.
- "Demographic profiles of Libreville and Lomé". *Reflections on Identity in Four African Cities*, edited by Simon Bekker & Anne Leildé. [South Africa] African Minds. 45-50.

- "Mid-vowels and vowel harmony in Civili". *South African Journal of African Languages* **26**(1): 26-39.

2005:

- "Considering a lexicographic plan for Gabon within the Gabonese language landscape". *Lexikos* **15**: 132-150.
- "Politique linguistique et éducation au Gabon: un état des lieux". *Journal of Education* **4**(1): 65-78. Réduit: Mauritius Institute of Education.

2004:

- "Vowel duration issue in Civili". *South African Journal of African Languages* **24**(3): 189-201.

Oral Presentations

In addition, several parts of the work contained in this dissertation have been the subject of oral presentations by the author (H.S. Ndinga-Koumba-Binza):

2007

- "The combined corpus project for Yipunu, Civili and Yilumbu". General Meeting of the Gabonese Research & Scientific Discussion Group (GRSDG). Stellenbosch: 10 June 2007. (In collaboration with L. Mabika Mbokou).
- "Phonetic & phonological aspects of Civili vowel duration". NUL-SU Workshop hosted by the Stellenbosch University. Stellenbosch: 23 March 2007.

2006

- "Prospecting data for a vowel-duration study in Civili". Interim Conference of the African Language Association of Southern Africa (ALASA). University of Cape Town, South Africa: 3-5 July 2006.

2005

- "Bantu languages and the syllabic nasal: Historical observations and experimental analysis". Regional conference of the African Languages Association of Southern Africa (ALASA). Western Cape region: 20 May 2005. Stellenbosch, South Africa. (In collaboration with L. Mabika Mbokou).

2004

- "Vowel quality in Civili: The issue of data and experimentation". Interim Conference of the African Language Association of Southern Africa (ALASA) held at the National University of Lesotho, Roma: 5-7 July 2004.

2003

- "Etude de la quantité vocalique en Civili: données phonétiques et théorie phonologique". 36th International Meeting of the Societas Linguistica Europaea (SLE). Lyon, France: 4-7 September 2003.
- "An aspect of the Civili tonal system: Tone formation through vowel lengthening". 12th biennial international conference of the African Language Association of Southern Africa (ALASA) held at Stellenbosch University, South Africa: 7-11 July 2003.

2002

- "Experimenting Civili vowel-sound system". African University Day. Stellenbosch University: 12 November 2002.

Symbols & Abbreviations

The current IPA notation as presented in the *Handbook of the International Phonetic Association* (1999) is used in this dissertation for the phonetic transcription of linguistic items and texts. However, some of the symbols used for specific phonological and orthographic purposes of this work differ from the symbols of the International Phonetic Alphabet (IPA).

As mentioned in Cresseils (1994: 26-27), it is customary for scholars of African languages to make use of some of the symbols of the African alphabet developed by the International African Institute (IAI). In addition, Gabonese linguists have developed the *scientific alphabet for Gabonese languages* (ASG) and the *orthography of Gabonese languages* (OLG). The latter has been used for the Civili orthographic items presented in this dissertation. The symbols, mostly used in the in orthographic spellings, are:

Used	**IPA**
j	dʒ
y	j
ny	ɲ
ü	y
c	tʃ

Orthographic transcriptions are made using the Gabonese orthographic system revised in 1999 (Idiata, 2002). The IPA, IAI, ASG and OLG charts are included in the appendices for ease of consultation.

It should be noted that in this dissertation the marking of tones and other suprasegmental features at the orthographic level does not occur. In addition, the Civili phone **[ə]** is orthographically represented as **a**, and phonologically transcribed as **/a/** at a word-final position following the traditional Civili phonological-orthographic representations.

Notes are presented at the end of each chapter. Abbreviations and conventions not explained in these end notes but used throughout this dissertation are the following:

C	Consonant
G	Glide
CG	Consonant + Glide cluster
H	High tone
HUMARGA	Computer Laboratory for Arts, Education, Law and Theology Faculties
L	Low tone
Lg	Long
MP	Minimal pair context

N	Nucleus or Nasal, depending on context of use
NC	Nasal + Consonant cluster
NG	Nasal + Glide cluster
O	Onset
RUEPUS	Research Unit for Experimental Phonology at the University Stellenbosch
Sh	Short
Speaker 1	GMN
Speaker 2	RMB
Speaker 3	SBT
Speaker 4	VM
SU-CLaST	Stellenbosch University Centre for Language and Speech Technology
UOB	Omar Bongo University
SU	Stellenbosch University
V or **v**	Vowel
V: or **v:**	Long vowel
VD	Vowel duration
x	Timing unit or position in the skeleton
[ ]	Phonetic tier
/ /	Phonemic tier
| |	Underlying tier
[ ]	Morphemic tier
[[ ]]	Morpheme limit within a word in autosegmental morphology

[O] Online reference

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VITAM IMPONDERE VERO ET CHRISTO, DEO SOLI GLORIA!

CHAPTER 1

Orientation

1.1 Introduction

This thesis focuses on phonetic and phonological aspects of vowel duration in Civili, an African language spoken in Gabon and a few of its neighboring countries[1]. It attempts to bring new insights to existing views on the phenomenon of vowel lengthening, and to assess the implications of these views for the creation of a standard orthography in this language.

This chapter is structured as follows**:** Section 1.2 contains the specific aims of the study. The rationale for the study and a demarcation of the research problem are provided in section 1.3. This is followed by a brief discussion of the potential impact of the study in section 1.4. Section 1.5 contains an exposition of the methodological approach adopted. In section 1.6, an overview of the socio-linguistic situation of Civili is given. Section 1.7 concludes with an overview of this study, providing a preview of each chapter of this thesis.

1.2 Aims

This study addresses problematic aspects related to vowel duration in Civili. The study is not only theoretical in nature but also includes an empirical component. Broadly stated, the primary aim of this study is to present an experimental description of vowel duration in Civili as prerequisite for standardization of the orthography of the language.

More specifically, the aims of this study are as follows:

(i) to determine the physical nature of the phenomenon of vowel duration in Civili, i.e., at acoustic and perceptual levels;

(ii) to refine existing phonological descriptions of Civili vowel duration in view of new experimental data obtained in this study; and

(iii) to contribute towards orthographic standardization in Civili.

Eventually, the knowledge of the Civili vowel system obtained in this study is expected to contribute to the advancement of Gabonese languages in general.

1.3 Rationale and Research Problem

Civili is a developing language. Although there are some works on the history and oral literature and others offering grammatical overviews of the language, scientific information on Civili is very limited. This language has not yet been studied systematically making use of experimental phonetics.

The present study addresses two problems related to vowel duration in Civili, namely the phonetics-phonology overlap and the issue of the orthography of vowels. These two problems are discussed in detail in Chapter 2; however, they are briefly discussed here in order to contextualize the research problem.

1.3.1 Phonetic and Phonological Background

The first systematic description of the phonetics and phonology of Civili was that of Ndinga-Koumba-Binza (2000), who explained certain phonological processes, such as lengthening, assimilation, vowel harmony, and nasalization, and listed the phonemes of Civili. However, his description was based entirely on impressionistic phonetic data he had gathered.

Ndinga-Koumba-Binza (2000) only partially explained a number of phonological phenomena on the basis of data at hand. For example, as far as vowel duration is concerned, he was not able to distinguish between phonological lengthening, natural underlying long vowels and the sequencing of two identical vowels. He overcame this problem by establishing a phonetic lengthening rule, which is contextually predictable, and a compensatory lengthening rule that stems from several phonological processes such as semivocalization, prenasalization and elision. This would have been an adequate solution, had he used more reliable data, and had the contexts in which phonetic lengthening took place and those in which phonological processes took place not overlapped.

A review of previous studies on Civili vowel lengthening shows that phonetic and phonological contexts often overlap (see Ndinga-Koumba-Binza 2004). This overlap had made the phenomenon of vowel lengthening in Civili difficult to examine in an accurate manner. This obviously has an effect on the credibility of the lengthening rules for Civili proposed by Ndinga-Koumba-Binza (2000). Moreover, Ndinga-Koumba-Binza (2000) did not provide any information on the acoustic and perceptual status of vowel duration in Civili. This is problematic because, as stated by Sara Garnes (1973: 273), "*if the resulting surface forms are not attested in the spoken language itself, the phonological analysis loses its credibility*".

The phonetics-phonology interface debate has shown that there is a close relationship between phonetic data and phonological analyses (Roux 1979, Ohala 1990). That is to say, a phonological analysis can be confirmed or refuted on the basis of phonetic data; alternatively, the phonetic output predicted by phonological theories could lend credibility to or negate an analysis. Ladefoged (2003: 2) remarks that "*without knowing the phonology of a language you cannot describe the phonetics ...Of course, without some knowledge of the sounds, you cannot describe the phonology of a language*".

There are obviously different views on the nature of phonetic data. However, when focusing on vowel phenomena, Ladefoged (2003: 57) is of the opinion that "*the best way of describing vowels is not in terms of the articulations involved, but in terms of their acoustic properties*".

Both the fact that previous studies made use of impressionistic data only and the flawed explanations given to above-mentioned phonological phenomena motivated the present experimental study of Civili vowel duration.

1.3.2 Theoretical Background

The theoretical background of the research problem in this work is the phonetics-phonology interface debate. In fact, the relation between phonetics and phonology has been on debate for the last three decades (Garnes 1973; Fromkin 1975; Keating 1988 & 1996; Ladefoged 1988; Blumstein 1991; Ohala, 1990a, 1990b & 1997; and Cohn 1998). Arguments have been presented supporting the existence or non-existence of the phonetics-phonology interface[2].

The acknowledgement of this interface refers to the acceptance of the co-existence of "*two separate domains (phonetics and phonology) with their own specific boundaries… that these two domains are connected in one way or the other*" (Roux 1991: 35). On the other hand, the negation of such interface has recently been the argument of phonetics-phonology integration (Kohler 1991; Ohala 1991 & 1995a Roux 1991; Clements & Hertz 1996; Warner 1998; Hyman 2001; Naidoo 2005).

This study supports the view of Ohala (1990a) as supported and verified by Roux (1991) with materials from African languages (particularly languages of the Bantu phylum of the Niger-Congo family). According to Ohala (1990a: 154), "… *phonology and phonetics are mutually autonomous or independent whether as part of the speech universe or as disciplines*".

In addition, Roux (1991: 36) has indicated that a mutually exclusive phonetics-phonology dichotomy, as promoted by specific phonological theories, may actually (i) obscure understanding of many phenomena and (ii) cause abstract phonological descriptions to loose credibility.

At the understanding of Roux (1991) and Naidoo (2005) an (inclusive) integrated approach of phonetics and phonology may "*lead to better understanding of a particular situation*" (Roux 1991: 36). In this approach, which is "*bridging the phonetics-phonology dichotomy*"(Naidoo 2005: 107), phonetic representations or outcomes are being incorporated into phonological descriptions (Ohala 1995a).

The integrated approach of phonetics and phonology has been applied in the study of a number of phenomena. The contributions of these studies follow two perspectives:

(i) either to demonstrate the phonetics-phonology integration (Roux 1979 & 1991),

(ii) or to better describe problematic phenomena (Ohala 1991; Roux 1979 & 1995a; Naidoo 2005; Roux & Ntlabezo 1996)

Vowel duration within the phonetics-phonology interface or integration has been the topic of few studies (Delattre 1962; Nooteboom 1972; Lehiste 1976; Lyberg 1977; Wissing & Burger 1991).

The present research work comes within the integrated approach of phonetics and phonology in the sense that (i) it aims to contribute to the illustration of the phonetics-phonology integration and (ii) it utilizes experimental information in order to facilitate the phonological description of vowel duration.

1.3.3 Socio-linguistic Background

The Republic of Gabon has been in the process of promoting its languages for the last twenty years. Judging by the recommendations of the Gabonese General States for Education and Training (Libreville, 17-23 December 1983), the Republic of Gabon attaches great importance to the development of native languages as well as to their integration into the education system. This is also demonstrated by the actions of the Ministry of National Education, on one hand, and that of the Ministry of Higher Education and Research, on the other hand. These actions include the following:

(i) The organization of seminars, workshops and conferences, like *Séminaire sur l'alphabet scientifique des langues du Gabon*[3] (20-24 February 1989), *Première table-ronde sur les politiques linguistiques et l'enseignement des langues gabonaises*[4] (9-11 December 1997) and *Session de concertation sur l'orthographe des langues gabonaises*[5] (8-10 April 1999).

(ii) The creation of the Department of Language Sciences at Omar Bongo University in Libreville (1994).

(iii) The creation of the Department of Applied Linguistics at the College of Education for teachers' training in Libreville (1998)[6].

(iv) The introduction of the teaching of five African languages in the Department of Anthropology at Omar Bongo University (1998).

(v) The creation of the Department of National Languages at the National Pedagogical Institute (1999).

(vi) The creation of the section of National Languages in the Department of Language Sciences at Omar Bongo University (2001).

(vii) The creation of the Department of African Literature at Omar Bongo University (2002).

Proceedings of most of the scholarly meetings mentioned above in (i) have been published and the recommendations made are progressively being put into practice.

Scientific knowledge of Gabonese languages could be a fundamental asset to the promotion of these languages and their introduction into the education system. Thus, linguistic and phonetic research enables didactic transpositions for teaching and learning's sake as well as durability of these languages. However, research on the phonetics of Gabonese languages is still at an embryonic level, as language sciences are new study and research fields in Gabon. According to Idiata (2002: 45), phonetic and phonological studies constitute about 40% of the linguistic work done on Gabonese languages from 1975 to 2000. However, these phonetic and phonological studies mainly focused on articulatory aspects of sounds as proper means to enable phonological analyses. No review of phonetic studies of Gabonese languages records a one on acoustic and/or perceptual aspects of any Gabonese language (see Ndinga-Koumba-Binza 1999, 2004; Idiata 2002).

1.4 Impact

This study will present the first set of experimentally verified acoustic-perceptual data on the vowel system of Civili, which in turn may be relevant for the following:

(i) A reassessment of the orthography of the language.

(ii) Linguistic studies, especially future phonological and phonetic studies.

(iii) Applications in the field of speech therapy, in the sense that the study will provide some form of normative data on Civili.

(iv) Future speech technology applications, in that the results may be of use when devising automatic speech recognition systems and/or speech generation systems.

Furthermore, this study will present a specific phonological analysis of a relatively unknown language, which puts certain theoretical concepts within non-linear phonological theories to the test.

As regards orthography, Civili is not standardized as far as vowel duration is concerned (see Chapter 2 for details). The re-exploration and a better explanation of vowel duration in Civili could contribute to the revision and standardization of the writing system of the language.

In addition, Civili is the only Gabonese language that belongs to Guthrie's zone H. It is usually grouped among zone B languages within an internal classification of Gabonese languages (Kwenzi-Mikala 1987, 1990, 1998; Ndinga-Koumba-Binza 2000). Hence, it is important that Civili is described accurately and comprehensively in order to sort out its particular properties. This will lead to an accurate classification of Civili within the internal classification of Gabonese languages (Idiata 2002, 2005; Ndinga-Koumba-Binza, forthcoming A). Language description is an indispensable preliminary to the establishment of language typology; so is language typology to any language policy.

Lastly, this study could contribute to the overall development of Civili, which is a marginalized Gabonese language, and may be used as an example for similar developments in other Gabonese or other marginalized African languages. Being the first study of its kind employing experimental techniques to analyze a Gabonese language, it could stimulate further research in the speech sciences. In this specific case, we hope to make a theoretical and practical contribution towards a better understanding of African languages in general and Civili in particular, in the field of phonetics/phonology.

1.5 Methodological Approach

In this study, the vowel system of Civili is re-examined within a methodological framework that integrates both phonology and phonetics, namely within the framework of experimental phonology. This section discusses and defines the methodology used in this study.

According to Ladefoged (1997: 137),

> "*There are remarkably few extensive phonetic descriptions of languages. A few well known languages, such as English, French and Japanese have recently become well documented from the phonetic point of view, because of the needs of speech synthesis systems. But in places where there is no commercial need for detailed phonetic knowledge, often only the most prominent phonetic features of the language have been described*" (Ladefoged 1997: 137).

Based on this view, it could be said that the phonetic descriptions of many smaller languages (and this includes Civili) are merely impressionistic by nature. Very often these descriptions have not moved beyond the articulatory level.

Due to their very nature, the types of data emanating from these descriptions have proven to be inaccurate, incomplete, non-representative and even misleading. Any phonological theory attempting to explain sound patterns is bound to run into difficulties if it relies on data of this kind. It is ironic that well construed phonological theories are often lenient with respect to the acceptance of any set of (impressionistic) phonetic data (Roux 1979): should the phonological theory not be able to account for the data, it is often the theory that is changed, rather than the data that are reconsidered (Hale & Reiss 1999; Haris & Lindsey 2000).

The availability of reliable experimental methods remains a prerequisite for adequately testing various claims. Many experimental paradigms have been proposed for testing phonological hypotheses (Ohala 1995: 714), and well-established methods exist for discovering the physical correlates of different linguistic messages in cases where these physical correlates are uncertain or disputed.

This phonetic-phonological study is conducted within the framework of post-generative phonological theories and models. In order to understand the structure and the phonological behavior of any language, it is necessary to have absolute clarity on the physical aspects constituting the particular language. The physical aspects of a language are attested at three levels, namely at *articulatory level* (the actual production of sounds), at *acoustic level* (the transmission of sounds) and at *perceptual level* (the recognition and interpretation of sounds).

This study takes place within the realm of experimental phonology and focuses on the experimental verification of Civili phonetic structures and on the interpretation of problematic phonological processes in terms of an appropriate phonological theory.

According to Clark & Yallop (1995: 416), experimental phonology, also known as laboratory phonology, represents an attempt to draw together at least three research styles, namely experimental phonetics, experimental psychology, and phonological theory. In this regard, Ohala (1997: 682) states that there is nowadays "*substantial overlap between phonological, phonetic, and psychological studies of speech*". Experimental phonology is not a theoretical model of phonology as such, but an approach that usually serves as a tool for modern phonological theories.

In the words of Clark & Yallop (1995: 416), experimental phonology can be said "*to submit hypotheses about phonological organization to testing and validation of the kind which is standard in the experimental sciences, and which has been taken over, to some extent at least, by researchers in fields such as psychology, psycholinguistics and instrumental phonetics*".

In essence, experimental phonology attempts to provide clear answers to the following three general questions (Beckman & Kingston 1990: 1):

> *First, how, in the twin processes of producing and perceiving speech, do the discrete symbolic or cognitive units of the phonological representation of an utterance map into the continuous psychoacoustic and motoric functions of its phonetic representation? Second, how should the task of explaining speech patterns be divided between the models of grammatical function that are encoded in phonological representations and the models of physical or sensory function that are encoded in phonetic representations? And third, what sorts of research methods are most likely to provide good models for the two components and for the mapping between them?* (Beckman & Kingston 1990: 1)

Regarding the relationship between the phonological and the phonetic components, Beckman & Kingston (1990: 3) note the following:

> "*How can we use the physical models and experimental paradigms of phonetics to construct more viable surface phonological representations? Conversely, what can we learn about underlying phonetic representations and processes from the formal cognitive models and computational paradigms of phonology? Determining the relationship between the phonological component and the phonetic component demands a hybrid methodology. It requires experimental paradigms that control for*

> *details of phonological structure, and it requires observational techniques that go beyond standard field methods*". (Beckman & Kingston 1990: 3)

Furthermore, Beckman & Kingston (1990: 3) claim that "*the techniques and attitudes of this hybrid laboratory phonology are essential to investigating the large group of phonic phenomena which cannot be identified a priori as the exclusive province of either component*".

Ohala (1990), who claims a fundamental unity between phonological and phonetic representations, argues that phonetic considerations should constrain the phonological description directly, by including in the phonological model the primitives and principles of (i) aerodynamics, (ii) the mapping from vocal tract shape to acoustic pattern, (iii) peripheral auditory processing of the signal, and so on. He suggests that, since such constraints are not an inherent or derivable property of autosegmental formalisms, more general physical ones should simply replace autosegmental representations.

This study provides an account of the phonetic-phonological interaction in Civili. This interaction comes within the principles of mapping from vowel tract shape to acoustic pattern (Ohala 1990) and of perceptual testing.

The specific experimental procedure employed in this study consisted of the following:

(i) Gathering appropriate data on the relevant aspects of Civili phonology. In other words, the acoustic waveform of sounds of speech was examined in detail.

(ii) Evaluating the obtained data by means of statistical methods.

(iii) Making a generalization based on the data.

(iv) Expressing this generalization as a fact, and fitting the facts into a model.

This discussion serves to justify the use of scientific procedures (acoustic and auditory) for the description of problematic Civili vowel phenomena. This study integrates the orientation inspired by authors such as Roux (1979, 1991 & 1995a), Ohala (1986; 1995), Ohala & Jaeger (1986) and Clark & Yallop (1995). The latter two authors affirm that "*this move [experimental phonology] is not always free of the implication that phonology is speculative and that evidence obtained experimentally is superior to any other kind of evidence*" (Clark & Yallop 1995: 416).

1.6 Socio-linguistic Situation of Civili

A language can be defined as the phenomenon of vocal and written communication among human beings (Matthews 1997: 198). In other words, a language is a system of vocal (and/or written) signs, specific to a given community that uses it as instrument of communication. Because a language, in this case Civili, is linked to a community (or communities), Civili's geolinguistic, geographic and historical features will be introduced. Specifically, this section deals with the denomination of the language, its classification, its location, and its dialectal varieties; it also provides a literature review of the sound system of Civili.

1.6.1 Denomination

The term *Civili* is the ethno-scientific denomination of the language that the Bavili people speak. Phonetically, it is transcribed as [tʃìβílḭ̀] according to the International Phonetic Alphabet. This glossonym is also sometimes written **Tchivili**, according to a French-based orthography. The form of spelling that government uses is usually **Vili** (i.e., without the Bantu noun prefix **Ci-**).

Catholic and Protestants missionaries, colonial administrators and speakers of other languages have granted the language with some other appellations such as *Monvili*, *Fioti* or *Fiote*, *Loango*, and *Lwangu*, or *Balwango* (Mabika Mbokou 1999: 9).

These terms are generally indicative of the history of the language or its speakers or of the social behavior of the speakers. For instance, the ethnic group of Bavili comes from the former Loango kingdom (Raponda-Walker 1967: 119). They distinguished themselves as Black people (*Fioti* or *Fiote*, terms still used to refer to some inhabitants of the Zaire province, north of Angola) in order to dissociate themselves from the Portuguese people who invaded the kingdom early in the 17th century (Merlet 1991). Also, because Civili was the standard language of the court and of the middle class during the former Loango kingdom era, it has been called as *Cilwango* [tʃílwá̰ːŋgù̥], which means "the speech form of Loango" (Ndinga-Koumba-Binza 2000: 10).

As far as Civili is concerned, the administrative denomination *Vili* can lead to misunderstanding, for two reasons. The first is that it refers not only to the language (Civili), but also to the ethnic group (Bavili) and the individual (Mvili). The second reason is that *Vili* is the administrative denomination of not only Civili, but also Yivili, a speech form of another Gabonese language, namely Yinzebi (Raponda-Walker 1998: 17, 91-92; Kwenzi-Mikala 1998: 217; Ratanga-Atoz 1999: 49-51)[7]. Importantly, Civili and Yivili are not mutually intelligible and their vocabularies differ greatly (Kwenzi-Mikala 1998; Ndinga-Koumba-Binza 2000: 10).

After attainment of independence, the newly established Gabonese administration maintained as administrative denomination the confusing spelling of glossonyms and ethnonyms of Gabonese languages and ethnic groups. It is recommended that the denomination of Civili be standardized as *Civili*, amongst other reasons because this is what Bavili people themselves call their language. The spelling of this denomination adheres to the orthography accepted for Gabonese languages in 1999 (Idiata 2002).

1.6.2 Classification

Civili is part of the Kongo group (H10) of the Bantu linguistic branch. According to Guthrie's (1948) classification, Civili is referred as "H12a". However, according to the geographical-administrative classification proposed by Kwenzi-Mikala (1988: 61, 1990: 122, 1998: 217), Civili is regarded as part of the Merye group.

In Kwenzi-Mikala's inventory, Gabonese speech forms ("*parlers*", including languages and dialects) are grouped into 10 language units (see Appendix A). A language unit is a group of different speech forms that are mutually intelligible (Kwenzi-Mikala 1988; 1990). In order to establish these language units, Kwenzi-Mikala used the criteria of intercomprehension (i.e., mutual intelligibility) and the opening greeting formality *I say that* (Emejulu & Nzang-Bie 1999: 2; Nyangone Assam & Mavoungou 2000: 254).

Jacquot (1985), and later Ndinga-Koumba-Binza (2000: 11), argued that there is no primary mutual intelligibility (such as that which exists within the H10 group) between Civili and Guthrie's B40 languages that comprise the Merye language unit, with the exception of the Yilumbu variety also spoken in Mayumba in Gabon. However, Civili is mutually intelligible with B40 languages at a secondary level due to the co-habitation of speakers of various languages.

Ndinga-Koumba-Binza (2000: 12) points out that the phrase *I say that* is *mitye* [mítyɛ̀] in Civili, and not *merye* as Kwenzi-Mikala assumed. Therefore, Civili would have been included in the Kwenzi-Mikala's other language unit named *Metye*, if the mutual intelligibility between Civili and Guthrie's B50 languages – which comprise the Metye language unit – were possible.

Finally, Jacquot (1978) and Ndinga-Koumba-Binza (2000: 13) suggest a unique class, of which Civili is the only component within a geographical-administrative classification of Gabonese languages (see Appendix A). In fact, in Gabon, Civili is the only language of those in Guthrie's group H10 in which languages such as Kiyoombi (H12a) and Bembe (H11) are mutually intelligible.

1.6.3 Location

Civili is mainly spoken in two towns, namely Mayumba (3°23′S, 10°38′E) and Ndindi (3°46′S, 11°10′E) in the 5th administrative province of Gabon, referred to as the "Nyanga Province".

This study focuses mainly on the variety spoken in Mayumba, where linguistic data were collected during on-field recordings and experiments. Nowadays, Mayumba constitutes the largest settlement in the north of what it used to be called *Sya Bavili* ("Land of Bavili") of the former Loango kingdom from Angola to Gabon (cf. Ndamba 1977). In Gabon, Mayumba is where Civili is under the most pressure from other languages, namely French, Yilumbu and Yipunu, as people are becoming more bilingual or trilingual: in Mayumba, a speaker of Civili often also speaks Yilumbu fluently, and a speaker of Civili often understands Yilumbu without the need of any interpreter, and vice versa, for instance. Conversation in which interlocutors make use of two languages, one speaker using Civili and the other Yilumbu, are very common in Mayumba.

Bavili (the ethnic group whose mother-tongue is Civili) and Balumbu (the ethnic group whose mother-tongue is Yilumbu) mostly populate Mayumba. However, people from other Gabonese ethnic groups as well as from other countries also live in Mayumba, for business reasons or because they have government-appointed positions. Therefore, three languages are commonly in use in Mayumba, namely

Civili, Yilumbu and French. By contrast, only two languages (Civili and French) are commonly in use in Ndindi.

Although Civili is mainly spoken in Mayumba and Ndindi, there are a number of native Civili speakers who were born in and/or live in other Gabonese towns in other provinces, such as Libreville (the Capital city of Gabon), Port-Gentil, and Mouila (Raponda-Walker 1967: 119) (see Map 1).

Civili is also spoken in some other countries of Central Africa (cf. Lumwamu 1978). For example, Civili is the main native language in the towns Nzambi, Loango, and Pointe-Noire in the Kouilou Province of the Republic of Congo (Brazzaville). According to Mabiala (1992: 141), Civili occupies in the Republic of Congo the whole coastal plain which is 170 kilometers long and 50 kilometers wide.

Map 1: *Civili area and other towns where many Bavili live in Gabon*

(Conception by H.S. Ndinga-Koumba-Binza & drawing by A. van Niekerk)

Furthermore, Civili is, together with Portuguese, the dominant language of the enclave of Cabinda (see Map 2). Some varieties of the language, known as dialects of the Kongo language (Mudimbe 1978), are also found in the hinterland of Angola and in the Democratic Republic of Congo (DRC – Kinshasa) (see Map 2).

Languages such as Koci, Lindji, and Yombe, all spoken from DRC to Angola (Mabiala 1992: 144), are usually considered to be Civili speech forms[8].

Map 2: *Overview of Bavili land*

(Conception by HS Ndinga-Koumba-Binza & drawing by A. van Niekerk)

1.6.4 Dialectal Varieties

To date, the dialectological system of Civili has not been the subject of any systematic study. However, Ndinga-Koumba-Binza (2000) attempted an overview of the dialectology of the language as it is spoken in the Republic of Gabon. Furthermore, Mabiala (1992) highlighted some aspects of the dialects of Civili as it is spoken in the Republic of Congo. Both studies were undertaken on the basis of field observations.

This sub-section does not contain a comprehensive dialectological description of Civili; rather, it discusses some dialectological issues in order to justify why the variety of Civili spoken in Mayumba was selected for investigation in the present study.

As stated above, Civili is spoken from Gabon to the northern province of Angola. In Gabon, native speakers mention at least four distinct speech patterns of their language, namely:

(i) Civili ci moongu "upper Civili" (literal translation: "Civili of upper reaches");

(ii) Civili ci waanda "lower Civili" (literal translation: "Civili of lower reaches");

(iii) Civili ci basë baanyi "Eastern Civili" (literal translation: "Civili of those from Banio lagoon"); and

(iv) Civili ci basë lukweeku "Western Civili" (literal translation: "Civili of those from the beach" – on the Atlantic Ocean).

At first glance, this subdivision seems to represent four distinct dialects in Civili. However, meticulous observations will refute such a claim. In fact, this subdivision is made on the basis of geographic elements, namely the Banio lagoon and the beach on the Atlantic Ocean.

Upper Civili is spoken in areas around upper reaches of the Banio lagoon; this includes towns such as Ndindi and Nzambi (the latter a border town in the Republic of Congo). Lower Civili is spoken in the lower reaches of the Banio lagoon; this includes towns such as Mayumba and Malembe village. Eastern Civili is spoken along the right shore of the Banio lagoon and on the edge of the Mayombe Forest; this includes villages such as Mambi, Tchanzi, and Tiya. Western Civili is spoken along the Atlantic Ocean, including the south-west area of Mayumba and the little town of Mpilakoumbi. One may note that this subdivision is mainly a regional subdivision of the language rather than a pure dialectal subdivision that requires a systematic dialectological study. In fact, there is no dialectal homogeneity in every distinguished area. For instance, in Eastern Civili, two strong variants are found, namely Civili ci basë Cyaanzi "Civili of Tchanzi" (literally, 'Civili of those from Tchanzi') and Civili ci Tiya "Civili of Tiya". The latter variant is closer to the speech form of Ndindi, whereas the former is different from both the Mayumba and the Ndindi variants. The speech form spoken in Mambi, which is equally part of the Eastern Civili, is also distinctive.

Civili as spoken in the Republic of Congo presents a very different dialectological situation. First, the dialectology of Civili is associated with Kiyoombi (H12b) and Kikongo (H16c). Kiyoombi is claimed to be a dialect of Civili, while both are claimed to be dialects of Kikongo (Mabiala 1992: 143; Lumwamu 1978: 505; Mudimbe 1978: 512). According to Mabiala (1992: 143), the claim that Kiyoombi is merely a variety of Civili is debatable, whereas the claim that both languages are variants of Kikongo is undisputable. However, Bavili people tend to call Yoombi speakers "Bavili that live in the forest" (Bayoombi are mostly found in the Mayombe Forest), as the Bavili as such live in coastal savannas and plains along the Atlantic Ocean.

Moreover, Civili is usually said to have three dialectal varieties in the Republic of Congo. These are geographically bound, determined by the three main roads from the city of Pointe-Noire suitable for motor vehicles. These three varieties are the following, as introduced by Mabiala (1992: 144):

(i) Pointe-Noire – Malélé (N1).

(ii) Pointe-Noire – Nzassi (Cabindan border).

(iii) Pointe-Noire – Madingo-Kayes.

To conclude: Although not ideal, the least confusing practice would probably be to identify each Civili speech form or dialectal variety according to the town or the village where it is spoken, e.g. Civili of Mayumba, Civili of Ndindi, Civili of Loango, Civili of Pointe-Noire, etc., until such time as a comprehensive dialectological study has been done on Civili.

Civili of Mayumba is the variety that is described is this study.

1.6.5 Sociolinguistic Aspects of Mayumba

With the exception of Pointe-Noire in the Republic of Congo, Mayumba is the place where Civili is the most in contact with other Bantu languages, on the one hand, and with the French language, on the other. It is also the place where the language is rapidly developing in terms of both vocabulary and sound change (Mabika Mbokou 1999).

Moreover, Mayumba is traditionally viewed to be a bilingual town because both Bavili (speakers of Civili) and Balumbu (speakers of Yilumbu) are native inhabitants of the town. Nevertheless, Mayumba remains the town with the largest population of Bavili. Recall that Bavili and Yilumbu are mutually comprehensible; people from each language converse (each of them speaking his/her mother-tongue) without any interpreter.

Mention must also be made that nowadays speakers of other languages also inhabit Mayumba due to business or government positions. It is also noticeable that these people mostly learn Civili rather than Yilumbu, for various unspecified reasons.

A comprehensive synchronic study of any language would be more relevant when it reflects the actual language. For this reason, this study aimed to consider linguistic items from a geographical area in which Civili is growing and also changing. This enables one to take into account new phonic and lexical developments. These are the reasons why the form of Civili spoken in Mayumba was selected for this experimental study of the vowel-sound system of the language. However, when and where needed comparisons are made with other variants of Civili.

1.6.6 Literature review on the Civili Sound System

A first literature review of Civili was done by Ndinga-Koumba-Binza (1999). Information on the sound system of Civili is now available that was not available for inclusion in the 1999 survey. Apart from studies focusing mainly on the sound system, the present survey also takes into account some other, more general, studies on the Civili language.

Except for phonological analyses based on articulatory descriptions of sounds, no acoustic-perceptual study has ever been applied to Civili or to any other Gabonese language. However, some works on Civili phonology and tonology are available (Ndamba 1977; Blanchon 1984 & 1990; Blanchon & Nsuka-Nkutsi 1984; Mabika Mbokou 1999; Ndinga-Koumba-Binza 2000). These studies are generally focused on the inventory of phonemes and their description, and on the analysis of some phonological processes that occur in the language.

The dissertation of Ndamba (1977) constitutes the first systematic linguistic description of Civili. It is mainly a study of noun phrases of the Civili variety spoken in Pointe-Noire (Republic of Congo). The study of phonology is regarded as the necessary preliminary to any complete grammatical description, and Ndamba (1977) broaches the phoneme inventory according to the functionalist approach of the French linguist André Martinet. The phonemic processing is mainly paradigmatical.

Blanchon (1990) presented a brief overview of the Civili phonological system within the framework of a seminar on the *Alphabet Scientifique des Langues Gabonaises* ("scientific alphabet of Gabonese languages"). Due to the brevity of this paper and the nature of the information provided, it is not possible to ascertain which variety of Civili was studied. However, on the basis of a Blanchon's previous paper on Civili – comparing Civili with Yilumbu and Yipunu from a story narrated in Yilumbu (Blanchon 1984) – and on the basis of Ndamba's work (Blanchon & Nsuka-Nkutsi 1984) one can assume that Blanchon (1990) does not take into account dialectal varieties of the language.

On the basis of Ndamba's grammatical study and from linguistic data gathered from Civili native speakers from Mayumba, Mabika Mbokou (1999) studied Civili analogical phenomena at the phonological level as well as at the morphological level. Her work also presents a preliminary overview of the phonology and the morphology of the language. The phonological study focuses on the phoneme inventory and on an explanation of allophones according to a functionalist approach based on Trubetzkoy's phonological principles.

In his *Phonologie du civili de Mayumba* ("Civili of Mayumba phonology"), Ndinga-Koumba-Binza (2000) deals with the phonology of Civili in the domains of segments and processes according to a generative non-linear approach. Two aspects of this study distinguish it from aforementioned studies of the sound system of Civili: firstly, this approach has not been used before, and secondly, Ndinga-Koumba-Binza preceded his phonological analyses by an identification and description of Civili phones from phonetic data he had gathered. However, this description of phonic features was only articulatory in nature.

Moreover, some reference works on Civili display some features of an early orthography of the language. A first example is the two bilingual dictionaries of Marichelle (1902 & 1912) which have French as target language and Civili as source language for the first dictionary (1902), and Civili as target language and French as source language for the first dictionary for the second dictionary (1912). The first dictionary, which covers 224 pages, comprises a brief outline of the Civili language (Nyangone Assam & Mavoungou 2000: 263), particularly focusing on the alphabet pronunciation, the word division and identification of noun prefixes.

A second example is Garnier's (1903) 96-page book written in Civili, which provides a description of Civili spoken in Mayumba. The study of the sound system and the grammar of the language enabled him to translate the Roman-catholic catechism book into Civili (Garnier 1904). However, some letters of the Civili orthography used in all of the works are French-based.

As can be seen from the above, thus far predominantly impressionistic sound studies of Civili have been performed and there are limited investigations as far as phonetic data are concerned. The nature of the data used in the present study is both acoustic and perceptual.

1.7 Overview of Thesis

This dissertation consists of six chapters. In Chapter 1, the specific aims of and rationale for the study were given, the research problem was demarcated, and the potential impact of the study, the methodological approach adopted and the socio-linguistic situation of Civili, the studied language, were presented.

Chapter 2 introduces the Civili vowel duration issue as the research problem of the study. The problem is presented as being both descriptive and orthographic. In Chapter 2, the analyses and data of previous studies related to the phenomenon are assessed. This chapter also shows the importance of using both acoustic and perceptual data when studying vowel duration in Civili.

Chapter 3 focuses on the physical nature of Civili vowel duration. It reports on the acoustic analyses and vowel duration measurements performed on selected words from the corpus. The chapter aims to determine the natural duration as one of the acoustic features related to vowels which should be taken into consideration in various phonological analyses.

Chapter 4 focuses on the auditory nature of the Civili vowel duration. It introduces the perception experiment conducted on native Civili listeners during this study for the determination of the perceived duration. It contains experimental data and analyses, and considers the input of these into the phonological analyses.

Chapter 5 details the input of experimental data to the description of vowel duration in Civili. It indicates the implication of vowel duration description for the standardization of Civili orthography. This chapter also re-explores the phonological analyses from previous studies and the present study, which integrates phonetic data and phonological analyses.

Chapter 6 draws the general conclusion of this experimental study of the Civili vowel duration by listing (i) acoustic, (ii) perceptual and (iii) phonological findings. The chapter also presents implications for (i) the phonological theory, (ii) speech technology and (iii) Civili orthography. This chapter finally contains suggestions for further research.

Endnotes in Chapter 1

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[1] See Section 1.5 for details.

[2] See Ohala (1997) for a comprehensive study of the relation between phonetics and phonology, Ohala (1990a & 1991) and Roux (1991) for a broad discussion on the phonetics-phonology interface debate as well as for supportive arguments on the phonetics-phonology integration. Textbooks such as Katamba (1989), Lass (1984), Laver (1994), Clark & Yallop (1995) and Hudson (2000) make a clear distinction between phonetics and phonology. See Fromkin (1975), Keating (1998) and Ladefoged (1988 & 1990) for supportive arguments on phonetics-phonology interface.

[3] Seminar on scientific alphabet for Gabonese languages. All translations in this thesis are made by the author.

[4] First Round Table about the linguistic policies and the teaching of national languages of Gabon.

[5] Meeting session about the orthography of Gabonese languages.

[6] We recently got the information that the Department of Applied Linguistics at the College of Education has been closed. We have no information on the reasons of the closure.

[7] This dissertation does not ascertain that Yivili and Yinzebi refer to the same speech pattern as suggested by some scholars (Raponda-Walker 1998: 17, 91-92; Kwenzi-Mikala 1998: 217; Ratanga-Atoz 1999: 49-51). In fact, there is not yet a proper description of Yivili that would warrant a comparison with Yinzebi.

[8] This was confirmed through personal communication with Mr Jean Ernest Oliveira (Libreville, December 2003).

CHAPTER 2

Civili Vowel Duration

2.1 Introduction

The main goal of this chapter is to make a detailed introduction of the research problem that motivated the present study. The chapter subsequently aims at highlighting the Civili vowel duration issue, and assessing analyses and data of previous works related to the phenomenon of vowel duration.

A general overview of the vowel duration issue in Civili was presented by Ndinga-Koumba-Binza (2004). This chapter intends to be more specific and to present detailed elements of the problematic phenomenon.

In order to examine the issue of vowel duration in Civili, previous studies undertaken on the language will be examined briefly. In this regard, the questions to be addressed are the following:

(i) What are their claims about the above-mentioned phenomenon?

(ii) Why is vowel duration a problematic phenomenon in this language?

The complexity of the phenomenon will be demonstrated by the differences between the analyses presented in the different studies, and through difficulties encountered by the different authors. That vowel duration in Civili is a problematic phenomenon will furthermore be evident from the weakness of each analysis to be discussed here.

Previous studies (Marichelle 1902 & 1912; Ndamba 1977; Blanchon 1990; Mabika Mbokou 1999; Ndinga-Koumba-Binza 2000) examined the phonology of the Civili language entirely on the basis of impressionistic phonetic data. In Ndinga-Koumba-Binza (2000), it was extremely difficult to explain the phonological phenomenon of vowel lengthening on the basis of the available data. This raises questions about the nature of the data necessary to investigate Civili vowel duration adequately.

2.2 Phonetic-Phonological Issue

The notion of phoneme is often based on the criterion of pertinence. A segment is said to be pertinent when within a minimal context its commutation with another segment brings about a change in word meaning. Maddieson (1992: 193) states that "*most traditions of phonological analysis establish, for any given language, a set of contrasting sound types which distinguish one word from another. This set is usually designated as the phonemes or the underlying segments of the language*".

In application of this principle, called “distinctive opposition” or “contrast”, a number of authors (inter alia Ndamba 1977; Blanchon 1984, 1990; Blanchon & Nsuka-Nkutsi 1994; Mabika Mbokou 1999) agree that the Civili vowel system contains five short vowel phonemes and five long vowel phonemes, the latter in distinctive contrast to the former.

Note that the vowel chart as presented by the above-mentioned authors records three aperture degrees. This does not take into account the phonetic differences between [e] and [ɛ] and between [o] and [ɔ]. Should one make these distinctions as well, this would render four aperture degrees, with [ɛ] and [ɔ] being the third degree and [a] then the fourth. (For further details on this issue of vowel quality, see Ndinga-Koumba-Binza 2006c).

It should also be noted that the segment /a/ appears in its reduced voiceless form as [ə] in the following two positions:

(i) In a final-syllable position of a word in isolation or of a sentence or phrase (cf. Ndamba 1977; Blanchon 1990; Mabika Mbokou 1999; Ndinga-Koumba-Binza 2000).

(ii) In an unstressed nominal prefix syllable (cf. Ndinga-Koumba-Binza 2000).

Likewise, the segments /u/ and /i/ appear in their reduced voiceless form as [u̥] and [i̥] respectively when they appear in a final-syllable position of a word in isolation or of a sentence or phrase (cf. Ndamba 1977; Blanchon 1990; Mabika Mbokou 1999; Ndinga-Koumba-Binza 2000).

After attending to most of all phonological specifications, the phonemic vowel system of Civili may be presented as in Table 1.

	Front		Central		Back	
	Sh	Lg	Sh	Lg	Sh	Lg
1st degree	i	i:			u	u:
2nd degree	e	e:			o	o:
3rd degree			a	a:		

Table 1: *Long and short phonemic vowels*

For the sake of phonetic realizations, we have kept the transcriptions [ɛ], [ɔ], [ə], [u̥] and [i̥] when necessary throughout the study.

The phonemic identity of all of these long vowels is observed within the framework of the minimal pairs presented and phonologically transcribed in (1) below. For the sake of the present discussion, these words are presented phonologically in the second column, and orthographically[1] in the third column.

(1)	/i:/ vs /i/	/mí:tì/	miiti	"*I say that*"
		/mítì/	miti	"*Trees*"
	/e:/ vs /e/	/kúbè:là/	kubeela	"*To be ill*"

	/kúbèlà/	kubela	"*To be wrong, to be guilty*"
/a:/ vs /a/	/mbáːsì/	mbaasi	"*Friend*"
	/mbásì/	mbasi	"*Tomorrow*"
/o:/ vs /o/	/lóːsù/	loosu	"*Rice*"
	/lósù/	losu	"*Dirtiness, obscenity*"
/u:/ vs /u/	/mbùːsà/	mbuusa	"*Net*"
	/mbùsà/	mbusa	"*Back*"

Finally, researchers on Civili do not necessarily agree that the vowel system of this language contains ten vowels at the phonological level, in consideration of the contrastive oppositions: five long vowels /i:, e:, a:, o:, u:/ versus five short ones /i, e, a, o, u/. Rather, the phonological status of vowel duration in Civili differs from one author to another.

The main question regarding the vowel system of Civili is as follows: Is vowel duration predictable or distinctive in Civili? In other words, is length an underlying feature of certain vowels or part of a phonological process? This question receives different answers from those who have worked on the language.

One of the problems is to determine the predictability of vowel duration in the studied language. It seems inadequate and over-simplistic to only raise the distinctiveness of long vowels and claim their phonological status.

In linear phonology, phonologists have to choose from the following alternatives, translated from Denis Creissels (1994: 37):

> "*Either length is regarded as a constitutive feature of certain segments, or long vowels are regarded as a sequence of two identical vowel segments*".

That is to say that, in a linear analysis, the researcher would come up against the choice to regard vowel length as a constitutive feature of certain segments or to regard long vowels as a sequence of two identical vowels.

However, unless the researcher decides subjectively, there is no evidence that draws him/her to choose between the above-mentioned options that regard vowel duration as (i) an intrinsic feature of certain vowels, or (ii) a mere succession of two identical vowels, respectively.

Ndamba (1977) regarded vowel length in Civili as a constitutive feature of the vocalic system. He established the pertinence of the phenomenon by ways of contrast, as observed in (1) above.

Mabika Mbokou (1999: 27-32) observed that vowel length is, on the one hand, predictable and, on the other, pertinent according to minimal pairs. According to her, the phonetic vowels of Civili can be lengthened under various circumstances (except the phone [ə], which is said to be a variety of the phoneme /a/ within an unstressed syllable).

She agrees with the phonological analysis that shows a system containing five long vowels which oppose short vowels, as presented in above. She also considers vowel lengthening to be predictable:

> "*Although vowel length is phonological in Civili, we have found cases where it is predictable. In fact, in this language, any vowel that precedes a sequence Nasal + Consonant (-NC) is automatically long. Likewise, any vowel that follows a sequence Consonant + Glide (CG-) is automatically long.*" (Translated from Mabika Mbokou 1999: 31)

That is to say, phonetically a normal short vowel is automatically lengthened when it precedes a cluster N(asal) + C(onsonant) or when it follows a sequence

C(onsonant) + G(lide). For Mabika Mbokou, such kind of length is predictable, as the conditioning factors (cluster /NC/ and sequence /CG/) are systematic. She regarded this lengthening process as a phonetic rule which she illustrated with the following examples.

(2)	/ŋgándù/	ngaandu	[ŋgá:ndù̥]	"*Caiman*"
	/mjókù/	myooku	[mjó:kù̥]	"*Arms*"
	/ɲénzì/	nyeenzi	[ɲé:nzì̥]	"*Joy*"

If the examples in (1) above are true minimal pairs, and considering that the examples in (2) are not minimal pairs in all (NC and CG) positions, the argument could be as follows:

(i) Civili has long and short vowels (cf. minimal pairs), and

(ii) a phonetic long vowel should be regarded as an underlying short vowel subjected to phonetic conditioning.

However, a question remains: Why do the cluster NC and the sequence CG end up with vowel lengthening?

It can also be understood from Mabika Mbokou that vowel duration is viewed in two ways, i.e., as vowel lengthening (phonetic and phonological process) when duration is predictable and as vowel length (phonemic) when it is not. However, Mabika Mbokou's analysis does not at all address the questions of

(i) the phonemic status of vowel duration;

(ii) the difference between length and sequence of two adjacent identical vowels; and

(iii) how one should treat vowel duration in particular theories.

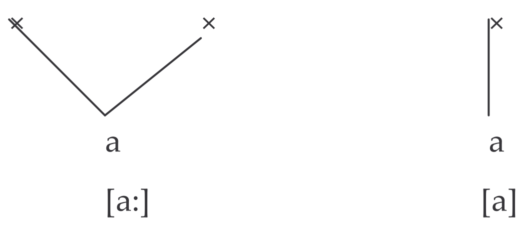
Ndinga-Koumba-Binza (2000) did not regard vowel duration as an underlying vowel feature. That is to say, vocalic length was not seen as an underlying feature of certain vowels. Following an autosegmental framework, Ndinga-Koumba-Binza (2000) escaped the alternative earlier quoted from Creissels (1994: 37), who points out that "*in a phonology that distinguishes segments from their syllabic functions, the analysis of vowels as unique segments associated with two successive positions in a* 'branching' *nucleus syllable (i.e., in a syllable whose* 'nucleus' *has two positions on the skeleton) allows to avoid this alternative*" (translated from Creissels 1994: 37).

Therefore, Ndinga-Koumba-Binza (2000) posited that a vowel is long when it occupies two timing units on the skeletal tier. In fact, Goldsmith (1990: 48) suggests this view of long vowels for every autosegmental analysis:

> "*Long vowels consist of a single vowel segment itself associated with two positions on a facing tier...*"

Fox (2000: 63) likewise notes that "*from a metrical perspective long vowels and consonants can be interpreted as geminates… occupying two positions in the metrical tree*". Thus, a long vowel could take the configurational form as illustrated in the representations in (3).

(3)



Note that **x** in (3) is a skeletal position, i.e., a timing unit. The range of x is the skeletal tier.

According to Gussmann (2002: 19), equally from an autosegmental phonological framework, "*this representation offers an extremely simple case since in a one-to-one relationship between melodic units and skeletal positions… there is quite a lot of evidence, however, which shows the need for the skeleton apart from the melodic representation*".

For this reason, the long vowels produced in Civili were theoretically regarded as a result of a lengthening process. What Mabika Mbokou regarded as predictable length was eventually explained through an autosegmental analysis as a compensatory lengthening rule that stems from phonological processes, namely prenasalization and semivocalization[2]. These processes, along with nasal deletion and vowel deletion, will now be discussed and exemplified.

Prenasalization

The process of prenasalization is the systematic association of the indeterminate nasal segment /N/ with the timing position of the adjacent oral consonant /C/, resulting in a prenasal segmental complex /NC/. This causes the adjacent vowel to spread to the skeletal position which became vacant due to the prenasalization process. This is illustrated in the configurations in (4).

(4) a. × × × × × (Underlying form)

ɲ e N z i

b. × × × × × (Disassociation of N from its ×)

ɲ e N z i

c. × × × × × (Fluttering of N)

ɲ e N z i

d. × × × × × (Prenasalization)

ɲ e N z i

e. × × × × × (Lengthening of e)

ɲ e N z i

(Other processes) e.g. final vowel reduction

[ɲé:nzì̥] "*Joy*" (phonetic output)

Semivocalization

Semivocalization or glide formation is the process by which a close vowel turns into a glide. Indeed, in Civili, the glides [j] and [w] derivate from the underlying close vowels /i/ and /u/, respectively, and for this reason, glides are not regarded as underlying segments in Civili (Ndinga-Koumba-Binza 2000: 64-66).

The semivocalization process takes place across word or morpheme boundaries where the first word or morpheme ends in /i/ or /u/ and the second starts with any vowel except /i/ or /u/. The residual vowel, the one that remains after the process of semivocalization, is systematically lengthened, occupying the skeletal timing position left vacant. This is illustrated in the configurations in (5).

(5) a. × × × × × (Underlying form)

m i o k u

b. × × × × × (Disassociation of i from its ×)

m i o k u

c. × × × × × (Fluttering of ×)

m i o k u

d. × × × × × (Semivocalization)[3]

m i o k u

e. × × × × × (Lengthening of o)

m j o k u

(Other processes) e.g. final vowel reduction

[mjó:kù̥] "*Arms*" (phonetic output)

Ndinga-Koumba-Binza (2000) added that, apart from prenasalization and semivocalization, the compensatory lengthening in Civili is also due to two additional processes, namely those of deletion of a nasal segment and vocalic elision.

Nasal deletion

In a succession of N + unvoiced C, the N is systematically deleted because of a constraint that prohibits the prenasalization of the N with a voiceless segment. The nasal deletion occurs in the same contexts as prenasalization, but only with an adjacent voiceless C. Both phenomena, i.e., prenasalization and nasal deletion, obey the constraint according to which, in a sequence N+C, the two units (N and C) should bear the *voiced* feature.

In Civili, when the N (i) precedes an unvoiced C and (ii) does not bear a tone[4], this N disappears automatically in the actual phonetic realization. This disappearance produces the systematic lengthening of the adjacent vowel that eventually occupies the skeletal position left vacant. This is shown in the configurations in (6).

(6) a. × × × × × (Underlying form)

b a N t u

b. × × × × × (Deletion of N)

b a (N) t u

c. × × × × × (Fluttering of skeletal position)

b a t u

d. × × × × × (Lengthening of a)

b a t u

(Other processes) e.g. nasalization of vowel a

[bá̰:tù̥] "*People*" (Phonetic output)

Nevertheless, orthographically, the N is written in order to keep the nasality feature that remains on the neighboring vowel. That can be seen in the orthography of the word in question in (6) above, which is normally written **Bantu**. This word, like many of those in which the vowel is usually heard as long, can also written **Baantu** (doubling the vowel), as the orthographic system of Civili has not yet been standardized.

Vowel deletion

The phenomenon of vowel deletion occurs in the same contexts as semivocalization, but only when the first vowel is not /i/ or /u/. This process appears according to universal principles proposed by Casali (1996): In a hiatus /V_1V_2/, V_1 elides. This deletion causes the lengthening of V_2, which recovers the timing unit left vacant.

Note that this process of vowel deletion is most of the time sensitive to suffixation. For example, in the configurations in (7), vowel deletion occurs in the production of the phrase "our tongue (organ)", where the suffix *–itu* "our" is added to the word *ndaka* "tongue".

(7) a. × × × × × × × × (Underlying form)

N d a_1 k a_2 i t u

b. × × × × × × × × (Deletion of a_2)

N d a_1 k (a_2) i t u

c. × × × × × × × × (Fluttering of x)

N d a_1 k i t u

d. × × × × × × × × (i spreading on x)

N d a_1 k i t u

(Other processes) e.g. final vowel reduction

[ndàkí:tù̥] "*Our tongue*" (Phonetic output)

Ndinga-Koumba-Binza (2000) also mentioned a case of phonetic lengthening that does not adhere to the compensatory lengthening rules stated above. In this particular case, vowel lengthening occurs, but not in a phonemic context of compensatory lengthening. In general, this special case of vowel lengthening only occurs before the liquids /l/ and /r/. Trask (2000: 190) stated that this seems to be a lengthening rule which commonly applies in some languages of the world. Specifically, the rule stipulates that any vowel is always phonetically realized lengthened when the vowel in question precedes a liquid (/l/ or /r/). This rule is illustrated in the following examples where a physically induced vowel length occurs.

(8)	/célà/	ceela	[cɛ́:lə̀]	"*Bait*"
	/kárásà/	kaarasa	[ká:rə́sə̀]	"*Pair of trousers*"
	/líbólà/	liboola	[líbɔ́:lə̀]	"*Basin*"

From the examples in (8) and his statement regarding vowel lengthening, it is evident that Ndinga-Koumba-Binza (2000) regarded vowel length as being predictable, both as an autosegmental phonological process and as a phonetic phenomenon. For that reason, Ndinga-Koumba-Binza (2000: 44) proposed the following as the set of underlying vowels of Civili, without taking into account assimilation through probable vowel harmony (cf. Ndinga-Koumba-Binza 2006c)[5].

	Articulation		
	Front	Central	Back
1st degree	i		u
2nd degree	e		o
3rd degree		a	

Table 2: *Underlying vowels (Ndinga-Koumba-Binza 2000)*

This table recognizes only five vowels. This is because it takes into account not the principle of distinctiveness but that of predictability. Only non-predictable segments are allowed to appear in this table. Thus, every segment of which the phonetic form can be explained in any way is excluded from this phonological table. On this view of Ndinga-Koumba-Binza (2000), long vowels in example (1) are predictably and configurationally explainable through autosegmental processes. This implies that there are no long vowels in Civili as such; rather, "long vowels" were lengthened through phonological processes. However, this conclusion still does not answer the question of differentiation between a lengthened vowel and the sequence of two identical vowels such as those illustrated in (9), for example.

(9)	[loːsu̥]	loosu	''*Rice*"
	[kubɛːlə]	kubeela	"*To be sick*"

The doubling of the vowel on the orthographic level indicates the duration of the phonic units [o] and [ɛ] (cf. Blanchon 1990). However, there is no evidence that may assist one in deciding whether this duration was caused by a long vowel ([o] or [ɛ], the lengthening of which can be explained autosegmentally through phonological processes) or by two identical adjacent vowels such as [oo] or [ɛɛ], indicated as V_1V_2. Deciding on the underlying form of a word which contains a long vowel (in this case |loosu| versus |losu|, or |kubeela| and |kubela|) is therefore a dilemma.

2.2.1 Limitations of Current Analyses

In Civili, long or lengthened vowels rarely appear in polysyllabic nominal stems. Neither do they appear in prefix syllables, if it is not a monosyllabic word or onomatopoeia such as those in (10).

(10)	/vóː/	voo	[βɔː]	"*Nothing*"

/vé:/	vee	[βɛ:]	"*Tranquil*"
/mbwí:/	mbwii	[mbwi:]	"*How is it? Fine!*"

That is to say that the contexts of appearance of long or lengthened vowels seem very restricted. In fact, the reader may have noticed from the examples given – with the exception of those given in (10) above – thus far that these vowels all occur in the penultimate syllable.

Although Ndinga-Koumba-Binza (2000) considered the contexts of appearance of long vowels and attempted to make a comprehensive analysis of the process of compensatory lengthening, some interesting cases of vowel length have not yet been studied. For example, the vowel duration such as seen in (10) above and in (11) below has been left unexplained, except for *mbaasi* "friend" and *loosu* "rice" which are the sole examples in this list to have contrasting equivalents with short vowels, as shown earlier in (1).

(11)	[kúlé:sì̥]	kuleesi	"*To show*"
	[kúlè:sì̥]	kuleesi	"*To lay*"
	[ɲ́cyé:tù̥]	n'cyeetu	"*Woman*"
	[mbá:sì̥]	mbaasi	"*Friend*"
	[tá:tə̀]	taata	"*Dad, father*"
	[má:mə̀]	maama	"*Mum, mother*"
	[já:jì̥]	yaayi	"*Oldest sibling*"
	[ló:sù̥]	loosu	"*Rice*"
	[ló:sì̥]	loosi	"*Shop*"

The challenge here is to explain this kind of duration. It is not explicable by means of a phonetic rule such as "Any vowel lengthens before the segments /s/, /t/, /m/, or /j/", because of cases such as those exemplified in **(12),** where short vowels occur in the same contexts as the long vowels in (11) above.

(12)	[míβésì̥]	mivesi	"*Bones*"
	[mátá]	mata	"*Guns*"
	[tʃílésì̥]	cilesi	"*Youngest*"
	[másì̥]	masi	"*Water*"
	[límɛ́mə̀]	limema	"*Goat*"
	[mə̀kájì̥]	makayi	"*Leaves*"
	[líbèjì̥]	libeyi	"*Mockery*"

Here it is observed that before the same segments /s/, /t/, /m/ and /y/, vowels do not lengthen. Moreover, the phonetic lengthening observed in (8) above (namely "a vowel is phonetically realized lengthened when the vowel in question precedes a /l/ or /r/") does not apply in many examples. A few of these examples are presented in (13) below. These examples like those in (12) also exclude the possibility of a rule which predicts vowel lengthening before a liquid.

(13)	[sɔ́lə̀]	sola	"*Plantation*"
	[mbúlə̀]	mbula	"*Palm wine*"
	[lúbálì̥]	lubali	"*Sardine*"

[kwɛ́rə̀]	kwera	"*Waistcoat, mini skirt*"
[kwárùtṳ̀]	kwarutu	"*Bedroom*"

These examples indicate that, despite occurring adjacent to liquids, vowels are not lengthened. This raises the question as to whether duration observed in the examples in (8), i.e., where vowels occur adjacent to liquids, and in (11) is due to the presence of long or lengthened vowels or simply to a sequence of identical vowels.

As will be argued later in this chapter, one of the principal shortcomings of previous phonological analyses is their lack of specific and reliable data. For instance, had sufficient data been obtained on vowel duration in the environments of liquids, a simple lengthening rule might not have been proposed.

In short, the following important questions regarding vowel duration remain unanswered. Answering these questions will require an examination of (i) both physical and perceptual aspects of duration and (ii) the role of the syntactic context.

(i) How should we interpret the vocalic length feature in Civili? Is there evidence on the basis of which one can decide whether these are lengthened vowels or long vowels?

(ii) Is length a structurally distinctive feature of certain vowels of this language, as observable from a limited number of minimal pairs?

(iii) Is it a length feature or a sequence of two identical vowels?

(iv) Many forms of vowel duration are observable at word level, but what happens to these forms in different syntactic environments?

(v) Is there a general rule for vowel lengthening in Civili, and, if so, how can one identify a sequence of identical vowels?

Answers to these questions require another systematic examination of the Civili vowel system. It must be accurately explained whether vowel duration is merely phonetic or whether it can be regarded as compensatory lengthening derivable by a phonological process, as mentioned previously.

Evidence must also be presented as to whether vowel duration observed in words such as *voo* [βɔ:], *vee* [βɛ:], and *mbwii* [mbwi:] presented in (10) above should be analyzed phonologically as sequences of identical vowels or not, seeing that this duration is brought about neither by compensatory lengthening rules proposed thus far, nor by the phonetic lengthening proposed by Ndinga-Koumba-Binza (2000). If one follows an autosegmental framework, it would, at first glance, be possible to assume an autosegmental configuration such as the following.

(14)

```
×    ×   ×    ×    ×
|     \ /     |    |
C      V      C    V
```

This representation seems theoretically more acceptable than the one in (15), which could render a sequence of identical vowels.

(15)

```
×    ×    ×    ×    ×
|    |    |    |    |
C    V    V    C    V
```

The problem with the configuration in (15) is that it does not obey the Obligatory Contour Principle (OCP), which does not allow the adjacency of two identical units in the underlying form. This configuration could also be problematic as far a syllable structure is concerned; one would have to stipulate whether two identical adjacent vowels imply two different syllables or not. To overcome these problems, the resulting identical vowel configurations merge according to the OCP, as shown in (14). However, nothing structurally explains why and by which process a single underlying segment in (14) occupies two timing units in the skeletal tier. Accordingly, within the theoretical framework of autosegmental phonology, there is no phonological rule to explain such vowel duration. Apart from a lack of comprehensive data, another shortcoming of the existing length/lengthening analyses (such as those of Ndinga-Koumba-Binza 2000; Marichelle 1902 & 1912; Ndamba 1977; Blanchon 1990; Mabika Mbokou 1999) could be due to the theoretical phonological patterns, i.e., due to their theoretical approach.

In other words, vowel lengthening in Civili is astride the phonetic and the phonological levels. That the problem of Civili vowel duration remains an unsolved issue is not only due to the lack of reliable data, but also to the limitations of the theoretical framework.

The phonological theories used in the available analyses of Civili vowel length need to be examined. As mentioned in the phonetics-phonology interface debate, phonetic data can confirm or disconfirm phonological analyses (Garnes 1973; Ohala 1990, 1997). Also, the phonetic output predicted by phonological theories could lend credibility to or negate the analysis. And although vowel length is seen to be phonetic, it is also considerable as phonological.

Moreover, as will be shown later in this chapter, during Mabika Mbokou's (1999: 47) investigation, different native speakers sometimes regarded Civili vowel duration as being phonologically relevant and sometimes not. The question arises as to how a phenomenon can be perceived both merely phonetic on the one hand and as phonologically relevant on the other. Surely if vowel lengthening does not bring about any semantic distinction, then it is a phonetic element depending on speech realization.

Thus, in the particular case of Civili, the difficulty in analyzing vowel length lies therein that this phenomenon seems to be regarded as both phonetic and phonological: as we regard the two dimensions as independent from each other, it should not be possible for both to be involved in the same phenomenon. In both phonetic and phonological manifestations, vowel duration is observed but hardly explainable in terms of the phonological theory.

2.2.2 Orthographic Aspect of the Problem

This sub-section intends to show the orthographic implications of the vowel duration issue in Civili. Orthographic systems of various languages are often built upon alphabets of these languages, and these alphabets are based on the phonetic and/or phonological systems of these languages (Coulmas 1996; Hombert 1990a).

The first record of an orthographic alphabet available for Civili is the one that appeared in Marichelle's dictionaries (1902 & 1912). Since then, a number of proposals (cf. Raponda-Walker 1932; Mayer 1990; Hombert 1990b; Carpentier de Changy & Voltz 1990; Idiata 2002) have been made for a unified orthography of Gabonese languages (Ndinga-Koumba-Binza 2006b & 2007c)[6].

At a conference held for the purpose of establishing a scientific alphabet for Gabonese languages (*Alphabet scientifique des langues gabonaises*), Blanchon (1990) presented not only an outline of the Civili phonology but also a proposal for the alphabet and orthography of Civili. His work consists of a brief overview of the phonological system of Civili: he lists consonants, vowels and tones, and then illustrates his proposed alphabet and orthography with a short text written in Civili. However, Blanchon (1990) does not explain how he analyzed the significance of vowel length mentioned in his proposed Civili orthography. He makes use of a succession of two identical segments in each context where it is possible to hear vowel lengthening.

Unlike Blanchon (1990), the works of Ndamba (1977), Mabika Mbokou (1999), and Ndinga-Koumba-Binza (2000) were not intended to contribute directly to the establishment of a standardized alphabet and orthography for Civili (cf. Ndinga-Koumba-Binza 2004: 190). These authors do not agree on vowel duration. For instance, from the Civili texts in Ndamba's appendices, it appears that Ndamba (1977) did not intend to indicate vowel length orthographically: the Civili words in (16) have phonetically audible vowel length; however, orthographically Ndamba (1977) and Blanchon (1990) will write them differently.

(16)	***Ndamba***	***Blanchon***	
	mama	maama	"*Mum*"
	tata	taata	"*Dad*"
	saku	saaku	"*Bag*"

It should be noted that what Blanchon did, as Creissels (1994: 37) puts it, might lead to a long vowel being regarded as a sequence of two distinct syllabic nuclei, i.e., as two syllables. This could pose some theoretical problems as well as practical difficulties during language description.

The current orthographic practice seems facultative according to the user, despite the requirements of the Orthography of Gabonese Languages of 1999. In fact, the revised orthographic system for all Gabonese languages requires doubling of the vowel for any vowel duration (Idiata 2002: 55, 2003: 40). However, the writing system of Civili, as for many Gabonese languages, has experienced a number of problems with the implementation of this requirement. Two problems need to be mentioned here:

(i) Since 1999, there has not been any campaign to inform the population of the proposed Civili writing system. In fact, the Government has been slow to endorse and implement the new orthography[7].

(ii) The practice of different users may be based on that of different views among researchers, as demonstrated in (16) above. A number of textbooks and publications reflect the non-standardization or non-harmony of the orthography with regard to vowel duration in Civili. For instance, Garnier (1903, 1904) does not consider vowel duration in his textbooks, whereas Marichelle (1902 & 1912) in his dictionaries consistently doubles vowels to indicate duration. Because different writing systems are modeled to users by the different researchers, it is advisable that the practices of the various researchers are reconciled.

In order to bring about such reconciliation, Ndinga-Koumba-Binza (2007b) has recently proposed that vowels are doubled even in predictable contexts, in order to make Civili learners aware of vowel duration. However, this proposal is not based on any evident phonetic fact.

Answers to the questions of the physical nature of vowel duration and of the difference between length and sequence of two adjacent identical vowels might help the process of standardizing the orthographic system of Civili. The following section deals with the issue of data with regard to vowel duration in Civili.

2.3 The Data Issue

The various studies available on vowel length in Civili all made use of data which can be questioned in some way. The first study to be discussed here is that of Mabika Mbokou (1999). Her corpus consisted of a list of 140 simple items, including nouns, adjectival phrases and verbs. She noticed some vowel duration – such as those presented in (1) above – that she analyzes as phonological and not as phonetic.

However, dealing with analogies when she tested her items on three native speakers of Civili, she observed that vowel length can be interpreted in various ways.

Her first speaker made a semantic distinction between short and long vowels. This establishes Civili vowel length as a pertinent phonological feature, as observed in the minimal pairs presented in (1) above. From her second informant, it appeared that long vowels do not exist; this speaker did not produce any vocalic duration. This poses another question, viz. How does this speaker distinguish between words such as those in (1)? As for the third speaker, vowel length appeared to be irrelevant: in what should be minimal pairs; this speaker did not make any distinction between long and short vowels, pronouncing them indifferently without semantic distinction. It is regrettable that Mabika Mbokou (1999) does not mention how her tests were conducted; this could have been crucial to comprehend the results obtained.

Consider three phonological studies of Civili vowels, each based on one of these informants. The conclusion would be that these three speakers each have their own phonology, one which differs from that of the other two speakers. In the words of Ladefoged (1990: 399), this "*could be true, but is by no means self-evident on other grounds*".

Because of her analogical objectives, Mabika Mbokou retraced her phonological analyses. She concluded that vowel lengthening in Civili might result from an analogical process, but she neglected to mention whether the underlying segment was short or long. She preferred to propose a basic underlying form which could be short or long, as it appears short for her second informant and both short and long without semantic distinction for her third informant. Two main points of criticism against Mabika Mbokou's work are her unknown (or unspecified) test procedures and her limited data. Not only is her corpus limited (consisting of only one set of 140 items), but it is also impressionistic. Moreover, she built her corpus with the view to do an analogical study on the phonological and morphological system of Civili. Thus, her data were not intended for a reliable treatment of the Civili vowel system, in general, or of Civili vocalic quantity, in particular.

As mentioned before, the data from Ndinga-Koumba-Binza (2000) as well as those from Mabika Mbokou (1999) were not consistent. The data gathered by Ndinga-Koumba-Binza (2000) were impressionistic and only suitable for a probable general (superficial) phonological study. The data of these two authors did not allow satisfactory analyses of vowel lengthening.

In fact, as Roux (1995b: 197) points out, "*linguists working within African languages have up to this day been quite complacent to rely almost exclusively on the impressionistic judgments of a 'trained phonetician' in compiling primary data*" (Roux 1995b: 197).

The works preceding Ndinga-Koumba-Binza (2000) could not give satisfactory answers to the issue of vowel lengthening in Civili, amongst other reasons because the phonetic data of these previous studies on the Civili vowel-sound system are very limited in nature. They are limited because they were gathered randomly without any expectation of further studies, apart from phonetic-articulatory description that enables phonological procedures such as segments inventory, features distinction and structures study.

These previous data are also impressionistic, as they were gathered from general wordlists made to serve in any kind of linguistic study. It may be assumed that these data were gathered not only for phonetic analyses, but also for morphosyntactical (Ndamba 1999), analogical (Mabika Mbokou 1999), phonological and tonological (Blanchon 1984, 1990; Blanchon & Nsuka-Nkutsi 1984; Ndinga-Koumba-Binza 2000) descriptions.

Also note that these studies did not have any acoustic data as primary source. Acoustic phonetics is the study and description of the acoustic properties of individual speech sounds, prosody and voice quality. It is a study that requires specific types of data for each specific analysis or examination. For this study, specific data for duration measurements are required. For a study focusing on Civili vowels, the first step is to gather appropriate data. According to Andy Tams (1999: 2), "*an efficient way of dealing with data is to evaluate its reliability by statistical techniques*".

In Ndinga-Koumba-Binza (2004), it was advocated that, in order to address the related phonological problem, one needs to apply scientific methods to authenticate existing Civili data and to explore larger sets of phonetic data, not only at acoustic level but also at perceptual level. The reason for this is that there is no direct relationship between the acoustic speech signal as such and its perception (Stevens 1997). For the same reason, quantified phonetic databases are required. Also argued in Ndinga-Koumba-Binza (2004: 199) is that, in order to address Civili vowel duration adequately, one should

(i) compile appropriate data;

(ii) apply procedures for acoustic and perceptual and testing; and

(iii) interpret analyses from these new data in terms of current non-linear phonological approaches.

Chapter 3 and Chapter 4 successively present these new data, which complements existing data from a previous study (Ndinga-Koumba-Binza 2000). In order to apply these phonetic data to the determination of phonological analyses, such data ought to "*satisfy at least criteria of (i) genuiness, (ii) correctness, and (iii) comprehensiveness*" (Botha, as quoted by Roux 1979: 4).

Roux (1979: 5-6) stated two criteria which data must satisfy, viz. correctness (a criterion also mentioned by Botha; cf. above) and relevance of the data. The criterion of relevance relates to data that "*represents the perceptual judgment of a speaker-hearer, then this datum is relevant to the construction/evaluation of a phonological analysis within the framework of* [post]*SPE theory*" (Roux 1979: 5-6).

For the specific case of Civili, perceptual data gathered through acoustic stimuli and perceptual tests should meet this criterion. In this study, both acoustic and perceptual data were gathered and analyzed. Gathering acoustic data consists of conducting a phonetic investigation into the acoustic properties of recorded speech (Fujimura & Erickson 1997; Ladefoged 1997, Laver 1994). Then the acquired acoustic and perceptual data were interpreted in terms of current non-linear phonological models, in a quest for a credible phonological analysis.

2.4 Summary

In this chapter, the problem regarding Civili vowel duration was introduced, as well as the need for adequate data in order to address this problematic phenomenon. It was suggested that a solution may be found in an experimental approach.

The mentioned phenomenon of vowel duration presents a certain complexity. This chapter highlighted this complexity by reviewing the existing studies and noting the irregularities of their different analyses. There are a number of questions which are extremely difficult to answer if one works with the phonological theory assumed in these studies.

Existent phonological studies based on impressionistic data and phonological theories could not clearly and efficiently explain the vowel length phenomena observed in Civili. Furthermore, for most of these Civili phonological analyses, "*the resulting surface forms are not attested in the spoken language*" (Garnes 1973: 273).

This is due to unreliable and limited data on the one hand and incapacities and limitedness of theoretical phonological frameworks on the other. Existent data and phonological analyses having lost credibility; therefore, a re-examination of the phonological processes is required.

Endnotes in Chapter 2

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[1] The orthographic system adopted in this portion of the text is that of Blanchon (1990) who recommends doubling of the vowel to indicate vowel length.

[2] Semivocalization is the process that some other authors call "glide formation" and/or "consonantization" (cf. Poulos & Msimang 1998).

[3] The process of semivocalization finally forms a consonantal cluster heard phonetically as Consonant + Glide, [Cj] or [Cw].

[4] In Civili, there are nasal prefixes that contain only the nasal unit (i.e., a prefix without a vowel). Such prefixes generally bear a high tone (Ndinga-Koumba-Binza, 2000; Mabika Mbokou & Ndinga-Koumba-Binza 2005), as in N'cyeetu [ńcjé:tù̥] "woman" and N'kwati [ńkwátì̥] "machete", for example.

[5] Acknowledging the relationship between /e/ and /ɛ/, on one hand, and /o/ and /ɔ/, on the other, might result in the vowels /ɛ/ and /ɔ/ being included into the table as underlying segments, seeing that they are not predictable.

[6] See Ndinga-Koumba-Binza (2007c) for a critical analysis of these various proposals.

[7] It is noticeable that, with regard to the development of local languages, the Gabonese Government has shown very little willpower since obtaining independence in 1960. Most pieces of evidence of development (writing system, learning and teaching, publications, etc.) are an inheritance from the colonial era through the work of missionaries and colonial administrators (Mayer 1990; Raponda-Walker 1998; Idiata & Leitch 2000; Mihindou 2001). In contrast to the government – for which these matters seem to bear low importance – Gabonese linguists have taken a number of steps towards the true development of Gabonese languages and the implementation of a proper language policy, as evidenced by a

number of publications and workshops in the last two decades. (For details, see Ndinga-Koumba-Binza 2005a, 2005b & 2006d).

CHAPTER 3

Acoustic Analysis

3.1 Introduction

This study acknowledges the existing difference between the real duration of phonetic segments and the perceived duration thereof. This chapter focuses on the physical nature of Civili vowel duration. It broadly aims to indicate that natural duration is one of the acoustic features related to vowels in Civili. The determination of this duration may assist in identifying in specific environments, contexts and position the existence of:

(i) short vowels;

(ii) long vowels, or

(iii) sequencing of two adjacent identical vowels.

This chapter mainly contains an account of speech data collection, and an acoustic analysis of vowel duration. Thereafter, the acoustic and statistical results are discussed. This is followed by a spectral analysis of long sounding vowels in order to determine the segmental status of these vowels (i.e. whether they can be interpreted as a sequence of two identical vowels or not).

The acoustic analysis is based on duration measurements made on test words drawn from acquired speech data. A test word is the word on which the measurement of vowel duration was performed[1]. The acoustic analysis also includes a statistical analysis.

3.2 Aim and Methodology

The acoustic analysis of this study was based on the following three hypotheses which, in turn, were based on claims stemming from the description of vowel duration in a language such as Civili:

(i) There are long vowels.

(ii) There are lengthened vowels due to a compensatory lengthening phenomenon.

(iii) There might be a sequencing of two identical vowels.

The main aim of this study was to test these hypotheses. Accordingly, the specific aim of the acoustic analysis was to provide information at the segmental level concerning vowel duration. More specifically, the analysis aimed at determining the real duration of each respectively short-sounding and long-sounding vowel in different contexts.

The methodology used was experimental in nature. It involved the collection and analysis of data. The method used for the collection of speech data is outlined in Section 3.3, whereas an account of the method used for the analysis of such data is given in Section 3.4.

3.3 Concepts

Throughout the analysis, the present work makes use of the following concepts, which are discussed below:

(i) Vowel duration, long-sounding and short-sounding vowels.

(ii) Contexts and positions.

3.3.1 Vowel Duration, Long-Sounding Vowel, and Short-Sounding Vowel

This work makes use of the neutral concepts of vowel duration, long-sounding vowel, and short-sounding vowel in order to avoid the labels “vowel lengthening” (or “vowel length”), “long vowel” and “short vowel” respectively, because these latter labels could imply that vowel duration in Civili is phonologically based. Since the issue of vowel duration in Civili has not yet been clarified (Ndinga-Koumba-Binza 2004), it appeared inappropriate to refer to these phenomena in the same way as which they were referred to in previous studies, given the noted incongruities in the different analyses of vowel duration.

Vowel duration is then herein understood as the natural time interval of a vowel in the speech production process. This vowel can be long or short depending on how long it takes for its production in the speech continuum. Long-sounding vowels are the so-called long or lengthened vowels in previous studies, and short-sounding vowels the so-called short vowels. Vowels in phonetic environments in which previous studies have claimed the occurrence of long or lengthened vowels have been retained with the label of "long-sounding vowels".

Short-sounding vowels are phonetically, orthographically and phonologically marked with one single vowel: as [V], V and /V/, respectively. Long-sounding vowels are phonetically marked with a single vowel plus a semi-colon ([V:]), and orthographically and phonologically with a double vowel (VV and /VV/, respectively).

3.3.2. Contexts and Positions

The corpus presented in this study will highlight some factors that might influence vowel duration. Among such factors are (according to Kent & Read 2002: 127 and Klatt 1976):

(i) tense-lax (long-short) feature of the vowel;

(ii) vowel height;

(iii) syllable stress;

(iv) speaking rate;

(v) voicing of a preceding or following consonant;

(vi) place of articulation of a preceding or following consonant; and

(vii) various syntactic factors, such as utterance position.

According to Kent & Read (2002: 127), "*some of these are inherent durational attributes (e.g., tenseness or laxness, vowel height), and other are determined by the suprasegmental properties or phonetic context (e.g., stress, speaking rate, consonant environment)*".

Since the present study builds on previous phonological studies of the vowel system of Civili, it is particularly concerned with the following factors:

(i) The position of the word to which the studied vowel belongs, i.e.,

   a. the word in isolation;

   b. the word as object in a phrase or sentence; and

   c. the word as subject in a phrase or sentence.

(ii) the context or environment of the vowel (immediate or direct phonological context, segments before and segments after).

According to certain views of the phonology of Civili, variation in duration could occur in the following environments:

(i) /C_NC/ (a vowel is long when it is followed by a nasal cluster).

(ii) /CG_C/ (a vowel is long when it follows a consonant-glide sequence).

In fact, a number of phonological descriptions and analyses (Batibo 1985: 23; Clements 1986: 45; Odden & Odden 1999: 2; Myers & Hansen 2005: 317) have stated that any vowel is lengthened or is long when

(i) it precedes a nasal segment, leading to the following formalism:

(17) $V \longrightarrow [+long] \quad / \quad \_\_N$

(ii) it follows a consonant-glide segment, thus leading to the following formalism:

(18) $V \longrightarrow [+long] \quad / \quad CG\_\_$

These claims apply to Civili, as could be seen from most of the previous studies (Marichelle 1902 & 1912; Ndamba 1977; Blanchon 1984, 1990; Mabika Mbokou 1999; Ndinga-Koumba-Binza 2000, 2003a, 2003b).

However, the organization of the corpus also took into consideration the following contexts that broaden the above theoretical formalized contexts.

(i) /C_N/ (when the vowel is followed by a single nasal consonant).

(ii) /C_C/ (when the vowel precedes a consonant stop).

(iii) /C_L/ (when the vowel precedes a liquid consonant).

In this study, then, the term "context" is mostly used to refer to the phonetic environment and the term "position" to the syntactic position in the sentence or phrase.

3.4 Speech Data Acquisition

Textbooks in phonetics – such as Laver (1994), Ashby (1995), Clark & Yallop (1995), Kent & Read (2002) and Collins & Mees (2003) – show a common agreement that the primary goal of phonetic research is threefold. Bird & Gick (2006: 463) outline this goal as:

(i) to document the different sounds that occur in natural languages (e.g., Ladefoged & Maddieson 1996);

(ii) to understand the acoustic and articulatory properties of these sounds (e.g., Miller-Ockhuizen 2003); and

(iii) to evaluate experimentally theories and models of phonetic and phonological structure (e.g., Bird & Caldecott 2004).

The present study takes place within the framework of the third aspect of the goal. As is the case for the other two aspects of the goal, it is crucial to acquire speech data from native speakers of the studied language. This study adheres to the following guideline (Bird & Gick 2006: 463):

> "*In some cases, speakers can be recorded in a laboratory setting; this is practical with many languages spoken in urban areas. When speakers cannot be brought to*

> *a laboratory, however, it is necessary to conduct phonetic fieldwork, i.e., to record speech outside of a laboratory setting*" (Bird & Gick 2006: 463).

Speech data for the present study were acquired "*outside a laboratory setting*" (Bird & Gick 2006: 463). This section intends to give an account of the speech data collection process.

3.4.1 Corpus and Test Words

This sub-section describes the general principles that governed the compilation of a set of test words compiled for data acquisition.

Given the need for new data for the experimental study of the problematic phonological phenomenon in Civili, a representative corpus for such an experimental study of the Civili vowel duration was constructed. The purpose of this corpus was to collect Civili speech data. Its function was to enable one to perform acoustic analysis and vowel duration measurements.

Linguists have often defined the term "corpus" as "*a body of written text or transcribed speech which can serve as a basis for linguistic analysis and description*" (Kennedy 1998: 1). However, for the specific purpose of this study, a corpus was taken to be a sample of language that has been collected in order to "*provide an empirical basis for describing and mapping out the use of language systems*" (De Klerk 2002: 25). This is a smaller purpose-designed corpus intended for a phonetic-phonological study.

Like many phonetic studies (e.g., Ohala 1997: 686), we aimed to use a set of minimal pairs in order to ascertain which of the cues differentiate between phonologically-specified contrasts. However, distinctive contrasts between long and short vowels are particularly rare in Civili. Therefore, the corpus consisted of:

(i) a range of words containing long-sounding and short-sounding vowels, on the one hand; and

(ii) a range of sentences and phrases containing the same words in both syntactical positions of subject and object, on the other hand.

The words included into the corpus were based on the following previous studies (available at present) on the Civili language spoken in Mayumba: Blanchon (1990, 1984); Mabika Mbokou (1999); and Ndinga-Koumba-Binza (2000).

In general, corpora have to meet certain criteria, which are usually subsumed under the general principle of representativeness. According to Kučera (2002: 246), "*in smaller specialized corpora…, the representativeness of the corpus may be a relatively straightforward principle: often it simply means the inclusion of all the relevant texts in their authentic form*".

According to Kučera (2002: 146), the principle of representativeness has been "*used and referred to rather loosely and vaguely in both corpus and non-corpus linguistics, and the differences between existing corpora suggest that there are differing views on how the general concept translate into the size and structure of a large versatile corpus*".

Compared to various corpora as dealt with in the specific field of corpus linguistics, the corpus of this study is a very limited and focused corpus. The reason for this is that, due to the aim of obtaining new and specific data for the measurement and analyses of vowel duration in Civili, it was necessary to build a reliable and specific corpus to be used for data recording.

The corpus contains 384 entries of single words in isolation and 768 sentences and phrases. The corpus is given in Appendix C. In this appendix, words are shown one by one according to the considered vowel as retained in the orthography and shown in the phonological system, i.e., the vowels /i, e, a, o, u/. There are three columns in each list. The first column shows words in Civili. The English translation of these words is presented in the second column in italics. The third column shows the French equivalents of the words. Table 3 below contains a sample of Appendix C.

	/i/	
ciima	*thing*	**chose**
lizina	*name*	**nom**
	/e/	
lisefu	*smile*	**sourire**
siseenda	*thorns, pickles*	**épines**
	/a/	
lisaafi	*lung*	**poumon**
ndaka	*tongue*	**langue**
	/o/	
n'cyoodu	*sword*	**épée**
tusoku	*spear*	**lance**
	/u/	
n'kuumba	*navel*	**nombril**
kutu	*ear*	**oreille**

Table 3: *Sample of the corpus in Appendix C*

3.4.2 Fieldwork & Informants

The fieldwork took place in the peninsula of Mayumba called "Bana" (3º23'S, 10º38'E)[2] during two periods, namely August to September 2002 and December 2002 to January 2003.

Prior to conducting fieldwork for data recording, ten Civili native speakers of various ages and educational levels were selected as informants in Mayumba in December 2001. At the time of the first fieldwork session (August-September 2002), only four speakers were available as informants, one woman and three men. One of the ten original informants had passed away before the fieldwork commenced, and another was hospitalized during the first fieldwork session and so could not be used as informant during the second fieldwork session. Another four of the originally selected speakers were also no longer available as informants. Details of the four speakers who did act as informants are given in Appendix B. Due to time limitations and logistical considerations, extra informants were not recruited.

A laptop computer with word processing facilities and a sound card was available during fieldwork. This computer incorporated PRAAT (version 4.3.12)[3] as software for actual recordings of large sets of speech data (Boersma & Weenink 1992-2001).

3.4.3 Recordings

Digital speech recordings were made of each informant individually over five sessions, without any prior rehearsal. The speech data were recorded directly at the default sampling frequency of 22 kHz using PRAAT. All recordings were made in a silent room of a house, after all occupants except the informant were asked to leave the house. All doors and windows of the house were closed in order to avoid any undesirable sound from the outside interfering with the recording.

Words and sentences from the corpus were not read to informants; every informant had to read by himself/herself the words or sentences printed on paper cards. Every single word was printed on the front of a card and two sentences (for the two positions subject and object) containing the word were printed on the back of the card. The words and sentences were all printed in French. The informants had to translate the words or sentences for themselves into Civili after reading it in French. All informants could speak and read French fluently. The reason why the words and sentences were not printed in Civili is because we wanted to ensure that the informants' pronunciation was not influenced by the orthography. Had they seen the written Civili words, they might have tended to pronounce them like they would have been written in Civili, i.e., rendering long vowels when seeing a double vowel, or short vowels when seeing a single vowel.

The informants did not see the words before the recording session, in order to prevent any pre-conditions, such as reflection on the word before producing it, as this could make the production of the words unnatural.

Each informant selected the next card by himself/herself, to ensure that the words were produced in random order. For the recording, the informant had to say the word or sentence in Civili immediately. The informant was allowed to say the word or sentence for a second time when he/she had read it incorrectly or when the microphone was misplaced or muted.

No data were recorded in spontaneous speech, except when the speakers were asked to give a short oral autobiography at the end of all recording sessions. For the present acoustic analysis, we did not use any of the spontaneous renditions.

Ladefoged (1997: 139) mentioned that "*when describing the phonetic structures of a language it is sufficient … to consider each of the phonologically contrasting items in comparable contexts*". This involved recording the complete set of vowel contrasts in a context of short versus long vowels, i.e., minimal pairs. Data whose duration has been observed in particular contexts – i.e., the context of nasal or nasal complex, the context of semivowels and the context of liquids – were also recorded.

3.4.4 Data Management

The speech data acquired during fieldwork were processed, and this data management consisted of

(i) saving sound files on the laptop computer;

(ii) identifying minimal pairs based on vowel duration (cf. Appendix D); and

(iii) selecting a list of test words for acoustic analysis.

Each word, phrase or sentence, was saved in a separate sound file with a unique filename in an appropriate directory (refer to the accompanying CD's). An example of such a file name is **G_saalu**, where the **G** is the initial letter of the speaker's name (Gilbert, in this case) and the **saalu** indicates the Civili spelling of the test word recorded in isolation.

Each speaker had five directories, one for each vowel (/i, e, a, o, u/) regardless of the sound duration (long or short). For speakers 1 and 2, each vowel directory contains two sub-directories, i.e., one for words as recorded and the other one for words as segmented in TextGrids. For speakers 3 and 4, each vowel directory contains three sub-directories, namely word in isolation, word as syntactic object and word as syntactic subject. In the sub-directory of each position, two other sub-directories are found, namely one for words as recorded and the other one for words as segmented in TextGrids.

It should be noted that the three syntactic positions were recorded in the same sound file for speakers 1 and 2, and in three different sound files for speakers 3 and 4. The change was due to a methodological mistake which occurred with the two first speakers. We found out that it was not methodologically correct to record the three syntactical positions in the same sound file. This produced very large sound files which made the transcription procedure more difficult. Note, however, that this mistake did not by any means affect the quality or the result of the data recorded.

Furthermore, linguistic items were recorded at both phonetic and phonological levels. The reason for recording at the phonetic level is because we expected to conduct an experimental phonetic investigation into the articulation and acoustic properties of the phenomenon of lengthening in order to reach the following goals (as stated by Roux 1979: 7):

(i) To gather a minimal corpus of experimentally verified phonetic data about the phenomenon.

(ii) To determine to what extent impressionistic phonetic claims may be supported, refuted, or complemented by the experimentally obtained data.

As will be shown later, these data were acoustically and perceptually analyzed (see Chapter 4 for perceptual analysis) in order to allow for phonological explanations and analyses.

Very few minimal pairs were identified for each underlying vowel (/i, e, a, o, u/). Table 4 shows a few of minimal pairs identified on the basis of vowel duration.

	/i/	
Ciika "*bed*"	vs.	Cika " *basis*"
N'tiinu "*the way to flee*"	vs.	N'tinu "*government*"
	/e/	
Ceesa "*luke*"	vs.	Cesa "*sneeze*"
Mbeela "*knife*"	vs.	Mbela "*wrong*"
	/a/	
Cibaamba "white"	vs.	Cibamba "home carboy"
Libaaku "*fever*"	vs.	Libaku "*stumble*"
	/o/	
N'tootu "*tube*"	vs.	N'totu "*earth*"
Loosu "*rice*"	vs.	Losu "*dirtiness*"
	/u/	
Mbuusa "*net*"	vs.	Mbusa "*back*"
Nduungu "*drum*"	vs.	Ndungu "*tree name*"

Table 4: *Some minimal pairs based on vowel duration*

It is important to note that, for the sake of time, not all captured speech data were measured acoustically. A selection was made from the corpus. This selection comprised (i) minimal pairs and (ii) single words containing lengthened vowels and/or compulsory contexts for vowel lengthening.

The list of test words excluded all verbs, because verbs cannot enter all the three syntactic positions considered in this study, i.e., isolation, subject, and object. The motivation for considering the syntactic positions of words resides on the fact that vowel duration is expected to be longer in penultimate syllables of sentences and/or phrases. (cf. Wissing & Burger 1991: 162).

It should be noted that for the vowel duration measurements within the acoustic analysis, the abovementioned environments are denoted as "contexts". Thus, items of the wordlist are classified into five contexts.

The acquired speech data management also entailed differentiating between the so-called long and the so-called short vowels. In fact, from recordings made on the basis of the corpus compiled, it was possible to identify and separate words containing short vowels from those containing long vowels. In order to do so, we had to listen to every word with a vowel produced in one or all the contexts for which the phonological claims stated a [+ long] feature.

3.5 Speech Data Analysis

The speech data analysis took place at one of the laboratories of the Stellenbosch University Centre for Language and Speech Technology (SU-CLaST). Speech analysis is usually defined in terms of the following three components (Ifeachor & Jervis 1993; Robinson 1998):

(i) Analysis of speech sounds, taking into consideration their method of production.

(ii) The extraction of "interesting" information as an acoustic vector.

(iii) The level or processing between the digitized acoustic waveform and the acoustic feature vector.

This study was concerned with the second component.

It is important to note that an acoustic vector is a representation of the speech sound at a specific time period of production of that speech sound. For example:

(i) the short-term power spectra;

(ii) a representation of the vocal tract shape; and

(iii) an estimation of the formant frequencies and bandwidths

However, prior to dealing with the core topics of the study, an overview of the acoustic characteristics of vowels is given. This overview aims to indicate that duration is one of the acoustic characteristics of vowels (Klatt 1976; Erickson 2000; Kent & Read 2002). Note that this is not an acoustic study of Civili vowels per se, as this was not one of the aims of the present study. For the specific purpose of this study, the core of the acoustic analysis consisted of

(i) labeling and segmentation; and

(ii) vowel duration measurements.

3.5.1 Acoustic Patterns of Vowels

This subsection intends to broadly outline the acoustic properties of vowels. However, it is not meant to fully represent a proper acoustic study of Civili vowels. The latter is not the aim of the current study. It is aimed to acknowledge that duration is amongst the acoustic characteristics of vowels (Kent & Read 2002; Erickson 2000; Klatt 1976).

Various models have been developed for the acoustic description of vowels, namely the simple target model, the elaborated target models, and the dynamic specification model (for an overview of each model, see Kent & Read 2002). The acoustic specification of vowels is often considered against these models (Kent & Read 2002: 110). According to Kent & Read (2002: 133), a full account of the acoustic cues for vowel perception seems to require consideration of:

(i) formant pattern: a particular combination of formants, as it is often used to describe the acoustic characteristics of a vowel;

(ii) spectrum: a graph showing the distribution of signal energy as a function of frequency; a plot of intensity by frequency;

(iii) duration: the physical time distance between the commencement and the end of a particular sound;

(iv) fundamental frequency (F0), also referred to as pitch, is used to indicate the perceptual phenomenon in which stimuli can be rated along a continuum of low to high:

(v) formant bandwidth; and

(vi) formant amplitude, which usually reflects the amount of energy available to the resonator.

These are the main properties used for distinguishing vowels. One should note that "*the formant pattern is reflected in the spectrum of a vowel, but vowel spectra contain information in addition to formants*" (Kent & Read 2002: 124). Vowels also vary among themselves in the fundamental frequency of phonation and in the transitions to adjacent segments, duration and amplitude, among others (Ladefoged 1975; Laver 1994; Roach 2001; Makashay 2003: 51; Collins & Mees 2003). However, these differences often are obscured by the many other factors that govern phonation, such as linguistic stress, speaker emotion and intonation (Kent & Read 2002: 128).

Kent & Read (2002: 127) have recorded duration as the third pattern for an acoustic description of vowels, after formant frequencies and spectral shape. They state that "*although duration is neglected in the traditional F1-F2 chart, it is almost always available as a cue in the physical signal of speech and many languages exploit duration as a vowel feature*" (Kent & Read 2002: 127).

The present study sought to distinguish vowels (short, long and/or double) according to the feature of duration. Therefore, detailed analyses were made of vowel segments of Civili, with specific attention to the status of long and/or double vowels.

Jones (2001: 11) mentioned that most acoustic studies on ambiguous sentences "*have revealed unanimity in their results, indicating that the fundamental frequency (F0) and segmental duration are important factors for disambiguating syntactically ambiguous sentences*". It was hypothesized that this same factor, namely segmental duration, may also be important for disambiguating Civili words within a minimal pairs. Therefore, the present study endorses the importance of segmental duration (or natural duration) in order to differentiate between short vowels, long or lengthened vowels and sequencing of identical vowels with regard to the issue of vowel duration.

In general, this analysis attempts to identify acoustic differences between original vocalic statements. Herein we agree with Jones (2001: 12) who states that the results should then be "*also statistically analyzed and then perceptually tested to increase the validity and authenticity of the research output*".

3.5.2 Labeling and Segmentation

PRAAT, the speech editing tool, has functions for speech analysis, speech synthesis, learning algorithms, labeling and segmentation, speech manipulation, listening experiments, etc. (cf. Boersma & Weenink 1992-2001). However, this study specifically made use of PRAAT's functions for speech analysis at primary level, labeling and segmentation, and listening experiments (details of the use of each function are given in the course of the chapter).

The purpose of labeling and segmentation was to identify the relevant segments, i.e., identified vowels. We used the speech-processing platform PRAAT for tagging and segmentation. Labeling and segmentation in PRAAT include:

(i) annotation, i.e., labeling intervals/waveforms and time points on multiple tiers;

(ii) the use of the phonetic alphabet; and

(iii) the use of sound files up to 2 gigabytes (3 hours), i.e., LongSound

Data are labeled in a TextGrid object, which is one of the types of objects in PRAAT. A few of the TextGrids created are represented in Appendix E, but most of them are contained in the accompanying CD-Rom. Test words were segmented and labeled from recorded utterances in the corpus, such that each phoneme in the transcription was aligned with its corresponding sound event. We provide time alignment for each test word as a whole. In the context of sentences and phrases, the segmental transcription and time alignment include only the test word; no segments from adjacent words were included in the transcription. Thus, if a segment or a pause is seen in the transcription, it was part of the pronunciation of that token. We marked beginning and end of time points of selected words and provided a segmental phonetic transcription for each word.

In the case of mid-vowels, a distinction is made at the phonetic level where these vowels are transcribed as [e] and [ɛ] for the [+FRONT] ones, and as [o] and [ɔ] for the [+BACK] ones. At the orthographic level, they are transcribed as /e/ and /o/, as respectively retained in the orthography of Gabonese languages (Idiata 2002) and in most of phonological descriptions of Civili (see Ndinga-Koumba-Binza 2006c for details on the quality of mid-vowel in Civili).

A transcription may be narrow or broader. It may be a transcription of how a word is generally uttered in a particular language, or it may attempt to capture the actual variation in how a word is uttered by one person on one particular occasion. Which level the researcher chooses to work at depends on the aim of the research. Figure 1 below, which is a PRAAT screenshot, displays the following: **A** indicates the source waveform, of recording of the word *mbeeli*; **B** is the spectrogram associated with the waveform; **C** is the tier for the name of the structure – the word *mbeeli* in this case; in **D** the phoneme under investigation is noted – the long-sounding vowel [e:] of *mbeeli*; in **E** the specific phonetic realization of the phoneme indicated in D is mentioned; and **F** indicates the space left for any relevant comments.

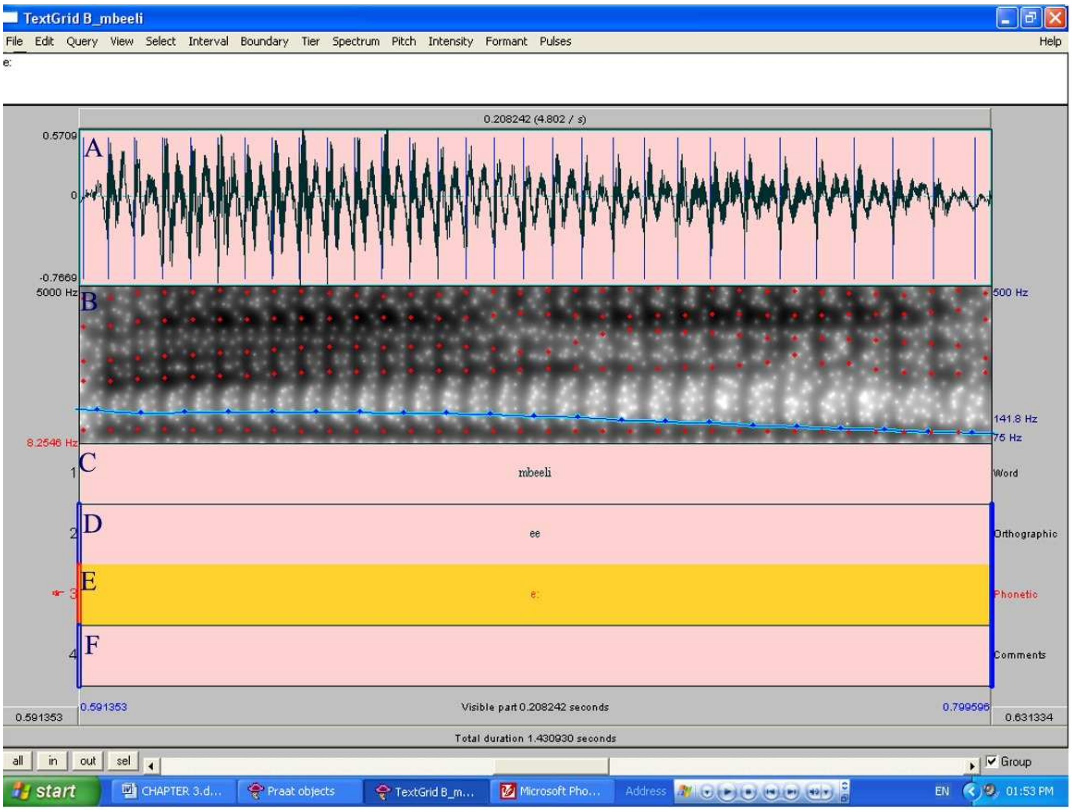

Figure 1: *A typical PRAAT screenshot showing the /ee/ within the word* /mbeeli/

Tags and transcriptions were inserted manually. The methodology of labeling and segmentation was both visual – using the source waveform (**A** in Figure 1) and the spectrogram (**B** in the figure) associated with the waveform – and auditory, as it also entailed listening to the marked speech segments.

3.5.3 Duration Measurements

Ohala (1997: 686) invokes one of the evident ways of integrating phonetics and phonology in the following terms:

> *"The common practice within phonetics of making a given measurement (e.g., vowel duration, formant frequency) on multiple tokens and reporting the means of these measurements is evidence that phonetics seeks some sort of pronunciation norm which is more abstract than any given speech token"* (Ohala 1997: 686).

This view was followed in determining the duration of Civili vowels involved in minimal pairs, and vowel duration in the identified contexts and the syntactical positions.

As mentioned earlier, the specific method for labeling and segmentation combined both auditory procedures and visual inspection procedure. Likewise, measuring the vowel duration of each target phoneme was visual. The PRAAT TextGrid shows the duration of items edited. Thus, measurements of vowel duration were made using synchronized spectrogram and waveform displays in TextGrids generated in PRAAT.

The procedure for measurement was first to determine the commencement and end of the target sound in order to set boundaries, one when the sound begins and the other when the sound ends.

The commencement boundary was set after the consonant release. The consonant release is "*the point in the expanded waveform at which wave amplitude and complexity began to rise*" (Myers & Hansen 2005: 325). Myers & Hansen (2005: 325) define the onset of the vowel as the consonant release.

Myers & Hansen (2005: 325) furthermore set the end of a non-final vowel at the onset of the following consonant. This is "*the point in the waveform where the decline in wave amplitude and complexity ended*" (Myers & Hansen 2005: 325).

In monosyllabic items and final vowels, we also followed the methodology used by Myers & Hansen (2005: 325): "*The end of a test vowel in utterance-final position was set at the end of the last fold pulse in which both F1 and F2 were visible. The measured vowel duration thus excluded the period of voiceless noise at the end of final vowels.*"

It should be noted that all measurements were made at the zero crossing line. When the studied vowel preceded a stop, the boundary was set at the last discernable period; when preceding a nasal or a liquid the boundary was set at the zero crossing line where there is distinctive change in the sound wave pattern as well as in the formant pattern; when preceding a fricative, the boundary was set at the zero crossing line of the first detection of stridency in both the waveform and the spectrum.

For the vowel onset, the boundary was set at the zero crossing line where appears the first clear indication of discernable formant frequencies given by the system.

Once boundaries were set, a tag or label could be inserted. For each tag that is selected, PRAAT shows the time, in seconds, at which the particular sound commences and ends. Finally, the duration of the target vowel was calculated as the time difference between the boundary for that vowel and the next boundary (Refer to Figures 2 and 3.).

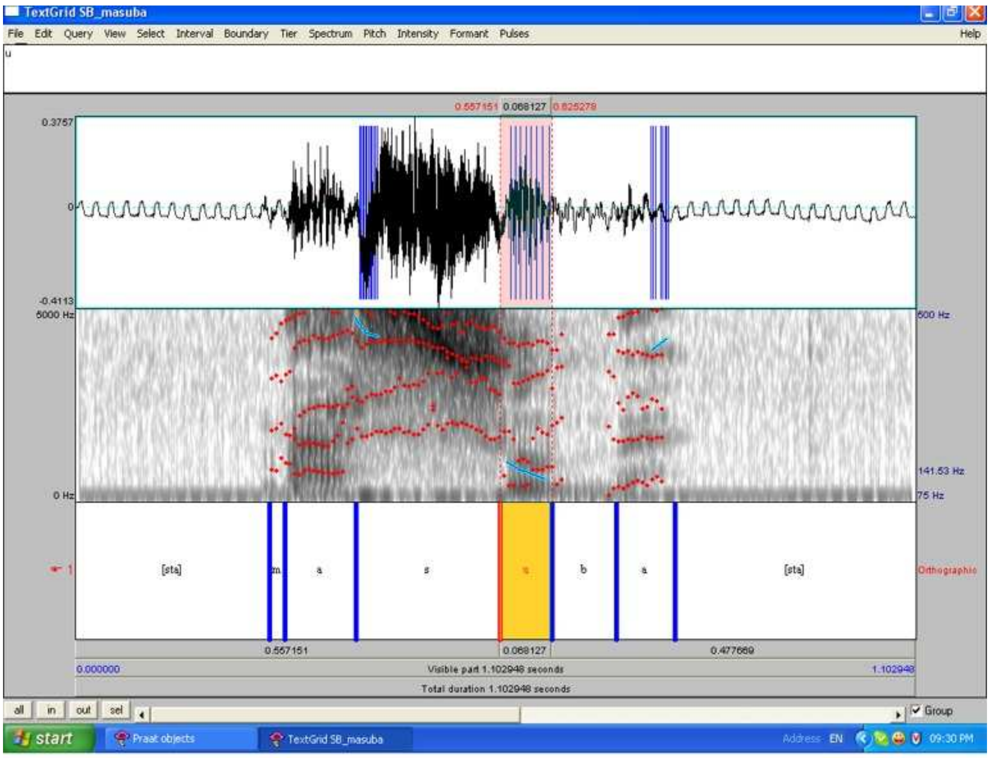

Figure 2: *Screenshot for the segmentation of the word* masuba

The screenshot in Figure 2 shows the labeling and segmentation the word *masuba*. Within the syntactical domain, the word is in its isolation position. The phonetic segments of the word are delimited with vertical boundaries. The screenshot contains only the orthographic tier of the transcription. The segment under investigation in this screenshot, the vowel [u], is highlighted (in yellow).

The selection of the highlighted segments allows a different screenshot which displays in a clearer way the specific features of the segment under investigation. (Note Figure 3 below.)

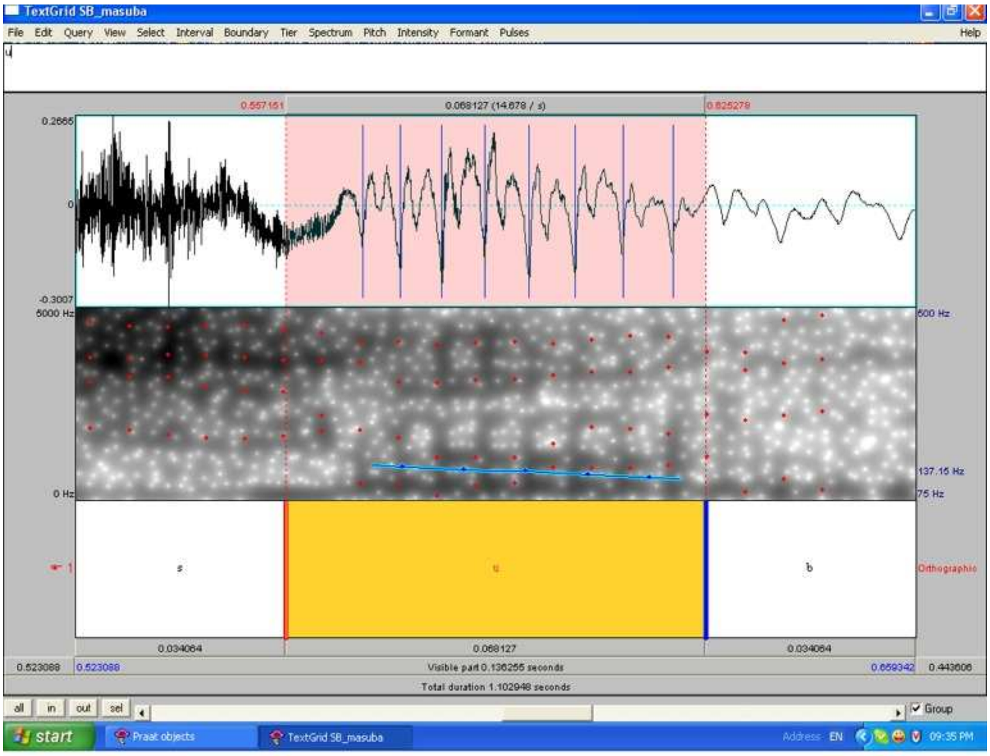

Figure 3: *Screenshot for the duration of the vowel [u] in the word* masuba

The aim of the screenshot in Figure 3 is to identify the physical duration of the vowel under investigation. The duration is shown in the screenshot as a so-called visible part. The screenshot shows a visible part of 0.068127 seconds as the physical duration of the vowel [u] in the word *masuba*. In the results tables (cf. Appendix F), the duration was recorded as 0.068 seconds.

3.5.4 Measurement Results

This section presents measurements results, most of which are quantitative results. Newman (1997) characterizes quantitative research as research which entails:

(i) measuring objective facts in a reliable fashion;

(ii) focusing on variables, independent of context, with the researcher also remaining detached from the research situation;

(iii) using relatively big sample sizes; and

(iv) conducting statistical data analyses.

The aim of conducting quantitative research is to develop empirical and "*observable measurements*" (Babbie & Mouton 2002: 52) in order to explain and elicit reliable deductions.

As first result of the measurement procedure, duration measurements have helped to establish the distinction between long-sounding and short-sounding vowels. In fact, duration averages across vowel qualities were calculated per speaker (cf. Table 8) rather than length ratios. However, the decision of this distinction was mainly supported on the perception since measurements were made both visually and auditorily.

Thus, across the first three speakers short-sounding vowels range from 0.039 to 0.145 milliseconds, and long-sounding vowels range from 0.046 to 0.277 milliseconds. For speaker 4, short-sounding vowels range from 0.091 to 0.223 milliseconds, and long-sounding vowels range from 0.092 to 0.296 milliseconds[4].

General results are presented in Tables 5, 6 and 7. Table 5 shows the total number of words and vowels measured for each syntactical position for all the four speakers.

Speakers	Sounding	Positions	Words	Vowels
4	2	3	1536	1536
Speakers 1, 2, 3 and 4, respectively	Long	Isolation	68	68
		Object	68	68
		Subject	68	68
		Total Long:	204	204
	Short	Isolation	60	60
		Object	60	60
		Subject	60	60
		Total Short:	180	180
		Total:	384	384

Table 5: *Total number of words & vowels measured for each position*

Table 6 shows the total number of words and vowels measured for each phonological context for each of the four speakers.

Speakers	Sounding	Contexts	Words	Vowels
4	2	5	1536	1536
Speakers 1, 2, 3 and 4, respectively	Long	C_NC	81	81
		CG_C	36	36
		C_N	18	18
		C_C	45	45
		C_L	24	24
	Short	C_N	39	39
		C_C	102	102
		C_L	39	39

Table 6: *Total number of words & vowels measured for each context*

Table 7 shows the total number of vowels measured for each sounding (long or short) and for each speaker.

Sounding	Vowels	Per word	Per position	Per speaker	Total
Long	ii	3	12	36	
	ee	3	13	39	
	aa	3	15	45	
	oo	3	15	45	
	uu	3	13	39	
	Total:		68	204	816
Short	i	3	9	27	
	e	3	11	33	
	a	3	13	39	
	o	3	11	33	
	u	3	16	48	
	Total:		60	180	720
Total number of vowels measured					1536

Table 7: *Total number of vowels measured for each sounding & each speaker*

In all three cases presented in Tables 5, 6 and 7, only one vowel from each word was measured.

Durational results of the duration measurement are presented in Appendix F. The measurement results (duration) for /i/, /e/, /a/, /o/ and /u/ (first long-sounding and then short-sounding) in various contexts and positions are indicated in separate tables in this appendix as follows:

Table F.1 shows measurement results (duration) for /i/ sounding long in various contexts and positions.

Table F.2 shows measurement results (duration) for /e/ sounding long in various contexts and positions.

Table F.3 shows measurement results (duration) for /a/ sounding long in various contexts and positions.

Table F.4 shows measurement results (duration) for /o/ sounding long in various contexts and positions.

Table F.5 shows measurement results (duration) for /u/ sounding long in various contexts and positions.

Table F.6 shows measurement results (duration) for /i/ sounding short in various contexts and positions.

Table F.7 shows measurement results (duration) for /e/ sounding short in various contexts and positions.

Table F.8 shows measurement results (duration) for /a/ sounding short in various contexts and positions.

Table F.9 shows measurement results (duration) for /o/ sounding short in various contexts and positions.

Table F.10 shows measurement results (duration) for /u/ sounding short in various contexts and positions.

The first column of each table in Appendix F indicates the contexts (phonetic environments) in which the measurements were made. The second indicates the words containing the individual vowel measured. Then follow twelve columns divided as three columns for each of the four speakers: one column for each of the syntactical positions (Isolation, Subject and Object).

Durational results were then entered into an Excel spreadsheet to enable statistical analysis. Prior the statistical analysis, no interpretation regarding durational results was made.

Table 8 below presents averages of all vowels measured as well as the duration of the shortest and longest vowels per group. The first group is short-sounding vowels.

Amongst the short-sounding vowels, the average duration of the shortest vowel is 0.053 seconds, whereas the average duration of the longest one is 0.148 seconds.

The second group is long-sounding vowels. Amongst the long-sounding vowels, the average duration of the shortest vowel amongst these is 0.068 seconds, whereas the average duration of the longest one is 0.276 seconds. Column 7 of Table 8 contains the average durations calculated across all four speakers.

	Vowels	Speaker 1	Speaker 2	Speaker 3	Speaker 4	Average across speakers
Average of each short-sounding vowel	i	0.069	0.075	0.073	0.128	0.086
	e	0.083	0.076	0.071	0.126	0.089
	a	0.078	0.077	0.085	0.144	0.096
	o	0.085	0.080	0.083	0.145	0.098
	u	0.072	0.076	0.071	0.127	0.087
Average of all short		0.077	0.077	0.077	0.134	0.091
Duration of the shortest of short		0.039	0.047	0.035	0.091	0.053
Duration of the longest of short		0.107	0.145	0.117	0.223	0.148
Average of each long-sounding vowel	ii	0.173	0.173	0.151	0.218	0.179
	ee	0.153	0.140	0.124	0.175	0.148
	aa	0.179	0.163	0.158	0.219	0.180
	oo	0.162	0.135	0.169	0.221	0.172
	uu	0.135	0.149	0.135	0.200	0.155
Average of all long		0.161	0.152	0.148	0.207	0.167
Duration of the shortest of long		0.081	0.054	0.046	0.092	0.068
Duration of the longest of long		0.256	0.275	0.277	0.296	0.276

Table 8: *Averages of vowel duration measured & duration of shortest & longest vowels per group*

3.6 Statistical Analysis

Data obtained in this experiment were the quantitative results of acoustic measurements. Values of the quantitative results in Appendix G were used as data for this statistic experiment. These data were analyzed statistically. This section gives an account of the experiment. The aim, the method, the results and the interpretation of results are given. The analysis was performed at the Centre for Statistical Consultation of Stellenbosch University, using the computer program STATISTICA.

3.6.1 Aims of the statistical analysis

The aim of the statistical analysis was to determine:

(i) in which context duration is significantly longer or shorter;

(ii) in which position duration is significantly longer or shorter; and

(iii) what the interaction between context and position could be.

3.6.2 Method

The technique used for the statistical analysis was the Repeated Measures Analysis of Variance. It was assumed that three effects could influence the natural vowel duration. The effects are:

(i) the context (CONTEXT), i.e., the phonotactic environments;

(ii) the position (POS), i.e., the position of the vowel in a word in isolation, in the subject position and in the object position; and

(iii) the context-position interaction (CONTEXT*POS).

The three effects were then tested. Each effect was tested on the basis of the following assumptions:

(i) The difference in duration might be due to the context if it is not due to the other two effects.

(ii) The difference in duration might be due to position if it is not due to the other two effects.

(iii) The difference in duration might be due to the context-position interaction.

The general hypotheses of the experiment were the following:

(i) For the context effect, all five contexts have the same value.

(ii) For the position effect, all three positions have the same value.

The hypotheses were to be rejected if the p-value was less than 0.05, which would indicate that the effect is significant. If an effect is significant, it denotes that there are differences in the means. It then requires looking at graphs, at visual pictures of the means, and/or at the Tukey HSD[5] table in order to establish where the differences are.

When the general hypothesis is rejected on the grounds of a p-value of less than 0.05, it leaves room for an alternative hypothesis, namely that at least one of the means differs from others. The visual pictures and the Tukey HSD table then allow one to determine which of the means is different.

It should be noted that the analysis on the effect CONTEXT*POS does not test the differences in the means, but rather the similarity of the changes in the different contexts. The research question of this test is stated as follows: *Are those changes in the means the same in the different contexts?* If there is no interaction, it means that the differences in the positions are the same for all the contexts. If there is interaction, the differences between the positions are dependent on the context. The remaining question would then be what this context is.

3.6.3 Statistical Results and Interpretation

The results of the statistical analysis are summarized below in Table 9, whereas Appendix I contains the detailed results. Vowels in their respective sounding form (long or short) are automatically numbered as displayed in the first column of Table 9 below. The second column presents the various vowels in their sounding form (long or short). The fourth and the fifth columns respectively indicate the p-value and the means. In the sixth column, the dependent variables are presented. The dependent variable is the element of the effect on which the difference falls. The variables for the effect CONTEXT are the five various contexts previously identified, whereas the variables for the effect POS are the three syntactical positions. The variables for the effect CONTEXT*POS are the variables of the two previous effects implicated in the context-position interaction.

Numbering	Vowels	Effects	P-value	Means (DV_1)	Dependent Variables
1.	a	POS	0.02	0.10	Isolation
2.	e	CONTEXT	0.001	0.10	C_N
3.	ee	CONTEXT	0.000001	0.10	CG_C
		POS	0.04	0.16	Isolation
4.	i	POS	0.02	0.09	Isolation
5.	ii	CONTEXT	0.007	0.15	CG_C
		POS	0.04	0.20	Isolation
		CONTEXT*POS	0.04		Variables interaction
6.	o	CONTEXT	0.05	0.09	C_C
7.	u	CONTEXT	0.04	0.09	C_N
		POS	0.01	0.07	Subject
8.	aa	CONTEXT	0.0001	0.15	C_L
		CONTEXT*POS	0.001		Variables interaction
9.	oo	POS	0.002	0.18	Isolation
10.	uu	CONTEXT	0.03	0.14	C_C

Table 9: *Summary of the statistical results*

These results allow for the following observations:

1. The effect CONTEXT is significant for seven different vowels, namely /e/, /ee/, /ii/, /o/, /u/, /aa/ and /uu/.
2. The effect POS is significant for six different vowels, namely /a/, /ee/, /i/, /ii/, /u/ and /oo/.
3. The effect CONTEXT*POS is significant for only two different vowels, namely /ii/ and /aa/.
4. All three effects can be significant for the same vowel without any further interaction (a situation of multiple significance). This happened only once in this study, but it happened three times that two effects were significant for the same vowel without any further interaction (a situation of double significance).
5. When the effect CONTEXT is significant, three variables namely /C_N/, /CG_C/ and /C_C/ play a role for two vowels each, whereas the variable /C_L/ plays a role for only one vowel.
6. When the effect POS is significant, only two variables play a role, namely Isolation for five vowels and Subject for only one vowel.
7. The effect CONTEXT*POS is only significant in situations of multiple or double significance.

The above observations and further ones about the statistical results are summarized in Table 10 below. Column 1 shows the sounding form of the vowel and Column 2 the significant effects. The vowels and the variables are in Columns 3 and 4, respectively.

Sounding	Effect	Vowels	Variables
Long	CONTEXT	ee	CG_C
		ii	CG_C
		aa	C_L
		uu	C_C
	POS	ee	Isolation
		ii	Isolation
		oo	Isolation
	CONTEXT*POS	aa	Variables interaction
		ii	Variables interaction
Short	CONTEXT	e	C_N
		o	C_C
		u	C_N
	POS	a	Isolation
		i	Isolation
		u	Subject

Table 10: *Summary of observations on significance of statistical results*

Table 10 allows for the following observations:

1. The effect CONTEXT*POS is not significant for short-sounding vowels since a third sub-row is missing from the main row of short-sounding vowels.
2. The effect CONTEXT*POS is only significant for the two long-sounding vowels /aa/ and /ii/.
3. The effect CONTEXT is significant for the three short-sounding vowels /e/, /o/ and /u/. The variables implicated are /C_N/ for the vowels /e/ and /u/ and /C_C/ for the vowel /o/.
4. The effect POS is significant for the three short-sounding vowels /a/, /i/ and /u/. The variables implicated are Isolation for the vowels /a/ and /i/ and Subject for the vowel /u/.

5. The effect CONTEXT is significant for the four long-sounding vowels /ee/, /ii/, /aa/ and /uu/. The variables implicated are /CG_C/ for the first two vowels, /C_L/ for the vowel /aa/ and /C_C/ for the vowel /uu/.

6. The effect POS is significant for the three long-sounding vowels /ee/, /ii/ and /oo/. The only variable implicated here is Isolation.

Both Table 9 and Table 10 show that for the effect CONTEXT*POS dependent variables are in interaction. It appeared relevant for this study to identify which variables are in interaction for this effect. Therefore, in Appendix I, Graph 5.10 (CONTEXT*POS; LS Means) and the Tukey HSD Test 5.12 are analyzed for the long-sounding vowel /ii/, and Graph 8.6 (CONTEXT*POS; LS Means) and the Tukey HSD Test 8.8 are analyzed for the long-sounding vowel /aa/. Again, the interaction was taken to be significant if the p-value is less than 0.05. The significant interactions observed are displayed in Table 11 below.

		1	2	3
		ISOLATION	OBJECT	SUBJECT
1	CG_C	ii	ii aa	ii
2	C_C	ii	ii aa	ii
3	C_L	ii	ii aa	ii
4	C_N	aa	ii aa	aa
5	C_NC	aa	aa	ii aa

Table 11: *Significant context-position interactions for vowels /ii/ & /aa/*

The following observations can be made from the results in Table 11:

(i) Except for context 5, interaction is significant for all contexts with position 2.

(ii) Interaction between position 1 and contexts 1, 2 and 3 is significant for /ii/ but not for /aa/. Likewise, interaction between position 3 and contexts 1, 2 and 3 is significant for /ii/ but not for /aa/.

(iii) Interaction between position 1 and contexts 4 and 5 is significant for /aa/ but not for /ii/. Likewise, interaction between position 3 and contexts 4 is significant for /aa/ but not for /ii/**.**

For the sake of generalization, it is important to look at these results from different angles. A closer look allows the groupings given in Tables 12 to 14. Each table groups vowels according to their height (High/Mid/Low) in three rows, and their tongue position (FRONT/BACK) in two columns. In each column, and where the effect is significant for both short and long-sounding vowels, the short-sounding vowels are placed on the left of the column and the long-sounding ones on the right.

Table 12 shows vowels affected by the effect CONTEXT, which is sensitive to both tongue position and vowel height. It is significant for neither High FRONT short-sounding vowels nor Mid BACK long-sounding vowels.

	FRONT		**BACK**	
High	ii		u	uu
Mid	e	ee	o	
Low			a	aa

Table 12: *Vowels for the effect CONTEXT*

Table 13 displays vowels affected by the effect POS. The effect POS is also sensitive to both vowel height and the tongue position. It is significant neither for High and Low BACK long-sounding vowels nor for Mid FRONT and BACK short-sounding vowels.

	FRONT		BACK
High	i	ii	u
Mid	ee		oo
Low			a

Table 13: *Vowels for the effect POS*

Table 14 presents vowels affected by the effect CONTEXT*POS. As can be seen from this table, the effect CONTEXT*POS is mainly sensitive to the vowel height. It is not significant for any Mid vowel.

	FRONT	BACK
High	ii	
Low		aa

Table 14: *Vowels for the effect CONTEX*POS*

3.7 Spectral Analysis

The acoustic measurements and the statistical analysis above have established the existence of long-sounding vowels in Civili. Now, through a short spectral analysis of these long-sounding vowels, this section aims to determine the segmental status of these vowels, i.e. whether they can be interpreted as a sequence of two identical vowels or not.

Table 15 below shows the wordlist used for the short spectral analysis. The spectra of the words are recorded in Appendix E. We used PRAAT TextGrids to make this spectral analysis.

The choice of these words was at random except that they needed to contain long-sounding vowels. It was also made sure they fall into the five contexts of duration measurements. The words were analyzed in their isolation syntactic position.

Sound files of these words were taken from the two native speakers male SBT (speaker 3 in Appendix F) and female VM (speaker 4 in Appendix F). This made a total of 10 spectra (5 from each speaker) observed. For this spectral analysis, speaker 3 was picked at random but the choice of speaker 4 was motivated by the fact she presents the longest vowel durations among the four speakers (cf. Appendix F).

	/i/	
miika	*Hair, coat*	**poils**
	/e/	
N'cyeetu	*woman*	**femme**
	/a/	
mbaasu	*nose*	**nez**
	/o/	
n'koombu	*arm*	**bras**
	/u/	
kuulu	*leg*	**jambe**

Table 15: *Wordlist of spectral analysis*

The spectral analysis consisted on determining the following:

(i) whether there was a breaking in the formant structure which could create an auditory impression that there are two different vowels separated by a juncture;

(ii) the pitch variation which could give the impression of two entities of same quality;

(iii) the tonal movement which could also give the impression of two entities of same quality bearing two different tones

The spectral analysis presented the following results.

(i) Nothing that suggest any formant breaking. Most formants go straight forward, quite steady and present normal formant frequencies.

(ii) For few words a tonal drop toward the end of the second phase with loss of intensity. This might indicate a falling tone situation which does exist in the language (cf. Ndamba 1977; Blanchon & Nsuka-Nkutsi 1984; Blanchon 1990; Mabika Mbokou 1999 and Ndinga-Koumba-Binza 2003b).

(iii) Very often the pitch also goes down and does not show any significant differential variation.

Finally, the spectral analysis does not show any support of the hypothesis that might regard long-sound vowels as double vowels of the same quality.

3.8 Discussion

This section contains a discussion of both the acoustic and the statistical results. This discussion seeks to:

(i) ascertain whether hypotheses previously made were borne out by the acoustic and statistical results;

(ii) correlate statistical input with the physical behavior of the natural sound; and

(iii) make deductions for a further phonological analysis of vowel duration.

3.8.1 Hypotheses, Claims and Results

3.8.1.1 Hypotheses and experimental results

Recall that the acoustic analysis was conducted on the basis of the following three hypotheses regarding vowel duration in Civili (cf. Section 3.2 of this chapter):

(i) There are long vowels.

(ii) There are lengthened vowels due to a compensatory lengthening phenomenon.

(iii) There might be a sequencing of two identical vowels.

The acoustic measurements conducted have helped to identify two categories of vowel sound based on vowel duration, namely short-sounding vowels and long-sounding ones. The average duration of short-sounding vowels is 0.091 seconds and that of the long-sounding vowels 0.167 seconds (cf. Table 8).

Furthermore, deductions from the acoustic analysis and the statistical analysis recognize the existence of both short and long (or lengthened) vowels in the Civili vowel system. It is then left to the phonetic-phonological integration to determine whether long-sounding vowels are naturally long vowels or lengthened vowels.

3.8.1.2 Claims and experimental results

Recall that the acoustic analysis was conducted on the basis of the phonological claim that any vowel can be lengthened or is long (cf. Section 3.3.8 in this Chapter):

(i) due to the effect of a certain syntactic position (Isolation, Subject or Object); or

(ii) when it is in a certain phonetic environment (Contexts).

The phonetic environments were identified as:

(i) a following nasal cluster (C_NC);

(ii) a preceding consonant-glide sequence (CG_C);

(iii) a following single nasal consonant (C_N);

(iv) a following voiced or unvoiced stop consonant (C_C); and

(v) a following liquid consonant (C_L)

Results from the statistical analysis made of the quantitative acoustic results permit the following observations (cf. Table 10):

(i) The results do not confirm any effect of the phonetic environment /C_NC/ on the duration of vowels in Civili.

(ii) The results confirm that the phonetic environments /CG_C/ and /C_L/ has an effect on vowel duration, but only that of long-sounding vowels.

(iii) The results confirm that the phonetic environments /C_N/ and /C_C/ has an effect on vowel duration, but most often on that of short-sounding vowels (cf. Table 10).

3.9 Summary

This chapter has presented an acoustic analysis of vowel duration. It provided information at the segmental level of vowel duration production.

Test words were extracted from recorded speech data on the basis of a specific purpose-built corpus. Measurements of natural duration were performed on test words using the speech analysis program PRAAT. On the quantitative results of the measurements, a statistical analysis was performed to determine the significance of different effects on vowel duration. Phonological hypotheses and claims from previous studies have been tested.

Endnotes in Chapter 3

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[1] The use of selected test words was based on the work of Beckman (1997), Myers & Hansen (2005) and Grosjean, Carrard, Godio & Grosjean (2007).

[2] See Subsection 1.6.5 of Chapter 1 for an account of the ethno-linguistic configuration of Mayumba.

[3] For this study, PRAAT was provided by the Stellenbosch University Centre for Language and Speech Technology (SU-CLaST).

[4] It should be recalled that speaker 4 is female. This might explain the large difference with other three speakers. It was noticed during measurements that vowels from speaker 4 were longer than those of the rest of the speakers.

[5] The Tukey HSD (high speed data) is a method for multiple comparisons in statistics.

CHAPTER 4

Perception of Vowel Duration

4.1 Introduction

This chapter focuses on the auditory nature of Civili vowel duration. The general aim was to determine the perceived duration of vowels in Civili. In order to determine the perceived duration, a perception experiment was conducted with native speakers of Civili. The perception experiment was conducted on the basis of the following hypothesis:

> In the context of minimal pairs, the perceived duration might also assist in determining the existence of short vowels and long vowels.

This hypothesis is based on the claims of previous studies (Marichelle 1902 & 1912; Ndamba 1977; Blanchon 1984 and 1990; Mabika Mbokou 1999; and Ndinga-Koumba-Binza 2000) that acknowledge the existence of two sets of vowels, i.e. short and long vowels. In these previous studies, the identification procedures of the two sets of vowels are (i) the commutation (minimal pairs), which was used in all studies mentioned above, and (ii) the phonological processes, as added by Ndinga-Koumba-Binza (2000).

Moreover, in Chapter 3 we have identified the existence of two sets of vowels – named short-sounding and long-sounding vowels – through acoustic measurements. The difference between the produced signal (acoustics) and the perceived signal (perception) is acknowledged in this work. Therefore, it is necessary to undertake the determination of the perceived duration as well, following the determination of the produced duration in Chapter 3.

The main topics of the present chapter are the following:

(i) An account of the perception experiment conducted,

(ii) The administration of perception tests, and

(iii) A perception data analysis (including a statistical analysis).

Prior the discussion of these three topics, the aim of this chapter as well as the general methodology of the perception experiment contained in this work are explicated. The chapter also gives an overview of vowel acoustic cues for speech perception.

4.2 Aim and Methodology

The primary aim of this chapter was to determine through a perception experiment the perceived vowel duration in the Civili sound system in order to confirm or refute the existence of the two sets of vowels acoustically identified as short-sounding and long-sounding vowels. Three perception tests comprise the experiment. Specific aims and procedures of each test are presented in Section 4.5 of this chapter.

To a limited extent, the present perception experiment is grounded in the sub-field of psychoacoustics, i.e., "*the whole area of testing what the listener can hear*" (Ball & Rahilly 1999: 191). Within psychoacoustics, various types of investigation, such as audiometry, are common. The present perception study does not follow any one particular investigation method, but some experimental psychoacoustic procedures are considered. For instance, according to Ball & Rahilly (1999: 195), "*different types of control on the part of the investigator are exercised according to whether the experiments are of the limits or constant stimuli type*".

The perception experiment of the present study is of the constant stimuli type, i.e., each of the three tests that comprise the experiment includes "*a variety of random stimuli … presented to the subject, who must identify one according to set criteria*" (Ball & Rahilly 1999: 195-196).

Moreover, psychoacoustic experiments are interested in four principal aspects of listeners' responses to experimental material (Borden & Harris 1980: 187-191, Ball & Rahilly 1999: 196), namely (i) detection, (ii) discrimination, (iii) identification, and (iv) scaling. In the present study, the perception experiment combines both discrimination and identification procedures. A brief definition of each of these procedures is provided by Ball & Rahilly (1999: 196):

> "*Discrimination is the process which allows the listeners to spot difference limens between sounds in terms of pitch, loudness, or segmental articulatory aspects … Identification is the activity whereby listeners are asked to label sounds in terms of a set of categories which have been provided by the experimenter*" (Ball & Rahilly 1999: 196).

This methodology made it possible to acquire perception data through the three perception tests. These tests are discussed in Section 4.4.

4.3 Speech Perception, Acoustic Cues and Vowel Duration

This section is a short overview of vowel acoustic cues for speech perception. The section aims:

(i) to present duration as an acoustic and perceptual cue in speech perception for the identification or discrimination of segments, and

(ii) to advocate that duration is also a cue in speech perception for vowel identification or discrimination in the context of minimal pairs.

The perception experiment conducted in this study comes within the general field of speech perception, which is understood as the study of the neuropsychological or psychoacoustic mechanisms governing the human ability to distinguish between speech items (Mitterer & Cutler 2006: 770; Crystal 1999: 316). The core value of perception studies alongside acoustic ones is carefully outlined by Ryalls (1996: 35) when he states:

> "*Evidence about the acoustic characteristics of speech comes not only from analyzing speech into its basic sound properties, but also from synthesizing speech using its basic properties as input*" (Ryalls 1996: 35).

Both sources of evidence – acoustic and perceptual – might reveal the very nature of the sound under investigation.

Studies in speech perception are often conducted to analyze "*the process whereby a listener extracts a sequence of discrete phonetic and linguistic units from the continuous acoustic signal of speech*" (Crystal 1999: 316). The aim of such studies is to establish acoustic cues that help the listener to identify or discriminate phonetic or linguistic items.

Regarding phonetic perception, there are a certain number of levels of distinction that the listener has to make. The most important for the purposes of this study are the following:

(i) distinguishing vowels from consonants,

(ii) distinguishing vowels from one another (quality), and

(iii) identifying a long vowel from a short vowel of the same quality.

Two important acoustic cues are used to distinguish vowels from consonants (Mitterer & Cutler 2006: 770, Borden & Harris 1980: 171), namely:

(i) the local maximal amplitudes, and

(ii) periodicity caused by the vibration of the vocal folds.

Mitterer & Cutler (2006: 770) provide the following explanation:

> "*The vocal fold vibration gives a rise to a periodic source signal with a large number of harmonics. This source signal is then filtered by the vocal tract. The vocal tract amplifies some of the harmonics due to its resonance characteristics. Regions with amplified harmonics are called formants*" (Mitterer & Cutler 2006: 770).

It is then clear that "*the acoustic cues to perception of vowels lie in the patterns created by the vocal tract resonances (formants) of the speaker*" (Borden & Harris 1980: 171). Moreover, vowels can be distinguished from one another by their steady state formant frequencies (Mitterer & Cutler 2006: 770). Apart from the dynamic properties of CVC and VC transitions, Mitterer & Cutler (2006: 770) state that "*cues to vowel identity are also provided by duration – even in languages that do not distinguish long from short vowels*". Thus, formant frequencies and duration are the acoustic cues which are usually used to distinguish vowels from each other.

It is agreed with Ryalls (1996: 26) that "[*i*]*f we sufficiently change the first two formant frequencies of synthesized speech, listeners hear a different vowel sound*". Therefore, when the formants change, so does the sound of the vowel we hear (Ryalls 1996: 29).

These cues (formant frequencies and duration) establish vowel distinction with regards to vowel quality (Pickett 1980: 173). For example, to differentiate [+High] vowels from [+Low] vowels, there is a prerequisite that low vowels are associated with high frequencies of the first formant (Mitterer & Cutler 2006: 776), whereas to differentiate [+FRONT] vowels from [+BACK] vowels, there is a prerequisite that back vowels are associated with low frequencies of the second formant (Lieberman & Blumstein 1998: 221-222). The two prerequisites are confirmed in the following statement by Ball & Rahilly (1999: 166):

> "*Vowel height is inversely proportional to F1 value, so that the high or close vowels have lower F1 values than low or open vowels. Tongue*

> *advancement is usually reflected in F2 values, with the effect that front vowels have higher F2s than back vowels. Finally, lip-rounding has the effect of lowering the overall energy throughout the formants"* (Ball & Rahilly 1999: 166).

This supports the assertion made by Ryalls (1996: 32) that *"the formant frequencies relate most directly to the position of the tongue and the length size of the vocal tract"*. The position of the tongue determines whether the vowel is [+FRONT] or [+BACK], and the length size of the vocal tract determines the height of the vowel, i.e., [+High] or [+Low].

Specifically, it has been shown that the longer the vocal tract is, the lower the fundamental pitch tends to be. Also, the longer the vocal tract, the closer in frequency the formant spacing will be (Picket 1980: 173). Thus, formant frequencies have been set as cues, and most vowel perception studies have mainly focused on the manipulation of these formant frequencies for vowel identification (Borden & Harris 1980, Ball & Rahilly 1999: 199, Swart 2000, Jones 2001).

A number of speech perception studies have been done on the use of vowel duration as a cue for segment identification (Ball & Rahilly 1999: 199; Flege 1991; Saravari & Imai 1983; Krause 1982; Hogan & Rozsypal 1980; Chen 1970). In fact, duration is one of the distinctive cues for the perception of many phonetic and linguistic units. For instance, the role of duration has been established in sorting syntactic ambiguous sentences (Lehiste & al. 1976), in determining imperatives (Swart 2001) and in describing queclaratives (Jones 2001).

However, not that many studies exist on differentiating vowels from each other, neither with regards to their natural duration nor with regards to experimentally perceived duration (Wang, Lehiste, Chuang & Darnovsky 1976; Lehiste 1970, 1976 and 1985; Pisoni 1997a and 1997b). Subsequently, very few studies have conducted experiments at the perceptual level on vowels duration-based minimal pairs (Grosjean, Carrard, Godio & Grosjean 2007; Nooteboom 1972). In most phonological studies, minimal pairs are perceived by the phonologist by means of a commutation procedure, but rarely by the native listeners on the basis of an experimental procedure. On this topic, no study was found on the Bantu languages.

In this Chapter, the study is concerned with duration as a cue for vowel identification or discrimination in a language where few contrastive minimal pairs on duration are found. Observed minimal pairs are tested at an experimental level in order to determine the perceived duration.

4.4 Preparation for Perception Tests

The present section is a report on the preparation for the perception tests that were administered to native Civili listeners. The section covers the stimuli preparation and the equipment used.

4.4.1 Preparation of Stimuli, Laptop Computer and Written Software

Stimuli were electronically prepared in order to conduct three perceptual tests with native speakers of Civili. Stimuli were prepared using PRAAT as instructed in the online manual of PRAAT (cf. http://www.praat.org).

A stimulus is often that which produces a change or reaction in an individual or organism (Richards & Schmidt 2002: 514). In the context of speech perception, stimuli are speech-like sounds produced by a computer using a speech synthesizer and played back for listeners to identify or discriminate.

In the present study, the preparation of stimuli consisted of:

(i) recording from one speaker a list of minimal pairs based on vowel duration,

(ii) re-writing the minimal pairs LongSounds into WAV format, and

(iii) randomizing the presentation of stimuli according to specified vowels (cf. Pickett 1980: 171).

The only manipulation of stimuli was that of recording the words in the minimal pairs containing long-sounding vowels with a high pitch. This was done because "*raising the pitch automatically causes a shortening in duration*" (Swart 2000: 94), and this sometimes made the minimal pairs to have the same duration values.

Stimuli were not further synthesized due to lack of reliable equipment and a reduced ability to master PRAAT. However, it was found to be better if the pitch was raised instead of lowered and the duration shortened instead of lengthened. This was to avoid the stimulus words sound more "natural" and to make it less easy to distinguish between the members of a minimal pair. When recording the stimulus words (cf. Appendix H), the speaker was instructed to speak in low tones and to produce sounds with long durations for words normally containing short-sounding vowels in minimal pairs. The list of words recorded for stimulation also contained verbs in their infinitive form (cf. Appendix H). Note that in Civili, infinitives provide an easier way to find minimal pairs.

The perception of speech, being an acoustic signal but also a linguistic message, involves both a psychoacoustical analysis, common to all types of sounds, and a cognitive analysis, which leads to the recognition of the stimulus (Van Wieringen 1995: 3). However, instead of incorporating traditional psychoacoustical experimental methods, the present study deals with the recognition of vowel duration which is not specifically a psychological correlate of acoustical parameters[1].

Stimulus parameters are necessary to explore the ability to distinguish minimal detectable changes in duration (Van Wieringen 1995: 3). A total of 100 stimuli were prepared and distributed as follows between the three perception tests (In Section 4.5., the three perception tests are presented in detail.):

(i) Perception Test I: 50 stimuli

(ii) Perception Test II: 20 stimuli

(iii) Perception Test III: 30 Stimuli

These are "*stationary and simple stimuli*" compared to the more complex "*carefully manipulated laboratory stimuli*" (Van Wieringen 1995: 5). Simple stimuli are often used for the study of specific speech phenomena such as vowel duration or vowel quality (Borden & Harris 1980: 171-173; Ryalls 1996: 31-35). With simple stimuli, "*the experimental procedures of speech researchers can be less rigid*", as stated by Van Wieringen (1995: 5).

Once the stimuli were created, a list of expected responses was set. Each stimulus was attached to a specific expected response. Stimuli and their respective expected responses are found in Appendix I.

For Perception Test I, the expected response was the meaning of the word (presented in French in the experiment). For Perception Test II, the expected response was the discrimination between SAME or DIFFERENT (again presented in French). For Perception Test III, the expected response was the discrimination between ICON OF A and ICON OF B (also presented in French). In Perception Test I, one response was expected from each stimulus; in Perception Test II, one response was expected from two stimuli; and in Perception Test III, one response was expected from three stimuli. In Section 4.5., some possible responses are given.

4.4.2 Laptop Computer and Written Software

The perception tests were administered on a multimedia laptop computer with word processing facilities and a sound card. This computer was the only one that participants could use for perception tests, as the relevant software could not be downloaded onto an extra computer.

The perception experiment was conducted using custom-written software developed according to instructions and the model specified by the researcher[2]. The model adopts patterns of the software that was developed for Jones (2001). The program ran under Windows XP and automatically collected participants' responses and personal details.

The computer program was written using PRAAT functions and Microsoft Excel (Ms Excel). PRAAT was used to write sound files from *.Sound* format to *.WAV* format. Ms Excel was used to write commands, to present text items in the program, as well as to create hyperlinks between pages and buttons. Pages as well as buttons were also hyperlinked to sound files. This software was helpful:

(i) to present the stimuli to the participants, and

(ii) to collect their responses automatically, since it was not ideal or even possible to convert these responses from paper to a computer readable form by hand for further analysis.

The program contained a total of 73 pages labeled from page 0 to page 72. These pages were distributed between the perception tests as follows:

(i) Instructions and generalities: 3 pages

(ii) Perception Test I (pages 1-50): 50 pages

(iii) Perception Test II (pages 51-60): 10 pages

(iv) Perception Test III (pages 61-70): 10 pages

Each page contained one stimulus for Perception Test I, two stimuli for Perception Test II, and three stimuli for Perception Test III. Page 0 of the program presented greetings, introduced the experiment, and gave general instructions to the participant. Page 71 congratulated and thanked the participant for completing the experiment, and it encouraged him/her to fill in the form on Page 72. This form was to record particular details of the participants.

4.5 The Perception Tests

As explained above, the perception experiment comprised three perceptual tests. Each test is discussed below.

4.5.1 Perception Test I

This was an A or B identification test.

Aim

The aim of this test was to determine how consistent Civili native speakers are in identifying long and short vowels within words in isolation.

Tokens

Tokens used in this test were 5 minimal pairs (cf. Appendix I) for each of the 10 vowels (5 long and 5 short ones). This gave a total of fifty stimuli for each vowel.

Process

As far as the process is concerned, listeners were presented all 50 stimuli in random order with the following instruction:

Listen to this word, and click on its meaning.

WORD	***MEANING 1***
	MEANING 2
	UNCERTAIN

The participant had to listen to a single word. The indirect question that he/she had to answer was: *What is the meaning of the word you have just heard?* Although not knowing exactly the question, the participant had to answer by choosing among the three choices above where ***MEANING 1***/***MEANING 2*** are a minimal pair. The terms in ***MEANING 1*** and ***MEANING 2*** were the French equivalents of the Civili word which is part of the minimal pair. When the participant thought that the word did not mean anything in Civili or he/she was uncertain, he/she could click on ***UNCERTAIN***.

MEANING 1, ***MEANING 2*** and ***UNCERTAIN*** are answers the participants had to give in responding to a stimulus by clicking on one of them. For the sake of automatic storage in the computer program, each answer was attached to a specific number, namely 1, 2 and 3, respectively (cf. Appendix I).

Illustration

Consider the following pair called AB. A and B are the stimuli. A is the Civili item **N'teela** "*hunter*", and B the Civili item **N'tela** "*height*". The testing of this minimal pair proceeded as follows.

Testing A (N'teela)

Listen to this word, and click on its meaning.

WORD	***HEIGHT***
	HUNTER
	UNCERTAIN

Testing B (N'tela)

Listen to this word, and click on its meaning.

WORD	***HEIGHT***
	HUNTER
	UNCERTAIN

Note that **Testing A** and **Testing B** were randomized, i.e., Testing B could occur after some other stimuli.

4.5.2 Perception Test II

This was an AB discrimination test.

Aim

The aim of this test was to determine how consistently native speakers of Civili in discriminate between minimal pairs based on duration.

Tokens

Tokens used in this test were two minimal pairs per vowel (cf. Appendix I). This rendered a total of twenty randomized stimuli.

Process

The participant listened to two words, after which he/she was asked the following question: *Do these words mean the same or not*?

Participants had to respond by clicking on either ***SAME*** or ***DIFFERENT***. Participants were to click on ***UNCERTAIN*** when they were uncertain regarding the ***SAME*** or ***DIFFERENT*** decision.

The administration of this test was as follows.

Listen to these words.

WORD A ***WORD B***

Are the meanings of these words the same or do they differ?

SAME

DIFFERENT

UNCERTAIN

WORD A and ***WORD B*** were played as two stimuli. For Perception Test II, ***SAME***, ***DIFFERENT*** and ***UNCERTAIN*** were answers the participants had to give in responding to stimuli by clicking on one of them. For the sake of automatic storage in the computer program, these answers were also attached to a specific number, 1, 2 and 3, respectively (cf. Appendix I).

Illustration

Consider the following minimal pair: **kuputa** (*to wrap*) vs. **kupuuta** (*to lie*). The first was ***WORD A*** and the latter was ***WORD B***. Note that participants did not see the words "**kuputa**" and "**kupuuta**" in writing, in order to avoid any possible influence of the orthographical forms of sub-stimuli on their decision.

The test was administered as follows.

Listen to these sounds.

WORD A ***WORD B***

Are the meanings of these words the same or do they differ?

SAME

DIFFERENT

UNCERTAIN

Note that presenting ***kupuuta*** as ***WORD A*** and ***kuputa*** as ***WORD B*** could possibly have influenced the responses of the participants. However, establishing whether the order of presentation was an influencing factor would have required another experiment, which did not fall within the scope of this study.

4.5.3 Perception Test III

This was an ABX discrimination test.

Aim

This test aimed to find out how consistently Civili native speakers discriminate between minimal pairs based on duration.

Tokens

Tokens used in this test were two minimal pairs per vowel (cf. Appendix I). One element of each minimal pair was repeated as an X element. This gave a total of thirty randomized stimuli.

Process

As far as the process is concerned, the participant listened to one (A) of the 3 stimuli of this test, then to a different one (B), followed by the third one (X) which was the same as one of the first two (Borden & Harris 1980: 189).

The task of the participant after hearing each triad was to determine whether X is like A or like B. The question the listener had to answer was: *Is X similar in meaning to A or to B?*

In order to answer this question, the participant had to choose among the three options by clicking on the icon that represented A or B. If the participant was not sure of which item X was similar to, he/she had to click on ***UNCERTAIN***.

The test was presented as follows.

Listen to these words.

WORD A ***WORD B*** ***WORD X***

Is X similar in meaning to A or to B?

ICON OF A

ICON OF B

UNCERTAIN

For Perception Tests III, ***ICON OF A***, and ***ICON OF B*** and ***UNCERTAIN*** were answers the participants had to give in responding to stimuli by clicking on one of them. For the sake of automatic storage in the computer program, these answers were again attached to a specific number, 1, 2 and 3, respectively (cf. Appendix I).

Illustration

Consider the minimal pair **kuputa** vs. **kupuuta**. The test was administered such that **kuputa** was ***WORD A***, **kupuuta** was ***WORD B*** and **kuputa** again was ***WORD X***.

The test was presented as follows.

Listen to these words.

WORD A ***WORD B*** ***WORD X***

Is X similar in meaning to A or to B?

ICON OF A

ICON OF B

UNCERTAIN

Again, presenting ***kupuuta*** as ***WORD X*** could possibly have influenced the responses of the participants. However, establishing this would have required another experiment, which did not fall within the scope of this study.

4.6 Tests Administration & Data Analysis

This section reports on the administration of the perception tests to native Civili speakers. Details on the participants in the experiment are given and the results of the experiment are presented. The results of this experiment are then identified as perception data of the larger present phonetic-phonological experimental study.

4.6.1 Participants

The perception tests were administered to 68 participants. Details (except names) of all participants are recorded in Appendix J. The number of 68 participants was sufficient to allow for a rigorous analysis and reliable findings. The participants in the perception tests were Civili native listeners ranging between 15 and 63 years old.

The selection of participants was based on the participants' readiness to cooperate and according to the questionnaire in Appendix K. The participants are labeled by the letter S (for Subject) and a number which indicates the position of the participant in doing the experiment. For instance, **S1** indicates that this participant was the first one to partake in the perception experiment and **S3** the third one.

4.6.2 Testing

The administration of the perception experiment took place outside of a laboratory setting, in Libreville and Mayumba, Gabon. A participant interacted with the perception test program using only the mouse and following instructions displayed on the screen. Figure 4 below shows the example instructions given at the beginning of each perception test. The example below was at the beginning of Perception Test I. Note the program interacted with the participants in the French language, which all of them spoke fluently.

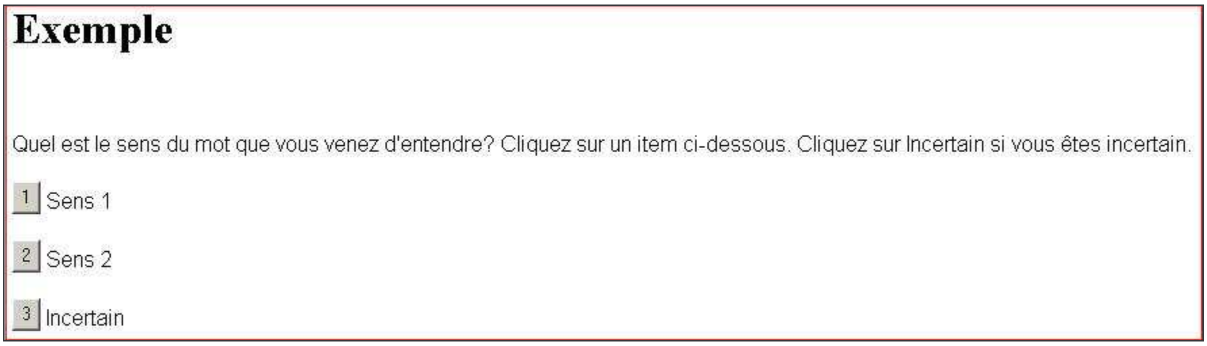


Figure 4: *Example given at beginning of perception tests.*

The program played over headphones one stimulus at a time for Perception Test I, two stimuli in succession for Perception Test II, and three stimuli in succession for Perception Test III. For all perception tests, a beep sound was played a second before the stimuli were played. The purpose of the beep sound was to attract the attention of the participant to the stimulus which would follow.

The program had a default prohibition hindering the participant to listen to the stimulus for a second time. Note that there was no time limit while the program was waiting for the participant to go to the next page or the next test. This allowed slower participants to maintain composure, avoiding confusion, and allowed progress at the individuals' own rate.

Every participant completed the experiment answering to every page of the program. Each participant had a personal workstation and had to enter the program with a username and a password. The identification letter S plus the position number of the participant, e.g. **S3**, was used both as username and password. This mode of entering the program was useful to prevent any participant of doing the experiment more than once. The program aborted automatically when recognizing a used identification.

The participant identification was used to create a unique file for each workstation for storing the responses. The responses were also automatically saved in Excel files per perception test and per page.

4.6.3 Results

The 100 stimuli were presented to the 68 participants in 70 testing pages. This amounted to 4760 (68 x 70) individual responses. These individual responses are distributed according to perception tests as follows:

(i) Perception Test I: 3400 (50x68) responses

(ii) Perception Test II: 680 (10x68) responses

(iii) Perception Test III: 680 (10x68) responses

As results of the perception experiment as well, a total 79 Excel files were automatically recorded from the computer program. 80 were expected, but an inexplicable defect in the program aborted the automatic saving of page 55. However, statistical comparisons showed that the missing values of page 55 did not influence the results in a significant manner. The 79 Excel files (labeled as **f**) were the following:

(i) f1 to f70 were the pages of the perception experiment as presented to participants

(ii) f71 recorded the summary of all the responses from the perception experiment for all pages

(iii) f72 recorded the number of pages completed by each participant, and the time and date that the participant did the experiment

(iv) f73 recorded all the responses for the vowel /**a**/ for Perception Test I from page 1 to 10 of each participant

(v) f74 recorded all the responses for the vowel /**e**/ for Perception Test I from page 11 to 20 of each participant

(vi) f75 recorded all the responses for the vowel /**i**/ for Perception Test I from page 21 to 30 of each participant

(vii) f76 recorded all the responses for the vowel /**o**/ for Perception Test I from page 31 to 40 of each participant

(viii) f77 recorded all the responses for the vowel /**u**/ for Perception Test I from page 41 to 50 of each participant

(ix) f78 recorded all the responses for all the vowels of Perception Test II

(x) f79 recorded all the responses for all the vowels of Perception Test III

All Excel files are stored in the accompanying CD-Rom of the present work. Table 16 below presents a summary of all responses as shown in f71. Column 1 shows the pages of the program (**ptpage**). It should be noted that only relevant pages, i.e., those containing experimental responses, are reflected in f71. Page 1 to 50 contains Perception Test I, Page 51 to 60 Perception Test II, and Page 61 to 70 Perception Test III. Columns 2, 3 and 4 present the number of responses for each answer (**ans**) in each page. Column 5 presents the total number of responses for each page. Columns 6, 7 and 8 show the percentage of each answer in each page.

	ans1	ans2	ans3	total	ans1%	ans2%	ans3%
ptpage1	32	23	11	66	48.4	34.8	16.6
ptpage2	45	14	7	66	68.1	21.2	10.6
ptpage3	9	46	11	66	13.6	69.6	16.6
ptpage4	37	16	13	66	56	24.2	19.6
ptpage5	35	6	24	65	53.8	9.2	36.9
ptpage6	48	5	13	66	72.7	7.5	19.6
ptpage7	58	8	0	66	87.8	12.1	0
ptpage8	53	9	4	66	80.3	13.6	6
ptpage9	52	12	2	66	78.7	18.1	3
ptpage10	13	43	10	66	19.6	65.1	15.1
ptpage11	31	10	25	66	46.9	15.1	37.8
ptpage12	56	7	3	66	84.8	10.6	4.5
ptpage13	46	15	5	66	69.6	22.7	7.5

ptpage14	51	10	5	66	77.2	15.1	7.5
ptpage15	2	63	1	66	3	95.4	1.5
ptpage16	46	12	8	66	69.6	18.1	12.1
ptpage17	23	6	37	66	34.8	9	56
ptpage18	8	53	5	66	12.1	80.3	7.5
ptpage19	60	3	3	66	90.9	4.5	4.5
ptpage20	21	26	19	66	31.8	39.3	28.7
ptpage21	60	2	4	66	90.9	3	6
ptpage22	21	24	20	65	32.3	36.9	30.7
ptpage23	8	57	0	65	12.3	87.6	0
ptpage24	9	53	3	65	13.8	81.5	4.6
ptpage25	41	11	13	65	63	16.9	20
ptpage26	57	5	3	65	87.6	7.6	4.6
ptpage27	31	25	9	65	47.6	38.4	13.8
ptpage28	23	27	15	65	35.3	41.5	23
ptpage29	64	1	0	65	98.4	1.5	0
ptpage30	19	44	2	65	29.2	67.6	3
ptpage31	20	39	6	65	30.7	60	9.2
ptpage32	56	7	2	65	86.1	10.7	3
ptpage33	10	48	7	65	15.3	73.8	10.7
ptpage34	33	22	10	65	50.7	33.8	15.3
ptpage35	56	9	0	65	86.1	13.8	0
ptpage36	5	56	4	65	7.6	86.1	6.1
ptpage37	4	60	1	65	6.1	92.3	1.5
ptpage38	42	15	8	65	64.6	23	12.3
ptpage39	0	64	1	65	0	98.4	1.5
ptpage40	52	5	8	65	80	7.6	12.3
ptpage41	1	61	3	65	1.5	93.8	4.6
ptpage42	51	8	6	65	78.4	12.3	9.2
ptpage43	15	43	7	65	23	66.1	10.7
ptpage44	18	43	4	65	27.6	66.1	6.1
ptpage45	8	55	2	65	12.3	84.6	3
ptpage46	54	8	3	65	83	12.3	4.6
ptpage47	35	17	13	65	53.8	26.1	20
ptpage48	52	11	2	65	80	16.9	3
ptpage49	4	59	2	65	6.1	90.7	3
ptpage50	11	45	9	65	16.9	69.2	13.8
ptpage51	27	36	4	67	40.2	53.7	5.9
ptpage52	25	38	4	67	37.3	56.7	5.9
ptpage53	27	38	2	67	40.2	56.7	2.9
ptpage54	15	40	12	67	22.3	59.7	17.9
ptpage55	17	48	2	67	25.3	71.6	2.9

ptpage56	28	37	2	67	41.7	55.2	2.9
ptpage57	22	43	2	67	32.8	64.1	2.9
ptpage58	29	34	4	67	43.2	50.7	5.9
ptpage59	16	50	1	67	23.8	74.6	1.4
ptpage60	12	55	0	67	17.9	82	0
ptpage61	15	43	9	67	22.3	64.1	13.4
ptpage62	56	8	3	67	83.5	11.9	4.4
ptpage63	16	51	0	67	23.8	76.1	0
ptpage64	54	7	6	67	80.5	10.4	8.9
ptpage65	7	59	1	67	10.4	88	1.4
ptpage66	10	57	0	67	14.9	85	0
ptpage67	59	6	2	67	88	8.9	2.9
ptpage68	9	57	1	67	13.4	85	1.4
ptpage69	56	10	1	67	83.5	14.9	1.4
ptpage70	59	8	0	67	88	11.9	0

Table 16: *Summary of responses from the perception experiment*

Detailed results of each page are found in the respective Excel files in the accompanying CD-Rom. These results constituted the perception data of the present study. These are perceptually derived data, rather than quantifiable physical data (Ball & Rahilly 1999: 191). However, in this format, results could not be interpreted in terms of listeners' identification and discrimination of stimuli. Further analysis was needed in terms of statistical and comparative perspectives.

4.6.4 Perception Data & Analysis

A statistical analysis of the perception results was conducted directly from the automatically stored Excel files. Results of this statistical analysis are presented in Appendix L. The statistical analysis separated pages per perception test.

The aims of the statistical analysis were the following:

(i) to confirm results automatically stored in f71 (summary of all responses) by calculating all responses per page and per perception test;

(ii) to establish the frequency with which participants could successfully identify and discriminate between stimuli;

(iii) to determine whether the participants could identify and discriminate between vowels of different duration (long vs. short) in the minimal pairs;

(iv) to present perception data in an easily readable format.

Figures 5, 6 and 7 below present in histograms samples of statistical results for Perception Tests I, II and III, respectively. The abscissas show the number of observations, which is also the number of the respondents for a specific answer. The three answers for each perception test are displayed in the axis.

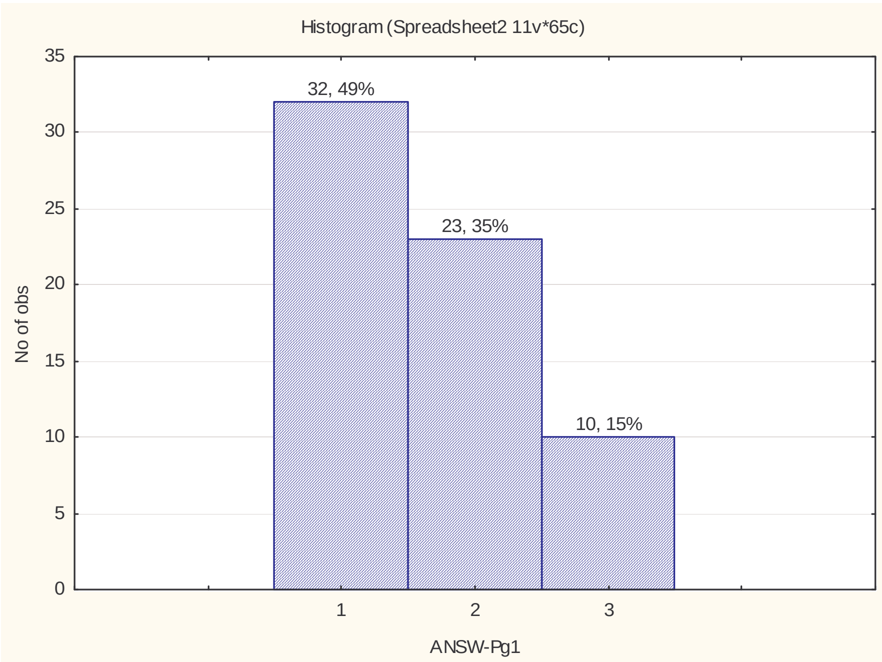


Figure 5: *Sample of statistical results for Perception Test I.*

Figure 5 displays results and answers from page 1 of the program. This page belongs to Perception Test I. It shows that 32 participants responded with answer 1, i.e., which constituted 49% of all responses to this item; 23 participants gave answer

2, i.e., 35% of the total responses; and 10 participants gave answer 3, i.e., 15% of the total responses.

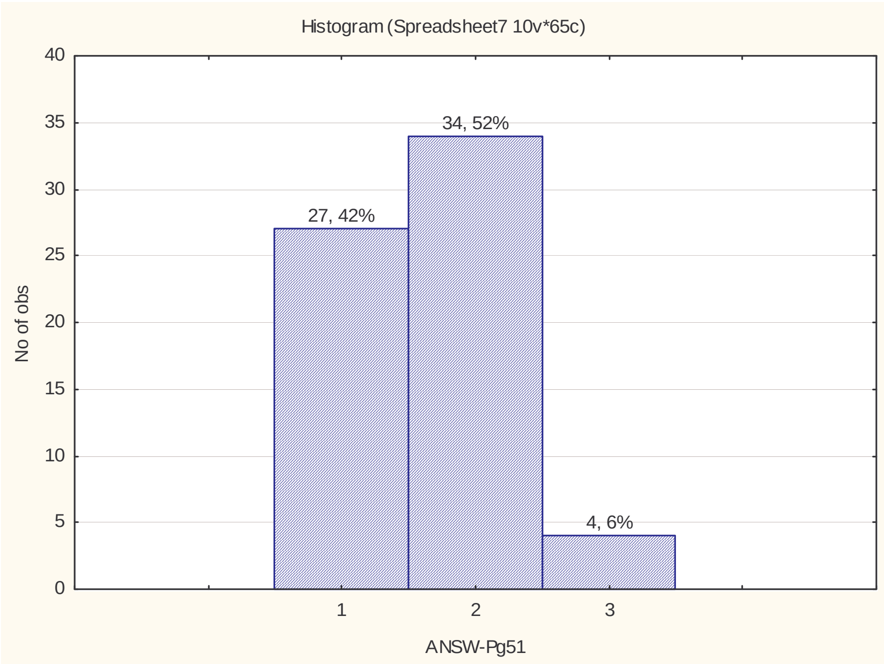


Figure 6: *Sample of statistical results for Perception Test II.*

Figure 6 displays results and answers from page 51 of the program. This page belongs to Perception Test II. It shows that 27 participants responded with answer 1 (42% of the total responses to this item); 34 participants (52%) with answer 2; and 4 participants (6%) with answer 3.

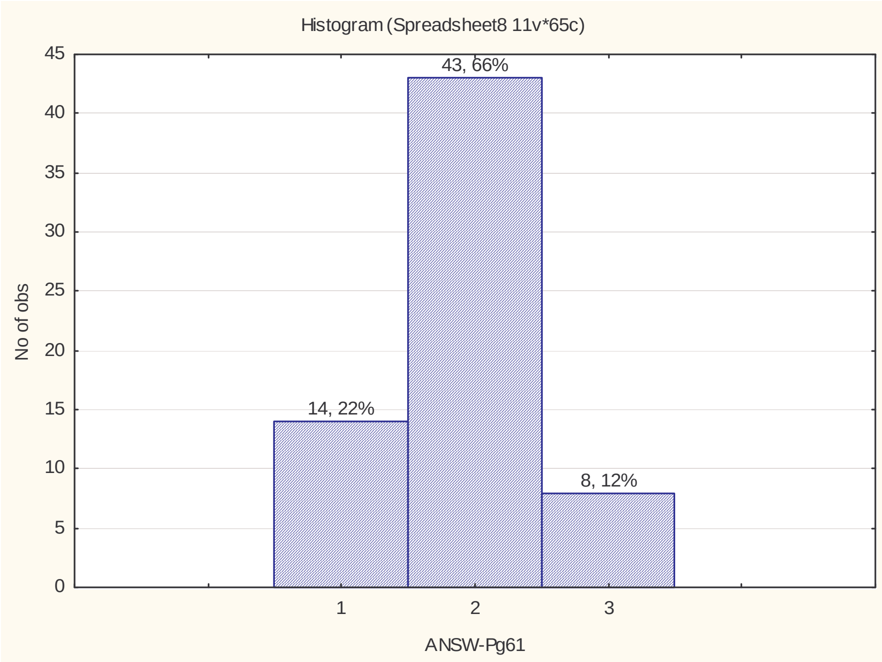


Figure 7: *Sample of statistical results for Perception Test III.*

Figure 7 displays results and answers from page 61 of the program. This page belongs to Perception Test III. It shows that 14 participants (22%) responded with answer 1; 43 participants (66%) with answer 2; and 8 participants (12%) with answer 3.

As was previously mentioned, for all the perception tests, each stimulus was attached to an expected response, as presented in Appendix I. Thus, the responses from the participants were divided and specified as Correct, Wrong and Uncertain answers (cf. Appendix I). Correct answers were responses that match the expected responses, whereas wrong and uncertain answers were afforded the same status (namely that of incorrect responses) for not matching the expected responses.

4.7 Discussion

In this section, both the perceptual and the statistical results are discussed. This discussion seeks to:

(i) confront hypotheses previously set with perceptual results,

(ii) correlate statistical inputs with the auditory behavior of the natural sound, and

(iii) make deductions for a further phonological analysis of vowel duration.

4.7.1 Discussion of Perception Tests Results

A statistical analysis was carried out in order to calculate the percentages means of each category of answers given by the participants (cf. Appendix I). The aim of this means calculation was to identify which category of answers had the highest percentage of occurrence.

4.7.1.1 Perception Test I: Illustration and calculation of means

Extracted from Appendix I, Table 17 below shows the following for Perception Test I:

(i) illustrations of answer types (correct, wrong and uncertain), and

(ii) calculation of their means per category.

The vowel **/a/** is used as illustration for Perception Test I.

Pages	Stimuli	Expected Responses		Answers		
		Meaning	Number on the pt page	% Correct	% Wrong	% Uncertain
1	Sala	*Travaille!*	2	35	49	15
2	Saala	*Salon*	1	69	20	11
3	Mbaasi	*Ami*	2	69	14	17
4	Mbasi	*Demain*	2	23	57	20
5	N'safu	*Atangatier*	1	55	9	35
6	N'saafu	*Change!*	1	74	8	18
7	Cibamba	*Dame-jeanne*	2	12	88	0
8	Cibaamba	*Homme blanc*	1	80	14	0
9	Salu	*Salon*	2	18	78	3
10	Saalu	*Sel*	2	65	20	15
MEAN PERCENTAGES				50	35.7	13.4

Table 17: *Illustration for Perception Test I: Answers and means per category*

From Table 17, it can be seen that for 6 out of 10 stimuli, respondents gave mostly correct answers: 50% of the responses in Table 17 constitute correct answers. Five tables of the type of Table 17 were made for Perception Test I, one for each of the five vowels, as shown in Appendix I. The mean percentages for each vowel are summarized in Figure 8 below.

Tables	**Answers**		
	% Correct	% Wrong	% Uncertain
Table L.PT1a for vowel /a/	50	35.7	13.4
Table L.PT1e for vowel /e/	40.6	42.6	16.9
Table L.PT1i for vowel /i/	38.8	50.7	10.7
Table L.PT1o for vowel /o/	51.6	41.4	7.00
Table L.PT1u for vowel /u/	41.4	50.7	7.9

Figure 8: *Summary of mean percentages for Perception Test I tables*

As shown in Figure 8 above, in 2 of the 5 tables mainly correct answers occurred. This means that respondents gave a majority correct (i.e., the expected) answers for only the two vowels, namely /a/ and /o/, in Perception Test I. For the rest of the vowels, the majority of participant responses were incorrect (i.e., wrong and uncertain).

4.7.1.2 Perception Test II: Illustration and calculation of means

Table 18 below was also extracted from Appendix I and it shows the following for in Perception Test II:

(i) illustrations of answer types (correct, wrong and uncertain), and

(ii) calculation of their means per category.

The vowel **/e/** is used here to illustrate the answers given to Perception Test II.

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
53	Kubeela Kubela	*Différent*	2	58	38	3
54	Ceesa Cesa	*Différent*	2	60	22	18
MEAN PERCENTAGES				59.00	30.00	10.5

Table 18: *Illustration for Perception Test II: Answers and means per category*

It is shown in Table 18 above that for, all the stimuli, respondents gave the majority correct answers: 59% of the responses in Table 18 were correct answers. Five tables of the type of Table 18 were made for Perception Test II, one for each of the five vowels, as shown in Appendix I. Their mean percentages for each vowel are summarized in Figure 9 below.

Tables	**Answers**		
	% Correct	% Wrong	% Uncertain
Table L.PT2a for vowel /a/	54.5	39.5	6.00
Table L.PT2e for vowel /e/	59.00	30.00	10.5
Table L.PT2i for vowel /i/	57.00	40.00	3.00
Table L.PT2o for vowel /o/	58.5	37.5	4.00
Table L.PT2u for vowel /u/	79.00	20.00	1.00

Figure 9: *Summary of mean percentages for Perception Test II tables*

From Figure 9, it can be seen that, in all five tables, the majority of answers given were correct. This means that respondents gave mainly correct answers for all five vowels in Perception Test II. The incorrect responses (wrong and uncertain) recorded in this test II were insignificant.

4.7.1.3 Perception Test III: Illustration and calculation of means

Table 19 below was also extracted from Appendix I and shows the following for Perception Test III:

(i) illustrations of answer types (correct, wrong and uncertain), and

(ii) calculation of their means per category.

The vowel **/u/** is used as illustration for Perception Test III.

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
69	Kututa Kutuuta Kututa	*Icône A (Premier)*	1	83	15	2
70	Mbuusa Mbusa Mbuusa	*Icône A (Premier)*	1	88	12	0
MEAN PERCENTAGES				85.5	13.5	1.00

Table 19: *Illustration for PT III: Answers and means per category*

From Table 19 above, it can be seen that, for all stimuli, respondents gave mainly correct answers: 85.5% of the responses in Table 19 constituted correct answers. Five tables of the type of Table 19 were drawn up for Perception Test III, one for each of the five vowels, as shown in Appendix I. Their mean percentages are summarized in Figure 10 below.

Tables	Answers		
	% Correct	% Wrong	% Uncertain
Table L.PT3a for vowel /a/	39.00	52.5	8.5
Table L.PT3e for vowel /e/	51.5	44.00	4.5
Table L.PT3i for vowel /i/	86.5	13.00	1.00
Table L.PT3o for vowel /o/	47.00	51.00	2.5
Table L.PT3u for vowel /u/	85.5	13.5	1.00

Figure 10: *Summary of mean percentages for PT3 tables*

Figure 10 above indicated that for 3 out of 5 tables pertaining to Perception Test III, the majority of responses were correct answers. These three vowels were /e/, /i/, and /u/. For the rest of the vowels, the responses were mostly incorrect (i.e., wrong and uncertain).

4.8 Summary

In this chapter, a perception experiment was conducted with the overall aim of identifying the perceived duration in the context of minimal pairs, on the basic hypothesis that this perceived duration may assist in determining the existence of short and long vowels in Civili. The procedure used to determine the perceived duration was a perception experiment comprising three perception tests administered to 68 native speakers of Civili.

This chapter has:

- given an outline of vowel acoustic cues for speech perception while placing the perception experiment conducted within the framework of speech perception studies;

- presented the aim and the methodology of the perception experiment performed in this study;
- given an account of how the perception experiment was conducted;
- described the administration of the perception tests which consisted of one identification test (Perception Test I) and two discrimination tests (Perception Tests II and III); and
- statistically analyzed and discussed perception data gathered from the experiment.

The conclusion of this chapter may agree with the acknowledgement that Civili speakers consistently perceive short and long vowels as being different within the context of minimal pairs.

Endnotes in Chapter 4

[1] Psycho-acoustics is the science that deals with the psychological correlates of the acoustical parameters (Van Wieringen 1995: 3).

[2] The software was developed by Jan Louw (HUMARGA) according to specific instructions and model given by H.S. Ndinga-Koumba-Binza (SU-CLaST). This software was developed specifically for the purposes of the present study and cannot have any other application. The aim and purpose of this software program was to (i) enable the perception experiment to be performed and, specifically, (ii) collect perceptual data for the present study on vowel duration.

CHAPTER 5

Phonology of Vowel Duration

5.1 Introduction

This chapter presents a phonological description of Civili vowel duration. Phonetic data relevant to this description stems from experimental analyses presented in Chapter 3 and Chapter 4 of this dissertation.

As it has been mentioned earlier, the present work is presented within the framework of experimental phonology which favors the integration of phonetics and phonology (Fromkin, 1975; Ohala & Jaeger 1986; Ohala 1991; Roux 1991; Naidoo 2006).

The chapter commences with a designation of its specific aims, followed by an outline of the experimental phonetic outcomes of this research. Finally, a phonological analysis of vowel duration follows a review of Civili phonological processes.

5.2 Aims and Issue Recall

The goal of this section is to present the aims of the present chapter and to give a succinct recall of the research problem of this study. In fact, the main aim of this chapter is to address the issue as presented in Chapter 1 and Chapter 2 in view of phonetic observations gathered in Chapter 3 and Chapter 4.

Thus, addressing the Civili vowel duration issue strictly consists herein on recalling its core questions and related aspects.

Firstly, it has been advocated in Chapter 1 that a phonological analysis can be confirmed or refuted on the basis of phonetic data; and alternatively, the phonetic output predicted by phonological theories could lend credibility to, or negate an analysis.

Secondly, the methodology advocated for a reliable description of the Civili vowel duration is that of experimental phonology. The particularity of this methodology is presented as follows:

(i) firstly, it recognizes the interaction between phonetics and phonology within a suitable study of any language sound system;

(ii) secondly, it recognizes the three levels of physical aspects attested in speech production: the *articulatory level* (the actual production of sounds), the *acoustic level* (the transmission of sounds) and the *perceptual level* (the recognition and interpretation of sounds).

This study has been concerned with the acoustic and perceptual levels. Now, the present chapter should consider whether:

(i) Civili has long and short vowels as they allegedly appear in minimal pairs;

(ii) a phonetic long vowel could be regarded as an underlying short vowel subjected to phonetic conditioning;

(iii) vowel duration has phonemic status;

(iv) a long vowel could not be interpreted as two adjacent identical vowels.

Subsequently, the specific aims of the current chapter are:

(i) to make deductions from the acoustic analysis as well as from the perceptual analysis for a phonological description of vowel duration;

(ii) to compare acoustic and perception results within the process of gathering reliable phonetic data;

(iii) to present new phonetic data as outcomes of the acoustic and perception studies contained in Chapter 3 and Chapter 4 respectively;

(iv) to review Civili phonological processes that involve vowel duration; and finally

(v) to present a phonological description of Civili vowel duration on the basis of new phonetic data.

Stemming from Chapter 1 and Chapter 2, questions to be answered in this chapter and in the subsequent phonological description are the following:

(i) Is vowel duration predictable or distinctive in Civili? In other words, is length an underlying feature of certain vowels or the result of a phonological process?

(ii) Is length attested on single vowel or should the phenomenon be regarded as a sequence of two identical vowels?

(iii) Why do the clusters NC and CG end up with perceived vowel lengthening as part of their phonetic realization?

(iv) Many forms of vowel duration are observable at word level, but what happens to these forms in different syntactic environments?

(v) How one should treat vowel duration in particular theories?

Addressing the above questions should consequently help not only (i) to determine evidence on the basis of which one can decide whether long-sounding vowels identified in Chapter 3 are lengthened vowels or naturally long vowels, but also (ii) to formulate a general rule or rules for vowel lengthening in Civili.

Thus, addressing the questions above will require the following in the present chapter:

(i) an overview of factors influencing vowel duration (Section 5.3);

(ii) an identification of experimental phonetic outcomes from both acoustic and perception experiments (Section 5.4);

(iii) a determination, from the two points above, of phonetic facts concerning Civili vowel duration (Section 5.5); and finally

(iv) a phonological analysis of vowel duration on the basis of new phonetic data (Section 6.5).

5.3 Factors Influencing Vowel Duration

The aim of this section is to present an overview of factors that influence vowel duration. It investigates factors other than the phonetic environments presented as conditions for the production of short-sounding or long-sounding vowels in Civili (cf. Chapter 3).

The identification of these factors, in the form of a literature review, does not only refer to universal phonetic facts (Keating 2003; Stevens 2003; Johnson & Hume 2003), but also to other studies on that topic, as well as to acoustically observable facts of the Civili sound system.

Vowel duration can be influenced at both levels of the production process (articulatory or acoustic) and the perception process.

5.3.1 On the Production Process

Firstly, cross-linguistically vowel duration is often influenced by the vowel position and the number of syllables in a word, the vowel quality, and the following consonant. Other factors influencing vowel duration are such as lack of onset, lack or presence of coda.

Secondly, Doty, Idemaru & Guion (2007) have shown that some acoustic correlates of the stop length contrast in Finnish beyond the duration of the consonant itself. Of interest are the durations of surrounding vowels, the duration of voice onset time (VOT), and the amplitude of the release burst and the following vowel.

Results of their study on Finnish indicate that for geminate stops, VOT is shorter and the amplitude of both the following vowel and the release burst are higher than for singleton stops.

It is also important to mention stress as one of the factors influencing vowel duration. The process occurs when there is stress on the syllable that contains a particular vowel as outlined by Gussenhoven (2001: 15295).

> "*Stressed positions in phonological representations not only attract more phonological contrasts, as the English and Russian vowel systems, but also lead to less casual articulation than unstressed positions. The intensity at the higher end of the frequency spectrum tends to fall off less steeply (even spectral balance), spectral targets of vowels are approached more closely (less vowel reduction), and their duration is longer*" (Gussenhoven 2001: 15295).

This implies a certain investigation on the relation between word prosodic structure and vowel duration (cf. Gussenhoven 1999; Rietveld, Kerkhoff & Gussenhoven 2004). For instance, Rietveld, Kerkhoff & Gussenhoven (2004: 349) have experimented in Dutch and found that "*measurements of vowel duration in reiterant speech showed that main stress, secondary stress, and right/left-edge position determine vowel duration*". Also see Fokes & Bond (1987) on vowel duration as a correlate of stress.

Further, the authors indicate that long vowels preceding geminate stops are shorter than those preceding singleton stops, although no difference was found for short vowels. Post-consonantal vowel duration does not vary as a function of consonant length, but is affected by the length of the first-syllable vowel.

Moreover, Williams & Poiré (2007) have examined variables influencing vowel duration of French spoken in Windsor, Ontario, in order to see whether their respective effects on vowel duration are organized hierarchically. The authors first consider the data distribution of four female speakers before carrying out a statistical principal components analysis.

The results of their study show that the variables are classified into three underlying factors: syllable structure, syllable position and vowel properties. This last factor group includes the factors of phonological vowel class and diphthong status, and always explains the majority of the variability in vowel duration. Syllable position also accounts for some of this variation in certain cases. The consistent hierarchy of these factors across the statistical analyses confirms that a vowel's properties are the most important in determining its duration, followed first by the syllable's position in the utterance, and second by the syllabic structure.

5.3.2 On the Perception Process

It is known that nasals and liquids are always voiced. Therefore, in the environment of a nasal or a liquid, a preceding (acoustically short) vowel might subsequently be perceived long and therefore written as long orthographically.

Krause (1982a & 1982b) has investigated vowel duration as a cue to postvocalic consonant voicing. In Krause (1982b), ten trials of six test words were analyzed, spoken respectively by 10 3-year-olds, 10 6-year-olds, and 10 adults, all with normal language and articulation and hearing. A significant interaction between the speaker's age and the voicing feature of the postvocalic consonant was found on measures of total vowel duration.

Krause (1982b) shows that the duration of vowels preceding voiceless stops was similar across ages, but vowel duration preceding voiced stops decreased sharply with age. In addition, decreased variability of vowel duration was observed with increasing age.

Furthermore, as mentioned earlier in Chapter 4, acoustic analyses of speech and perceptual studies indicate that the dominant acoustic correlates of vowel perception are the frequencies of the first three formants. However, it is also been indicated (Sawusch 1998), that most vowels are not completely steady-state (even in isolation) and that formant frequencies change with variation in the surrounding consonantal context, prosodic influences, speaking rate, and vocal tract length of the speaker. These phenomena might produce a formant movement which in turn might produce a vowel duration variation.

Finally, the perception of duration is also influenced by the relationship between a tone and its tone-bearing unit. In fact, cross-linguistically, vowel duration is often found to be inversely related to the approximate average of f_0; all else being equal, vowels on low tones are longer than those on high tones, while vowels on rising tones are longer than those on falling tones (cf. Lehiste 1976; Pisoni 1976; Yu 2003 & 2006; Ndinga-Koumba-Binza 2003b). According to Yu (2006) this type of interplay between tonal contrasts and duration is commonly reflected in the world's languages.

5.4 Experimental Phonetic Outcomes

The discussion in this section has the following aims:

(i) to present experimental phonetic outcomes;

(ii) to observe whether there is any significant difference between acoustically measured duration and perceived duration, and if so, to identify the conditions of this difference.

5.4.1 Phonetic-Phonological Deductions from the Acoustic Analysis

The statistical results from the acoustic analysis have shown that the three effects tested are significant for various vowels (long or short sounding) of the Civili vowel system with various variables being implicated. However, the objective of the discussion here is to determine:

(i) the effect responsible for the longer duration in the vowel system, and the variables implicated for this effect;

(ii) the effect responsible for the shorter duration in the vowel system, and the variables implicated for this effect.

The variability of results does not allow general deductions. For instance, there is no context-position interaction for all long-sounding vowels. Thus, it will not be possible to state that the effect CONTEXT*POSITION is responsible for longer duration.

Likewise, the same dependent variables do not play a role in the same effects for the same vowels. Differences are important to the extent that they hardly indicate which variable is exactly responsible for the longer or shorter duration for all vowels.

In this discussion, we adapt and apply three principles from phonological theory to this analysis in order to differentiate conditions for the longer or shorter duration.

The first principle is that of phonological universals, the second principal is neutralization and the third one is the distinctive contrast principle.

5.4.1.1 *Adaptation of the Phonological Universals Principle*

Phonological universals can be referred to as a set of features that all languages have in common (Cristofaro 2006a; Hammond 2006). Cristofaro (2006a: 222) states that features for linguistic universals are of two types, namely:

(i) features pertaining to the types of rules and constraints that have to be present in the grammar, such as phrasal formation rules, derivation rules, and constraints thereon; and

(ii) features pertaining to the material that provides the basic building blocks of linguistic structure, such as phonological distinctive features in phonology (Hammond 2006), or parts of speech and the notion of syntactic trees in syntax.

Vowels may belong to the second type of universal features. However, the presence or absence of vowels is part of distributed single features that do not prevent the application of "*constraints stating that all languages behave in the same way*" (Cristofaro 2006b: 225). Cristofaro (2006b: 225) and Croft (2003: 52) agree on the unrestricted universal that all languages have vowels.

The point of this discussion is that if all languages may have vowels, the basic duration pattern of these vowels might be short. There may be languages with both short and long (or lengthened) vowels, or languages with short vowels only. The existence of languages with long (lengthened) vowels but no corresponding short vowels is excluded.

In the present study, the existence of short vowels is *de facto* acknowledged. These vowels could also be considered as being short. Thus, determining the effect or effects responsible for shorter duration of vowels will not be of scientific interest. In fact, if there exists an effect responsible for shortening vowel duration, it would mean that vowel should pre-supposedly be naturally long or lengthened (cf. Caisse 1982).

5.4.1.2 *Adaptation of the Neutralization Principle*

Neutralization is a linguistic principle used in phonology and morphology. "*When a contrast that is normally made in a language is not marked, this is called neutralization*" (Richards & Schmidt 2002: 358). In the terms of this study, neutralization is the process that ensures that there is significative distinction in the comparison of effects and dependent variables.

The neutralization pattern has been adapted in the same order as it has been used in various ways to address a variety of issues in both phonetics and phonology (see Dinnsen & Charles-Luce 1984; Jassem & Richter 1989; Port & Crawford 1989; Kim & Jongman 1996; Ramer 1996; Beckman 1997; Wilson 2001; Myers & Hansen 2005; Hall 2006, among others). Like vowel duration, most of the phenomena addressed belong to the phonetics-phonology interface. In the present study, the principle of neutralization (Lass 1984: 39; Akamatsu 1988: 10) is used at an abstract level in the circumstance of impossible contrast between two effects tested in the statistical analysis.

It is observed that the effects CONTEXT and POS are equally significant for both short and long-sounding vowels. The contrast short versus long sounding thus appears neutralized for the above effects. In fact, "*the output of a neutralization needs not to belong to one of the two sets of sounds that contrast*" (Hall 2006: 605).

On the other hand, the effect CONTEXT*POS is not significant for short-sounding vowels but only for long-sounding ones. This means that the effect can be significant for the contrast short versus long sounding vowels.

5.4.1.3 *Adaptation of the Distinctive Contrast Principle*

This subsection aims to find the pertinent effect and/or variable that is responsible for long or short sounding in the Civili vowel system. Phonological descriptions have often used the principle of distinctive contrast within the procedure of commutation in order to distinguish one unit of a language from another. Thus, phonologically a unit is distinctive (or pertinent) when it is different from other units and that difference causes "*crudely a change in meaning*" (Matthews 1997: 61). A unit is not pertinent at all if it does not cause any difference in meaning.

In the present study, the aim of commutating one effect with another is to establish how pertinent both contrasted effects are on vowels for which they are significant. This adaptation of the distinctive contrast principle in the present analysis may assist in eliminating ambiguity on multi- and double significances from tested effects for Civili vowels.

Table 20 below presents all three effects in contrastive positions and their distinctive values on each vowel. The positive value (+) indicates that both effects are contrastive and that their substitution may have an influence on the production of the vowel.

UNITS / MEANINGS	CONTEXT vs. POS	POS vs. CONTEXT*POS	CONTEXT*POS vs. CONTEXT
i	+	+	+
e	+	+	+
a	-	+	+
o	+	+	+
u	-	+	+
ii	-	-	-
ee	-	+	+
aa	+	+	-
oo	+	+	+
uu	+	+	+

Table 20: *Distinctive values of effects on vowels*

The adaptation of the principle of distinctive opposition to this analysis presents the three tested effects and their results in distinctive opposition on the basis that two or all three effects can be significant for the same vowel. If two contrasted effects (UNITS) are significant for the same vowel (MEANING), then both effects have no distinctive value on that vowel. This means that the substitution of one effect by another will make no difference to vowel duration because it will still produce the same vowel.

Table 20 also reflects the multi- and double significances of effects in a clear way. The question is whether, although both effects are significant for the same vowel, both effects influence the vowel duration? And if both have an influence on the duration of the vowel, the questions remaining are why and how.

As could be seen earlier from Table 9 (cf. Chapter 3), situations of multi- or double significance are only found with long-sounding vowels. Furthermore, recall that these situations of multi- or double significance primarily involves the effect CONTEXT*POS and either one or both of the other two effects. In the application of the distinctive contrast principle, the three effects have no pertinent value for the High FRONT long-sounding vowel /ii/. Likewise, the two effects CONTEXT*POS and CONTEXT have no pertinent value for the Low BACK long-sounding vowel /aa/. Seeing that the effect CONTEXT*POS is significant for only these two vowels, one may conclude this effect cannot be of high significance for Civili vowel duration.

5.4.1.4 *Phonetic-Phonological Deductions*

From an acoustic point of view, the discussion above allows the following phonetic-phonological deductions based on the acoustic analysis:

(i) There are naturally short vowels in Civili.

(ii) These vowels can be lengthened or appear long in certain contexts and positions.

(iii) The interaction between context and position does not play a major role in vowel duration.

(iv) In contexts and/or positions in which the vowel should appear long, the vowel is shortened due to a certain effect.

5.4.2 Phonetic-Phonological Deduction from the Perceptual Analysis

Recall that one of the general hypotheses was that determining perceived vowel duration may assist in determining the existence of short and long vowels. Results of both the perception experiment and the statistical analysis of perceptual results show that Civili native speakers make consistent distinctions between short-sounding and long-sounding vowels.

Recall that in Table 17 (cf. Chapter 4) the mean percentage of correct answers equals that of the sum of the wrong and uncertain responses. However, it was presented in Chapter 4 that the mean percentages in Tables 18 and 19 show large consistency for Civili native speaker's ability to discriminate between short and long vowels in the context of minimal pairs.

However, it was not the case with vowels in contexts other than minimal pairs. In these contexts, long vowels might simply be phonetically conditioned.

Ultimately, the sole phonological deduction from this perception experiment is that "*by making such distinctions, the listeners are effectively making decisions that are phonemic in nature*" (Mitterer & Cutler 2006: 770).

5.4.3 Comparative Acoustic-Perceptual Analysis of Minimal Pairs

Throughout this study we have made a clear distinction between the physical (acoustic) duration and the perceived duration, the same way Malmberg (1974: 191) had to distinguish the physical duration from distinctive length. In fact, in the process of human language communication there is a difference between the produced signal (acoustics and/or articulatory) and the perceived signal (perception).

However, there is an increasing interest of studying the production (acoustic and/or articulatory) and perception in parallel in order to find out whether perception is based on the production (articulatory or acoustic) templates and in which manner production is controlled by auditory templates (cf. Eerola, Laaksonen, Savela & Aaltonen 2003; Ru, Chi & Shamma 2003; Frieda, Walley, Flege & Sloane 2000).

In the context of minimal pairs, this distinctiveness is expected to be observed acoustically and established perceptually. In this subsection we present a short comparative analysis of acoustic and perceptual results of minimal pairs in order to ascertain this distinctiveness. This analysis is a phonetic confirmation of phonological minimal pairs.

5.4.3.1 Analysis

In order to perform the comparative acoustic-perceptual analysis, a limited number of minimal pairs were observed. Effort was made to withdraw minimal pairs within the phonetic environments (Contexts) established for acoustic measurements. However, only three contexts appear to hold for minimal pairs, i.e. the following contexts:

(i) when the vowel is followed by a single nasal consonant, i.e. /C_N/;

(ii) when the vowel precedes a consonant stop, /C_C/; and

(iii) when the vowel precedes a liquid consonant, i.e. /C_L/.

Note that these contexts are the only phonetic environments where short-sounding vowels appear as presented in Chapter 3. It should be recalled that the distinction established between long-sounding and short-sounding vowels was based on the calculation of the duration averages across vowel qualities per speaker (cf. Table 8 in Chapter 3) and mainly supported on the perception-based (visual and auditory) physical measurements.

Now, Table 21 below gives a summary of the analytical acoustic-perceptual observation. Column 1 numbers the minimal pairs. Column 2 presents the words of each minimal pair. Column 3 indicates whether the vowel in the pair was acoustically measured short or long. Column 4 designates whether the vowel in the pair was perceived short or long. In Columns 3 and 4, the value (X) specifies the duration (short or long) concerned. Column 5 presents results of the comparison. The positive value (+) indicates whether the perceived duration is identical to the acoustic duration.

Pairs	Words	Acoustic Duration		Perceived Duration		Results
		Short	Long	Short	Long	
1	Biima		X		X	+
	Bima	X			X	-
2	Mbeela		X		X	+
	Mbela	X			X	-
3	Baana		X		X	+
	Bana	X		X		+
4	N'tootu		X		X	+
	N'totu	X		X		+
5	Mbuusa		X		X	+
	Mbusa	X		X		+
6	Saalu		X		X	+
	Salu	X			X	-

Table 21: *Comparative Acoustic-Perceptual Analysis*

5.4.3.2 Results and Discussion

Table 21 shows the following results for the minimal pairs observed:

(i) the short-sounding part of the minimal pair is acoustically measured short and perceived short as well in three cases (thus 3 out of 6 cases);

(ii) the long-sounding part of the minimal pair is acoustically measured long and perceived as long in all cases (thus 6 out of 6 cases);

(iii) 9 out of 12 cases show that the perceived duration is identical to the physical duration.

Note that the three cases where the perceived duration does not match the acoustic duration concern the two phonetic environments of /C_N/ and /C_L/, i.e. the vowel is preceding a nasal or a liquid. In these cases, vowels measured as short are perceived as long.

This subsequently confirms the idea that in general cases the vowel is perceived long when it is preceding a nasal or liquid consonant. This has been seen with phonetic (acoustic) factors that influence vowel duration in these two contexts (cf. Section 5.3 above).

Finally, the difference between the physical duration and the perceived duration is not that significant to deny the existence of minimal pairs based on duration. Therefore, this comparative acoustic-perceptual analysis confirms the phonemic distinctiveness of vowel length in Civili minimal pairs.

5.5 New Phonetic Features

Through the literature review in Section 5.3, we have identified that the following are among others factors that allegedly influence vowel duration:

(i) on the production process

a. vowel position
b. syllable position
c. number of syllables in the word
d. VOT duration
e. vowel quality
f. voicing of surrounding consonants
g. surrounding stops
h. absence of onset
i. absence or presence of coda
j. stress

(ii) on the perception process

a. voicing of surrounding consonants (nasals & liquids)

b. age

c. formant frequencies

d. tones

The conclusion of the study from Doty, Idemaru & Guion (2007) allows the following comparison with the sound of system of Civili, a language in which geminates are not attested.

> Post-consonantal vowel duration stays short in a final-position syllable. This may explain why all long vowels (except for onomatopoeias) in Civili are found only in the first syllable of disyllabic words or penultimate syllable of polysyllabic words.

In the specific case of vowel duration in Civili the following phenomena were observed through waveforms in TextGrids (cf. Appendix E & accompanying CD-Rom) as influencing vowel duration:

(i) Vowel position (cf. vowels involved in minimal pairs). In most cases, it is the vowel in V_1 position of the nominal stem.

Note the following examples in (20):

Teela	“*Mischievousness*”
Tela	“*TV*”

(ii) syllable position (cf. syllable involved in minimal pairs and situation of the penultimate syllable)

Note the following examples (21):

Cibaamba	“*white person*”
Cibamba	“*home carboy*”

(iii) number of syllables (cf. number of syllable in canonic Civili nominal stem or word)

Note the following examples (22):

Makungulu	"*knees*"
Lisusuku	"*hip*"

The canonic nominal stem in Civili is –CVCV, i.e. it is disyllabic (cf. Ndamba 1977; Mabika Mbokou 1999: 39; Ndinga-Koumba-Binza 2000: 66-67). It is noted that stems with more than two syllables hardly have long vowels.

(iv) voicing of surrounding consonants (including nasals and liquids)

Note the following examples (23):

Simbiinda	"*jars*"
Lusyeemu	"*flash of lightening*"

Vowels are often lengthened when preceding [+voice] stops, nasals or liquids.

(v) absence of onset (cf. nominal stems with vowel as initial segment)

Note the following examples in (24) for /VCV/ stems:

Mwana	|mu-ana|	"*child*"
Meenu	|ma-enu|	"*teeths*"

(vi) absence of coda (cf. Civili syllable structure)

Note the following examples in (25) for /CV/:

Vee	|ve|	"*tranquil*"
Sinjeembu	|si-njee-mbu|	"*bats*"

Codas are not attested in the syllable structure of Civili. The absence of coda might either motivate or prevent any vowel lengthening process.

In addition, it has been shown in Chapter 3 and Chapter 4 that vowel duration is dependent on the following:

(i) certain phonetic environments (Contexts)

(ii) syntactic positions (Isolation, Subject or Object)

(iii) existence of minimal pairs on the basis of vowel duration

These phonetic observations confirm the existence of both short-sounding and long-sounding vowels. On the basis of these observations, it is believed in this research that:

(i) short vowels are natural;

(ii) long vowels are derived from phonetic factors, thus regarded as the result of phonological processes;

(iii) the vowel is realized or perceived long in a phonetic environment that should normally induce a short vowel due to the interaction between two factors.

Finally, these factors can be grouped into four situations of influence of vowel duration:

(i) the phonetic environment, including the following factors:

   a. voicing of surrounding consonants

   b. absence of onset

   c. absence of coda

(ii) the position, which can be metric, syllabic or syntactic includes the following factors:

   a. vowel position

   b. syllable position

c. number of syllables

d. the syntactic position

5.6 Phonological Analysis of Vowel Duration

The present section tries to give an answer to each of the following questions.

(i) How do these results impact on the whole issue of vowel duration?

(ii) Do these results support any claims from previous studies?

In order to address these two questions, this section will have two subsections. Firstly, it will present phonological processes involving vowel duration on the basis of new phonetic features and at the same time formulate rules for each process. Secondly, it will suggest a Civili vowel phoneme system making reference to vowel duration.

5.6.1 Long versus Short Vowels

To the question whether vowel length is predictable or distinctive in Civili, the comparative acoustic-perceptual analysis of minimal pairs and the new phonetic features outlined allow to posit the following:

(i) Vowel length is distinctive as it has been proven through minimal pairs.

In fact, results of this study yields favorable support for the following vowel chart of Civili on the basis of vowel duration as presented in Table 1 (cf. Chapter 2) and Table 22 below.

/i/ /i:/		/u/ /u:/
/e/ /e:/		/o/ /o:/
	/a/ /a:/	

Table 22: *Civili Phonemic Vowel Chart*

The chart contains both long and short vowels. The phonemic status of long vowels is attested not only at perceptual level, but also at acoustic level.

(ii) There is a phonetic variation within [long] and [short] vowels. This phonetic variation bears the following characteristics:

a. It does not make any difference in meaning (i.e. non-phonemic).

b. It may reflect personal variation since some speakers produce longer vowels than other speakers, and some listeners perceive long vowels where other listeners do not.

c. The variation is also conditioned by phonetic factors. The conditions, which make vowel length to be predictable in certain situations, are discussed in the subsection (5.6.2) that follows.

To the question whether long vowels do bear a length feature or should be regarded as a sequence of two identical vowels, results of the spectral analysis (cf. Section 3.7 in Chapter 3) did not yield any support for acoustic evidence of double vowels in Civili. Spectrographic inspection showed a maintained steady state in formant structure of all vowels analyzed. There was no indication of internal transitions, i.e. junctures such ^{h}, ^{w} or ^{j} in vowel formant structures. Such transitions would have supported a /VV/ hypothesis claim or even a /V^{t}V/ hypothesis (^{t} indicates the internal transition) in the phonology of long vowels in Civili.

Finally, the spectrographic analysis supports the idea that long vowels in minimal pairs bear the length feature and are not a sequence of two identical vowels. For the sake of clarity long vowels are marked with a semi-colon in the phonological chart.

5.6.2 Phonological Processes

It is true that in order to describe the phonology of a language one needs the phonetics (Ladefoged 1997: 138). To this point, we have gathered phonetic features in order to support or reject phonological claims that were stated in previous studies of vowel lengthening in Civili (cf. Ndamba 1977; Mabika Mbokou 1999; Ndinga-Koumba-Binza 2000 & 2004).

However, as it has been previously mentioned, the influence that factors may have on vowel duration is twofold: (i) to lengthen the vowel or (ii) to prohibit vowel lengthening in certain contexts and positions.

Thus, phonological processes involving vowel duration are of two types, i.e.:

(i) Vowel lengthening, and

(ii) Lengthening prohibition

Our analysis will successively focus on both vowel lengthening and short-vowel maintaining processes.

Dubois (1994: 380) mentions that a process is a grammatical or linguistic mechanism that implies a set of successive operations. In other words, any evolution or transformation, any change that occurs during the combination of phonemic units of the same phonological system is to be called a phonological process.

The interest of a study of phonological processes in this dissertation is twofold. First, it is true that linguistic universals proceed from particularities of the world's languages. Thus, a study of particular phonological processes might contribute to the general knowledge of various phonological phenomena. Within a purely diachronic perspective, this might allow setting up a theory of universals from the study of phonological changes, a theory included to the view that focuses on determining what a family of languages is.

Moreover, within a framework of applied linguistics, educationists agree that a good evaluation of phonological processes allows an easy formulation of a reliable writing system.

5.6.2.1 Vowel Lengthening

As introduced in Chapter 2, Ndinga-Koumba-Binza (2000 & 2004) intended to explain the vowel lengthening process through the configurational model of autosegmental phonology as suggested by Paradis (1993) and Creissels (1994). This subsection intends to describe the processes on the basis of newly acquired verified phonetic data.

Table 23 below shows phonetic and syntactic environments and processes that induce vowel lengthening in Civili.

Environments	Processes & Positions
Phonetic and phonological environments	- semivocalization - nasal deletion - vowel deletion - liquid influence
Positional environments	- phrase/sentence-final position

Table 23: *Environments and Processes related to Vowel Lengthening*

5.6.2.1.1 *Phonetic and phonological environments*

Chapter 2 discussed in detail phonological processes related to the phenomenon of vowel lengthening:

(i) Prenasalization (see example (5)),

(ii) Semivocalization (see example (6)), and

(iii) Nasal deletion (see example (7)),

These analyses were adequately presented in terms of the formalisms of an autosegmental non-linear phonological model. However, in addition to the configurational explanations, the **phonetic motivation** becomes quite evident when the nature of the acoustic signal is assessed as such.

In order to demonstrate that the duration of a glide may contribute to the impression of a long vocalic segment, consider the following spectrogram (Figure 11) of a sequence /**bwala**/ ("*village*") where /w/ occupies a voiced time slot (it is not just a consonantal offglide) which is long enough to create an impression of a long vowel.

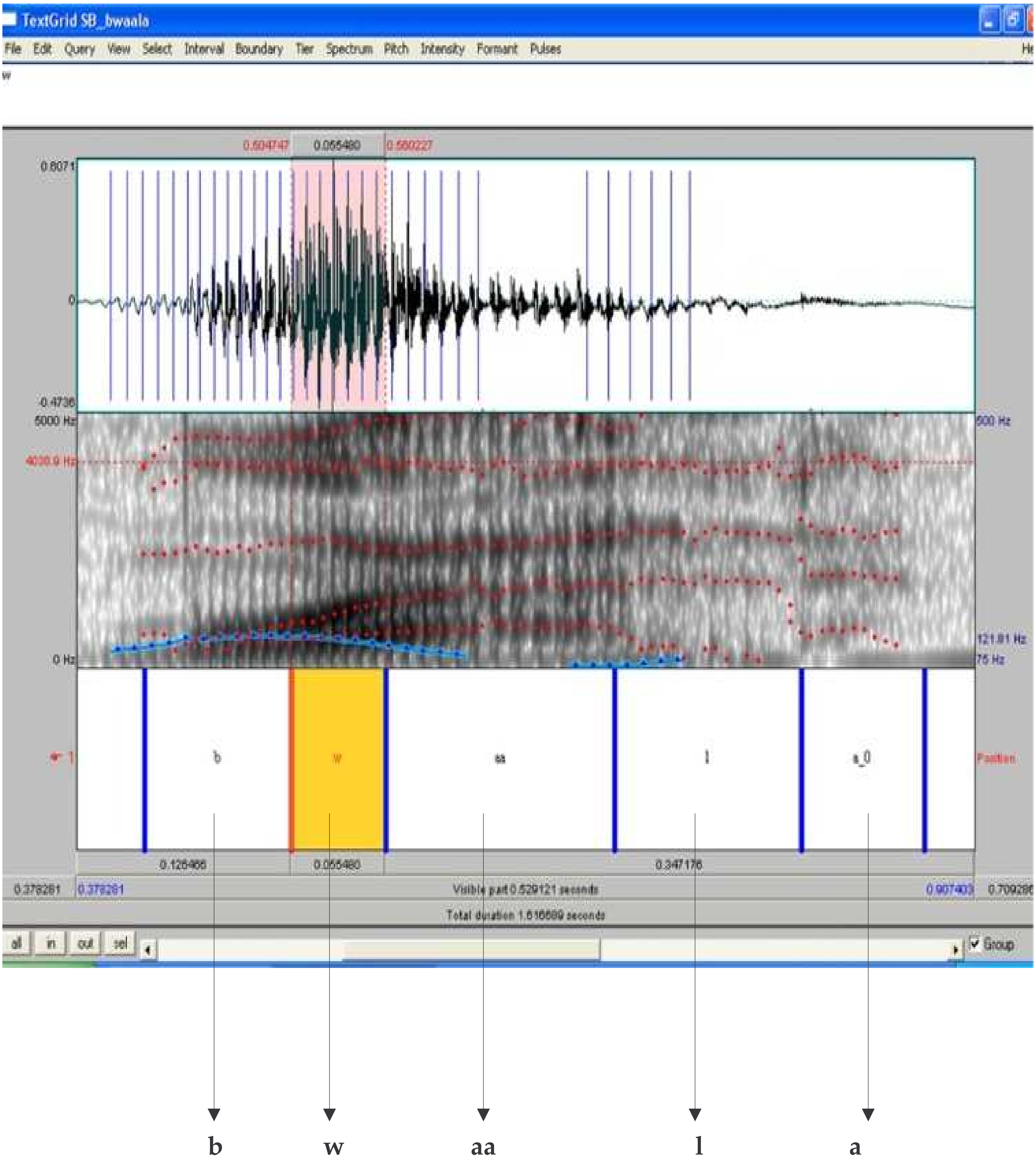


Figure 11: *Segmental Duration of Glide [w]*

It should be noted that the semivocalization process occurs at the morpheme boundary between a nominal prefix and a vowel-initial stem, e.g. *mu-ana, *mi-oku, *li-esu. The phonetic environment of absence of onset in nominal stems motivates a semivocalization phenomenon which is in turn a condition for vowel lengthening. Spectrograms in TextGrids (cf. Appendix E) of some of these words show a very short duration of the glide (semivowel), but a longer duration of the following vowel.

Moreover, in order to demonstrate that the duration of a "deleted nasal" may also contribute to the impression of a long vocalic segment, consider the following spectrogram (Figure 12) of a sequence /**bantu**/ ("*people*") [bá̰:tʰù̥].

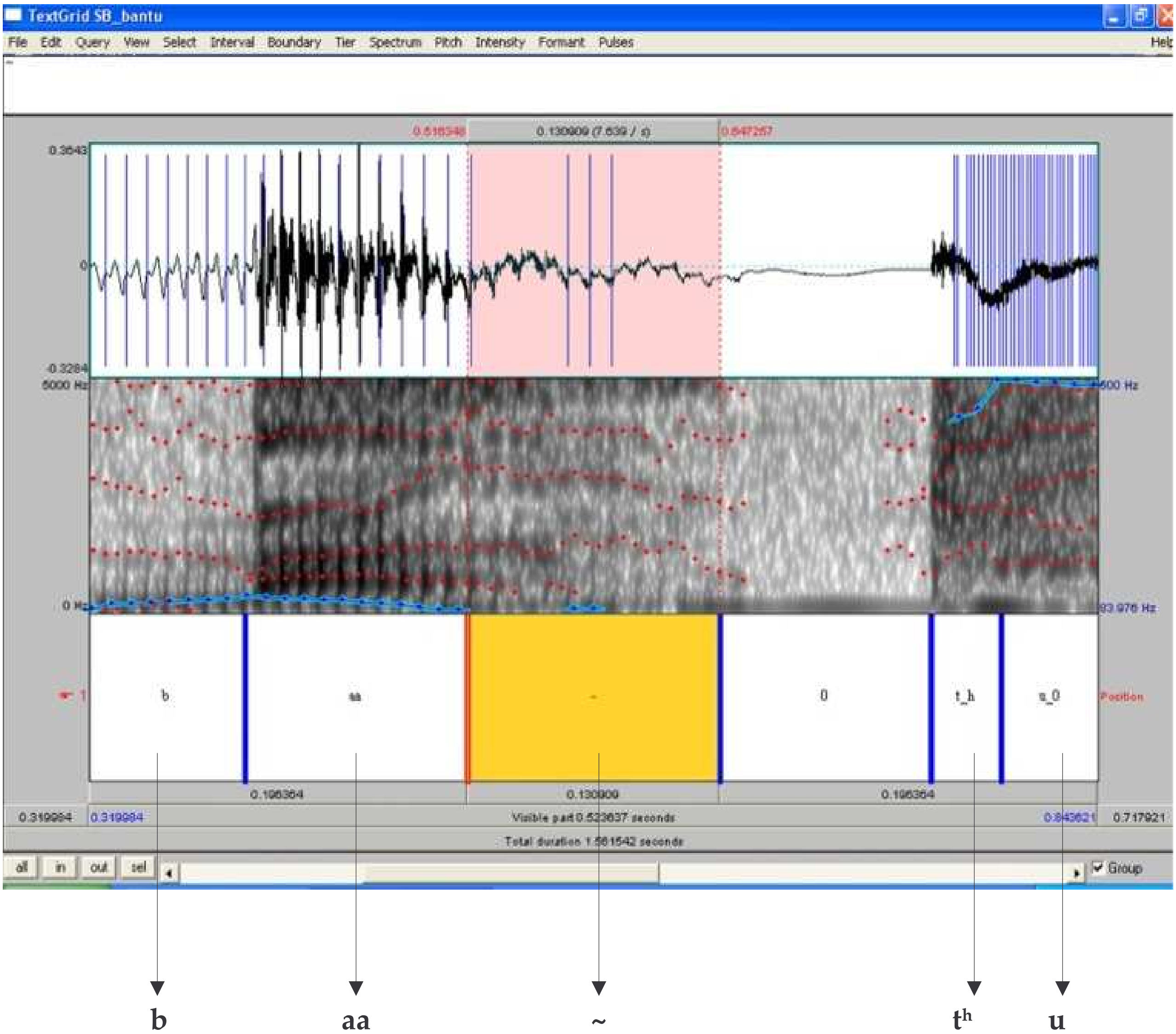


Figure 12: *Segmental Duration of a "Deleted Nasal"*

The spectrogram shows a very weak nasal, which is only perceived through the nasality of the vowel. The weak nasal nevertheless occupies a time slot (i.e. duration), which creates the auditory impression of a long nasalized vowel.

Note that nasalized vowels are phonetically-conditioned and not phonemic in Civili (cf. Blanchon 1990, Mabika Mbokou 1999 and Ndinga-Koumba-Binza 2000).

A phonological process such as vowel deletion also gives rise to vowel lengthening. Vowel deletion is a phonological process by which a phoneme is deleted (Collins & Mees, 2003: 242). The process is also sometimes termed as phoneme deletion (Crystal, 1999: 83, 102; 2003: 128, 258; Davenport & Hannahs, 1998: 125). Davenport & Hannahs (1998: 125) note that deletion is "*expressed in terms of a segment becoming Ø (zero)*". Clark & Yallop (1995: 90) refer to elision as "*the special loss or omission of segments or syllables*".

In Civili, a given vowel is systematically deleted when it is in contact with another vowel. This process obeys universal principles highlighted by Casali (1996). In fact, in a V_1V_2 hiatus and in certain contexts (considering that V_1 and V_2 are two vowels of different qualities), V_1 is usually deleted. The phenomenon is represented as follows in (26).

(26) × × × × × (underlying form)

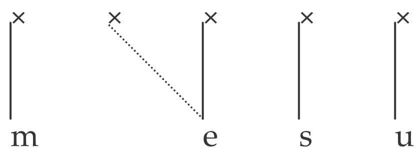
| | | | |

m a e s u

× × × × × (deletion of a)

| ǂ | | |

m (a) e s u



(lengthening of e)

(other processes)

[mɛ́:sù̥] "eyes" (output)

Meanwhile, vowels /i/ and /u/ do not elide when they are followed by another identical vowel. The sequence V_1V_2 when V_1 and V_2 are identical often results in a vowel-lengthening process that was introduced in Chapter 2. Moreover, the sequence V_1V_2 when V_1 is /i/ or /u/, and V_2 is a vowel of a different quality also results in a semivocalization process that is presented in Chapter 2.

Elision is often recounted as the loss or omission of a segment when it is so weakly articulated that it has no longer auditory significance (Clark & Yallop, 1995: 90), i.e., unstressed phonetic items are particularly prone to be elided (Crystal, 2003: 158).

However, this view defines elision within the context of connected speech and singularizes the phenomenon of elision with stress only. In other contexts, the occurrence of the phenomenon has been identified as also proceeding from segments interaction. For instance, Ndinga-Koumba-Binza (2000: 79-81) has shown in Civili the elision of nasals when followed by voiceless consonants; and Poulos & Msimang (1998: 103-104) have also mentioned that the adjunction of the Zulu suffix **-ana** to the noun stem provokes the elision of –**a**, -**e**, or –**i** that ends that noun stem.

5.6.2.1.2 *Positional Environments*

The following positional environments may cause vowel lengthening:

(i) vowel position,

(ii) syllable position

(iii) number of syllables

(iv) syntactic position

Within the positional environments a distinction should be made between occurrences of long vowels and the lengthening process itself.

Occurrences refer to what could be called "state structure". The phonetic features of vowel position, syllable position and number of syllables belong to the state structure. Long vowels occurring in state structures are not the "*outcome of a process*" (Bauer 2007: 73); but occur in fixed positions. Thus, in Civili, long vowels occur in

(i) a specific vowel position: i.e. as V_1 of the nominal stem, .e.g. |**ma-be:na**| "breast" and |**ci-ko:la**| "*school*";

(ii) a specific syllable position: i.e. as CV_1 of the nominal stem or CV_2 of a polysyllabic word, e.g. |**ci-to:ka**| "*well*" and |**ci-vada:ngu**| "*duke*" (in most of the cases vowels are all short in polysyllabic stems);

(iii) disyllabic words such as |**ba:na**| "*children*" and |**ko:ku**| "*arm*" with some exceptions such as onomatopoeias (e.g. |**vo:**| "*nothing*!"), and trisyllabic word (e.g. |**sapa:tu**| "*shoes*"),

The phonological lengthening process *per se* occurs due to the syntactic position only. This is a syntactic-position environment. It has been mentioned earlier in this chapter and in Chapter 3 that the effect POS plays a role in vowel duration. The POS effect comprises three variables: Isolation, Subject and Object. It was also mentioned in Chapter 3 that any vowel can be lengthened or is long due to the effect of a certain syntactic position.

Now, which position is responsible for vowel lengthening? Or are all three responsible for vowel lengthening? Statistical analyses on the basis of acoustic measurement have shown the following:

(i) the effect POS was significant for the long-sounding vowels /ee/, /ii/ and /oo/, and

(ii) the variable playing a role was only "Isolation".

This means that in an Isolation position of the Civili word vowels have longer duration than in the other two positions. This could be true, but the Isolation position has never been identified elsewhere as a phonetic motivation for a phonological vowel-lengthening process (cf. Fokes & Bond 1987:S66).

In fact, Bauer (2007: 85) states that "*words are not pronounced the same way in word-lists as they are in ordinary conversation*". Subsequently, words are not pronounced the same way in isolation as they are in a complete phrase or sentence. However, studies of production and/or perception of vowel duration in sentence situations (Klatt & Cooper 1975; Oller 1973; Klatt 1975; Ueyema 1999) show that vowel lengthening is syntactically determined. Thus, a vowel can be lengthened depending on the position that the word has in the sentence.

Specific cases of vowel duration whose acoustic measurements (cf. Appendix E and accompanying CD-Rom) were made both visually and auditorily show that in a phrase- or sentence penultimate syllable the duration of the vowel is longer than in other positions.

5.6.2.1.3 Phonological Rules for Vowel Lengthening

We have seen that there exist two types of environments for vowel lengthening in Civili:

(i) the phonetic-phonological environments, and

(ii) the syntactic environments.

These environments explain the phonetic variation observed earlier between [long] and [short] vowels. Two types of lengthening rules can be formulated from these two environments: a phonetically-conditioned rule and a syntactically-conditioned rule.

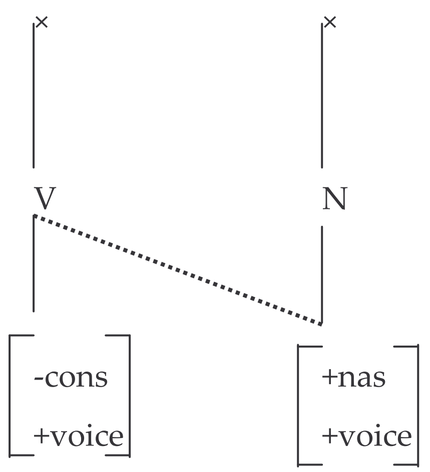
1- *Phonetically-conditioned rule*

Firstly, it should be recalled that the phonetic feature [voice] always assumes duration of one kind or the other. The phonetically-conditioned rule of vowel lengthening will be presented in terms of autosegmental configurations.

(27) Rule 1a: Nasal induced lengthening

A single vowel is realized or perceived long when it precedes a nasal consonant. The nasal consonant is [+voice]. Consider the following configuration in (28).

(28)



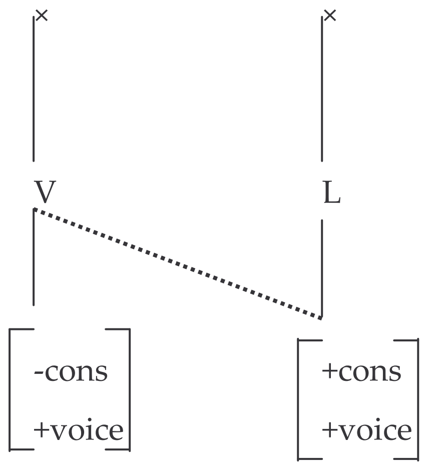
Spreading of [+voice] on V

Because of the voicing attached to nasals, the preceding vowel is perceived [+long].

(29) Rule 1b: Liquid induced lengthening

A single vowel is realized or perceived long when it precedes a liquid consonant. The liquid consonant is [+voice], and hence the following configuration in (30) arises:

(30)



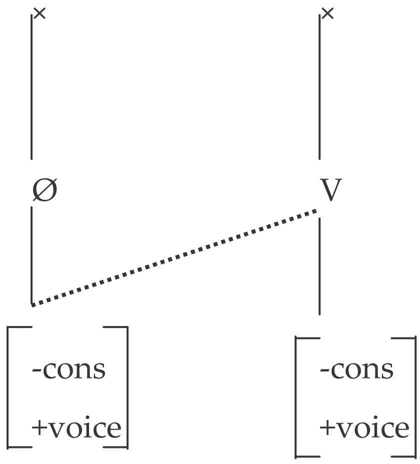
Spreading of [+voice] on V

Because of the voicing attached to liquids, the preceding vowel is perceived [+long].

(31) Rule 2: Vowel Deletion induced lengthening

A single vowel is perceived long following a vowel deletion process. The vowel is deleted at segmental tier with its skeletal position and features remaining. Note the configuration in (32).

(32)



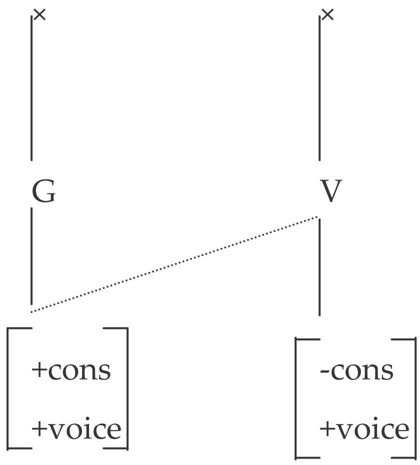
Spreading of [+voice] on V

Because of the voicing attached to vocalic skeletal position, the adjacent vowel is perceived [+long].

(33) Rule 3: Semivocalization induced lengthening

A single vowel is perceived long when it follows a Consonant + Glide (CG) cluster resulting from a semivocalization process. The glide is [+voice]. Note the following configuration in (34).

(34)



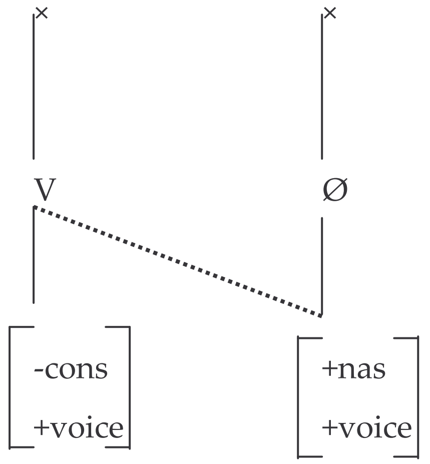
Spreading of [+voice] on V

Because of the voicing attached to the glide, the adjacent vowel is perceived [+long].

(35) Rule 4: Nasal Deletion induced lengthening

A single vowel is perceived long following a nasal deletion process. The nasal deleted is [+voice]. Note the following configuration in (36).

(36)



Spreading of [+voice] on V

Because of the voicing attached to the nasalized skeletal position, the preceding vowel is perceived [+long].

In all of the preceding rules perceived long vowels are the result of the spreading of the [+voice] feature to an adjacent element.

However, the occurrence of long vowels preceding voiceless consonants such /s/, /p/, /k/ and /t/ can be ascribed to processes such as nasal deletion, semivocalization and vowel deletion as formulated in the rules above.

Cf. the following examples in (37).

(37)	Bantu	[bḁ́:t^{h}ù̥]	*"human beings"*	(nasal deletion)
	Lyesu	[ljɛ̂:sù̥]	*"eye"*	(semivocalization)
	Mesu	[mɛ̂:sù̥]	*"eyes"*	(vowel deletion)

2- *Syntactically-conditioned rule*

We have seen that vowel duration is longer at the syntactic tier on the penultimate syllable of a phrase or sentence-final word. The phonological lengthening process here can be formulated as the following rule.

(38) Rule 5: Vowel lengthening

$$V \longrightarrow [+\text{long}] \quad / \quad \_\_CV\#\#$$

A single vowel is perceived long when it is in a penultimate syllable position of a phrase or sentence-final word. This rule is in line with a general rule in Bantu languages assigning length to the penultimate syllable of a phrase (cf. Watkins 1937: 10; Nurse 1996: 279; Childs 2003: 205).

5.6.2.2 Vowel-Lengthening Prohibition

In the event that phonetic and syntactic environments are in interaction, the vowel is maintained as short. There is no particular process except that the vowel-lengthening process is prohibited. It is a prohibition on vowel-lengthening.

On the basis of the acoustic analysis of Chapter 3, we have mentioned earlier in this chapter that there is no context-position interaction for the majority of long-sounding vowels.

Moreover, it has been shown in Chapter 3 that the interaction (CONTEXT*POS) phonetic environments and the syntactic position was significant for a certain number of short-sounding vowels.

This means that the interaction between the phonetic environment and the syntactic position prevents the vowel-lengthening and subsequently maintains the vowels as short. Note the following examples in (39) and (40).

(39) Isolation: /bwala/ [bwá:lə̀] "village"

Note the following spectrogram in Figure 13 for time duration of the vowel.

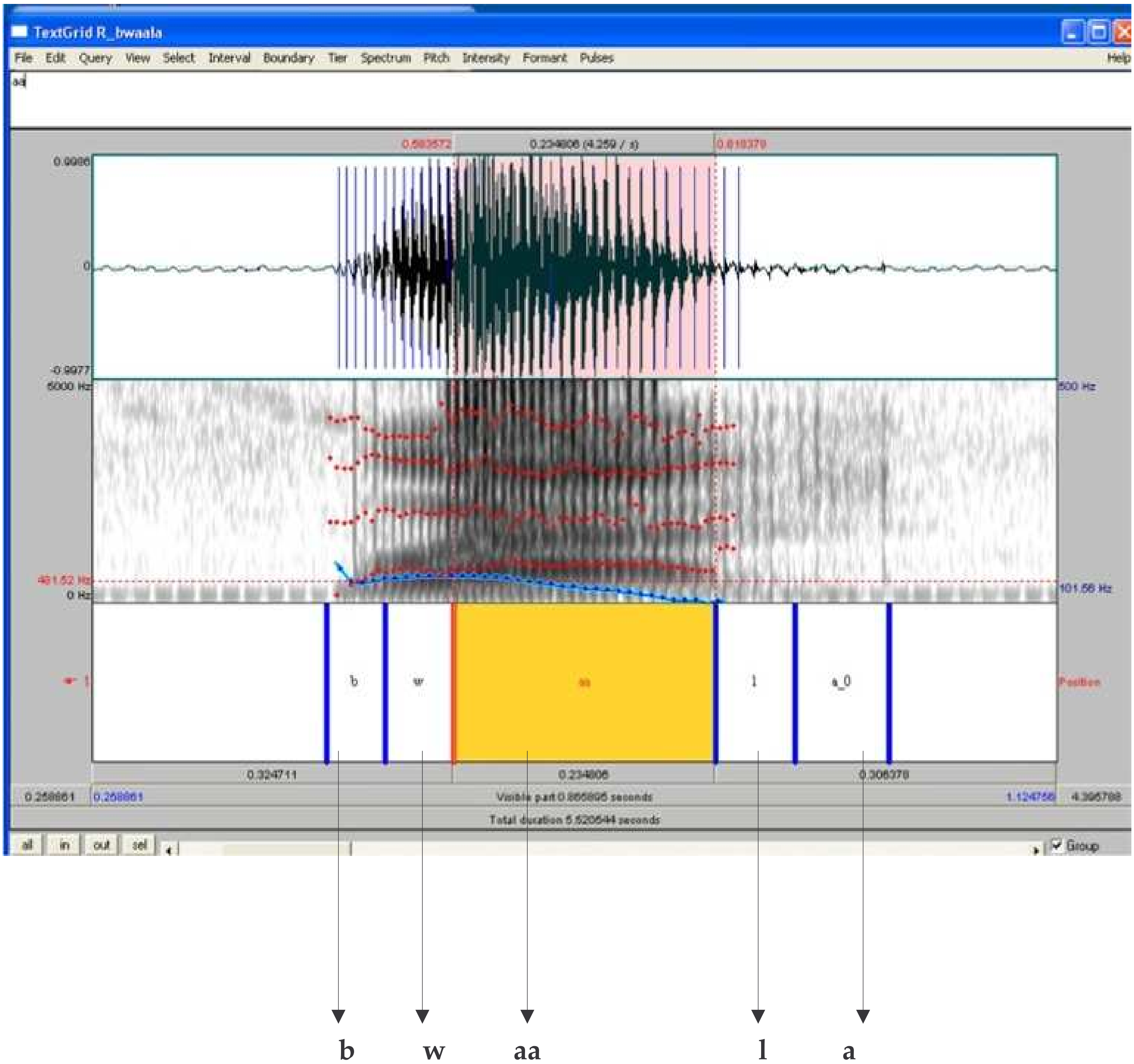


Figure 13: *Duration of V*$_1$ *in /bwala/ in isolation*

In isolation, the time duration of the vowel /a/ (V$_1$) in the word **/bwala/** is **0.234** seconds. This measurement fits into long-sounding vowels. The vowel is also in the phonetic environments for vowel lengthening. In fact, it not only follows a glide, but it also precedes a liquid consonant. But consider the following appearance of /bwala/ in (41).

(41) Sentence-median position:

Sentence: /panga bwala bu kulu/ [pʰà̰gə̀ bwá:lə̀ bú kúlù̥]

Note the following:

Panga “*Panga*” (place name)

Bwala “*village*”

Bu “*who*” (conjunctive)

Kulu “*to be old*”

Instead of a literal translation *Panga village who to be old*, the sentence should be translated as: *Panga is an old village*. The word /bwala/ is in the middle (median) position of the sentence in the source language, but in the object position of the sentence in the translation[1].

Note the following spectrographic screenshot in Figure 14 for time duration of the vowel.

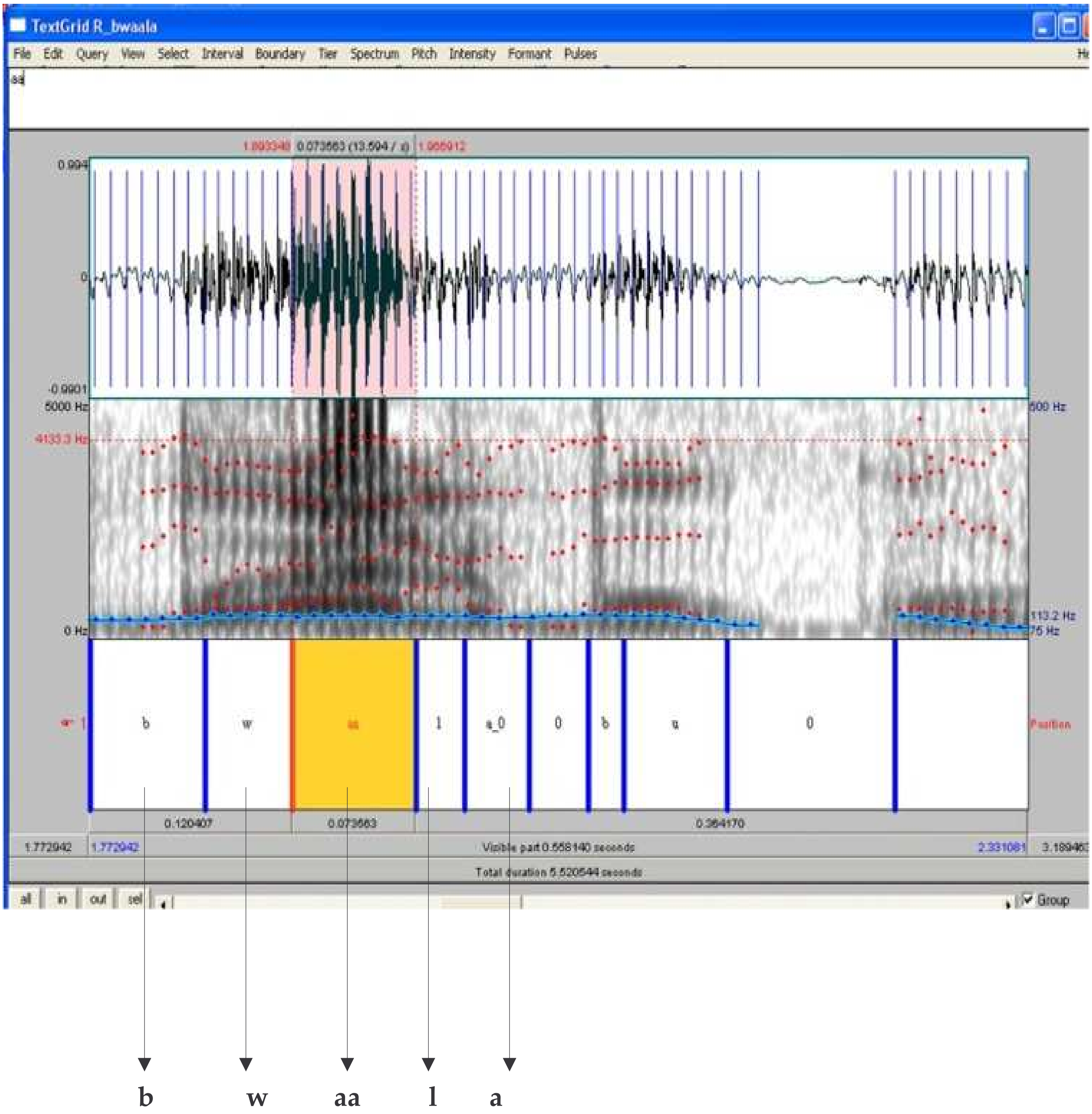


Figure 14: *Duration of V_1 in /bwala/ in sentence-middle position*

In sentence-middle position, the time duration of the vowel /a/ (V_1) in the word /**bwala**/ is 0.073 seconds. This measurement fits into short-sounding vowels. The vowel is also in the phonetic environments for vowel lengthening. In fact, it not only follows a glide, but it also precedes a liquid consonant.

The phonological interpretation of this analysis is that vowels in a phonetic environment of vowel lengthening are prevented to lengthen due to the interaction between the phonetic environment and the syntactic position. Apart from the sentence-middle position, the interaction between the subject position and the phonetic contexts induces short vowels (cf. Chapter 3). Note the examples such as in (38), (39) and (40)

(38) Isolation:	/libola/	[lìbɔ́:lə̀]	"basin"
(39) Phrase subject:	/libola li masi/	[lìbɔ́lə̀ lì másì̥]	"*a basin of water*"
(40) Sentence object:	/ya sukula libola/	[yà súkúlə̀ lìbɔ́:lə̀]	"*I have washed the basin*"

5.7 Summary

In this Chapter we have presented a phonological description of Civili vowel duration on the basis of new phonetic data. Features were derived from acoustic and perception data manipulated in Chapter 3 and Chapter 4 respectively.

Section 5.2 has presented the aims of the Chapter and given a succinct recall of the research problem of this study. Section 5.3 has presented an overview of factors influencing vowel duration at both production and perception levels. Section 5.4 has dealt with phonetic outcomes of both acoustic and perception experiments. The same section has not only outlined phonetic-phonological deductions from both the acoustic analysis and the perceptual analysis, but also enhanced a comparative acoustic-perceptual analysis of minimal pairs.

Discussions of the two latter sections finally induced new phonetic-phonological and syntactic environments presented in section 5.5. These phonetic and syntactic facts assisted in the phonological analysis of Civili vowel duration as presented in section 5.6. The analysis is mainly a description of phonological processes involving vowel duration in the studied language. This section has also confirmed the Civili vowel chart as containing both short and long vowels.

Endnotes in Chapter 5

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[1] Note that the determination of positions as isolation, subject and object was according to the sentence structure of the source language. However, in most of the data recorded we tried to capture as much as possible sentence that was matching the sentence structure of the two target languages, i.e. French and English.

CHAPTER 6

Conclusion

6.1 Introduction

The present chapter concludes this research on Civili vowel duration. Some measures of "scientific phonetics" have been applied in this dissertation. According to Ohala (1997: 682), scientific phonetics does not have a payoff in phonology only, but it "*constantly expands its horizons; it develops new data, concepts, and methods; it rejects or revises earlier beliefs shown to be deficient, and, to the extent that the surviving beliefs or theories have congruence with the universe, it has practical payoff, e.g., in language teaching, speech pathology, and speech technology*".

Thus, this chapter commences with recommendations for the standardization of the Civili orthography with regards to the representation of vowel duration. Section 6.3 outlines the contribution of the research findings to phonological theory. Section 6.4 introduces implications of this type of study for speech technology. Finally, Section 6.5 provides conclusions on results and accomplishments, and then formulates general suggestions for further research.

6.2 Recommendations for the Civili Orthography

Subsection 2.2.2 made mention of the orthographic implications of the Civili vowel duration issue. An assessment of existing proposals for the orthography of Civili, as well as for all Gabonese languages, revealed inconsistencies and inapplicability for popular use (cf. Ndinga-Koumba-Binza 2007c for a critical analysis of these various proposals.).

This is due to the fact that most of these proposals did not comply with certain methodological and social-acceptability principles for orthographic conventions

(Coulmas 1996; Touré 1990; Capo 2002). The situation with regard to an acceptable and standardized orthography for Civili is indeed extremely confusing. In order to set a standard and an effective orthographic system for Civili, this research suggests considering functions and characteristics of an efficient orthography as presented by Capo (2002: 8-9).

(41) *Functions of an Efficient Orthography* (Capo 2002: 8-9):

(i) Unifying and demarcating functions

(ii) Anti-colonial function

(iii) Interactive function

(iv) Normalising function

(v) Stabilising function

(vi) Perennising function

(vii) Enhancing progress

Capo (2002: 9) indicates that "*to assume these functions, an efficient orthography must have definite characteristics*". Among these characteristics he enumerates the following:

(42) *Characteristics of an Efficient Orthography* (Capo 2002: 9):

(i) Use graphemes that are easy to reproduce and discriminate

(ii) Absorb predictable pronunciation differences

(iii) Save the graphic image of the word

(iv) Preserve the very idea of the language

With regards to the specific case of vowel duration in Civili, it has been found that the Civili language makes distinctions between short and long vowels through minimal pairs. However, in many cases long vowels are predictable due to either phonetic environments or syntactical positions. Results have also shown that the phonetic realization in these contexts may vary from speaker to speaker, however less so in minimal pairs.

Given these considerations (including functions and characteristics suggested by Capo 2002), the following two **recommendations** are made with respect to the orthographic representation of vowel length in Civili.

(i) Vowel length should only be orthographically represented by a double vowel in case of minimal pairs to avoid semantic confusion. In fact, long vowels in minimal pairs are basically long and should also be written as long. Note the examples below.

a. Mbila "*call*" versus Mbiila "*type, kind*"

b. Mbela "*wrongness*" versus Mbeela "*knife*"

c. N'totu "*earth*" versus N'tootu "*tube, pipe*"

d. Libaku "*clash, stumble*" versus Libaaku "*fever*"

e. Mbusa "*back*" versus Mbuusa "*fishnet*"

(ii) Predictable vowel length should not be marked orthographically, i.e. in all other cases a single vowel should be used orthographically. Note the following examples:

a. Lumbotawu [lùmbótá:wù̥] "*button*"

b. Mabena [mə̀bɛ́:nə̀] "*breast*"

c. Simpinda [sɪ̰̀pʰɪ̰́:ndə̀] "*peanuts*"

d. Mpokongu [mpʰókò:ŋgù̥] *"problems, harassment"*

e. Sintumbu [sḭ̀tʰṵ́:mbù̥] *"needles, syringe"*

The present recommendation promotes the notion that Civili vowels are primarily short and hence represented by a single separate vowel symbol. Phonetically perceived long vowels similarly, are represented by a single symbol, unless it is part of a minimal pair in which case a double vowel is used as has been the tradition. Furthermore, marking a double vowel only in minimal pairs provides a simplified orthographic vowel system which is user-friendly and accessible for language learners and users. Moreover, these recommendations yield support for orthographic symbols (for vowels only) suggested by Ndinga-Koumba-Binza (2007b) as presented in Table 24 below.

	Small	**Capital**	Examples	
1.	**a**	**A**	Liba	*"palm tree"*
2.	**e**	**E**	Ndebu	*"fishnet"*
3.	**i**	**I**	Livapi	*"wing"*
4.	**o**	**O**	Tolu	*"sleep"*
5.	**u**	**U**	Munu	*"mouth"*

Table 24: *Vowels Representation for Civili Orthography*

However, recommendations in Table 24 above differ from that of Ndinga-Koumba-Binza (2007b) in one aspect:

> No predictable differences are represented, including the most used vowel [ə]. Table 24 adheres to the prescription to not represent [ə] in the orthography since it is a reduced form of [a] (see Ndinga-Koumba-Binza 2000; Mabika Mbokou 1999; Blanchon 1990 and Ndamba 1977 for details) Thus, Table 24 to have one vowel less than in Ndinga-Koumba-

Binza (2007b) and long vowels should not be represented, except in minimal pairs.

Finally, this recommendation seeks to standardize the orthography of the language which suffers from various inconsistent proposals (Marichelle 1902 & 1912; Garnier 1903 & 1904; Ndamba 1977; Blanchon 1990; Idiata 2002; Ndinga-Koumba-Binza 2007b). The current proposal primarily differs from the previous mainly on the fact that it rejects any marking of the vowel length in situations other than in minimal pairs.

6.3 Contribution to Phonological Theory

This study has contributed to the phonetics-phonology interface debate. It yields support for the incorporation of phonetic representation into the phonological description. This is referred to as the integration of both domains. In Chapter 5, the phonetics-phonology dichotomy is bridged through the use of experimental data to facilitate a phonological description of Civili vowel duration.

The integration of experimental results embraces a methodological perspective of laboratory phonology. The current description of vowel duration in Civili incorporates statistically analyzed acoustic information together with experimentally verified perceptual information.

This study has also contributed to the domain of data acquisition. It gives support to the idea that experimental data can enhance phonological analyses. It has presented a procedure of gathering data for a specific study of vowel duration. This consisted on making observations in order to make reliable statements.

Deriving phonetic facts from data was the whole point of the experimental procedure which consisted of:

(i) gathering appropriate data,

(ii) evaluating and analyzing the data by statistical methods,

(iii) arriving at a generalization concerning the data,

(iv) expressing this generalization as a fact, and

(v) fitting the facts into a model.

The experimental procedure as conducted for the study of the Civili vowel duration in this dissertation is summarized in Figure 15 below.

EXPERIMENTAL PROCEDURE:
Data Acquisition & Processing

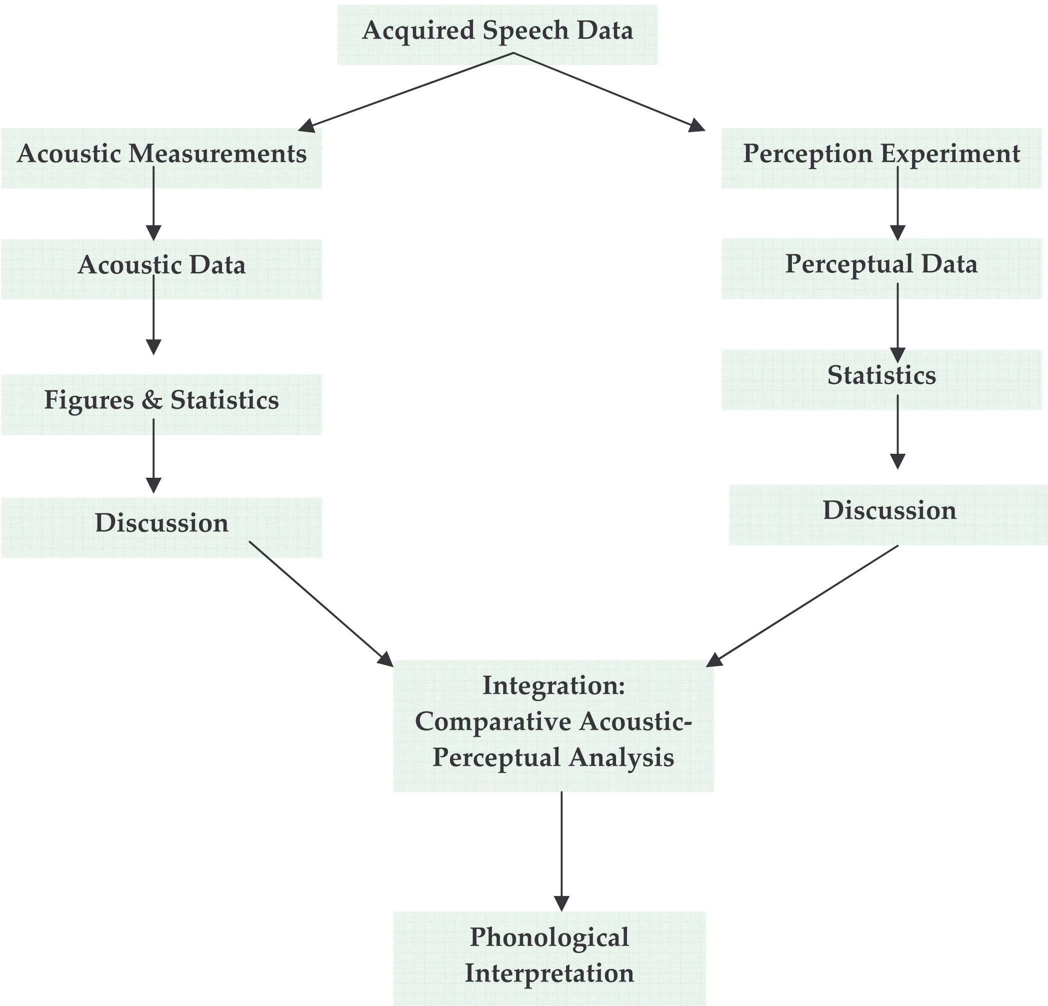

Figure 15: *Experimental Procedure for Data Acquisition & Processing*

6.4 Implications for Speech Technology

Speech technology (also known as speech processing) includes several subfields (cf. Cole, Mariani, Uszkoreit & Battista Varile 1998; Laver 2006):

(i) Speech synthesis, the artificial synthesis of speech, which usually means computer generated speech.

(ii) Speech recognition, which deals with analysis of the linguistic content of a speech signal.

(iii) Speaker recognition (or voice recognition), where the aim is to recognize the identity of the speaker.

(iv) Speech compression (speech encoding and time-compressed speech)

(v) Multimodal interaction, which provides the user with multiple modes of interfacing with a system beyond the traditional keyboard and mouse input/output.

This study has provided new and quantified data on vowel duration characteristics that would be extremely useful for research and development in the general domain of speech technology for a language such as Civili.

According to Laver (2006: 645) "*to illustrate the place of speech technology in overall developments in the study of speech in general, consider the case of speech synthesis: do specialists in the disciplines concerned with speech technology know enough about speech to construct a synthetic human voice?*"

It is believed that data and analyses gathered in this dissertation would benefit any research in speech synthesis should it be undertaken in Civili. For instance, Kaiki & Sagisaka (1992) show in their study how to control segmental duration in speech synthesis. This thesis has presented a number of features that specify vowel duration in Civili. These features could serve for any domain of speech synthesis.

Furthermore, Nusbaum & Shintel (2006: 24) indicate that "*some text-to-speech systems use a combination of approaches to convert the orthographic form of a word into a phonological form*". This study has provided concrete suggestions for a standardized orthographic system for Civili vowels that could simplify grapheme-to-phoneme conversions necessary for text-to-speech systems in a language such as Civili.

Finally, this study of Civili vowel duration does not only contribute to the potential development of speech synthesis systems in Civili, but should also spark interest in related Gabonese languages such as Yilumbu and Yipunu. After all, "*there are remarkably few extensive phonetic descriptions of languages. A few well known languages, such as English, French and Japanese have recently become well documented from the phonetic point of view, because of the needs of speech synthesis systems*"(Ladefoged 1997: 137).

6.5 Conclusions

The main objective of this study was to give an answer to some questions on the nature of vowel duration. We have made efforts to present patterns of vowel duration that exist in Civili. This has led not only to review existing phonological studies on this topic, but also to determine phonetic mechanisms that might govern vocalic length in this language.

In order to understand the structure and phonological behaviour of any language, and specially a particular phenomenon such as vocalic quantity, it is necessary to have absolute clarity on the physical aspects of that particular language.

Except at articulatory level (the actual production of sounds), the physical aspects of the vowel-duration phenomenon were analyzed both at acoustic level and at perceptual level. This approach was motivated by the fact that phonetic descriptions of Civili had unfortunately never moved beyond impressionistic descriptions at articulatory level.

Section 1.2 outlined the aims of this study. The primary aim of presenting an experimental description of vowel duration was achieved. This description was presented as a prerequisite for standardization of the orthography of the language by the achievement of specific aims, notably

(i) the determination of the physical nature of vowel duration at both acoustic and perceptual levels;

(ii) the assessment of existing phonological descriptions and the presentation of a phonological analysis of Civili vowel duration in view of new experimental data obtained; and

(iii) the contribution towards the standardization of the Civili orthography.

To conclude, while many questions are still open and a considerable amount of further research has to be conducted on relevant issues, the work reported here shows that the experimental study of vowel duration can provide interesting insights into the phonological description of languages and the standardization of their orthographic systems in terms of representing vowels.

The study is the first of its kind in Gabonese languages, and in Bantu languages of the western coast of Africa. It not only enhances the domain of laboratory phonology in these languages, but also provides a primary step to develop human language technologies in that part of the world. It is hoped this work to lead many into a better understanding of the Civili vowel system, and to a fuller knowledge of African languages.

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APPENDICES

Appendix A: Groupings of Gabonese Languages

A.1. **Gabonese Language-Units according to Kwenzi-Mikala**
Up-to-date version published in Raponda-Walker (1998)

The author inventories 62 speech forms (no distinction between languages and dialects) and groups them into 10 language-units.

1- **MAZUNA**: faŋ-atsi, faŋ-make, faŋ-mvaï, faŋ-ntumu, faŋ-nzaman and faŋ-okak.
2- **MYENE**: eneŋga, galwa, mpoŋgwe, ŋkomi, oruŋgu and adjumba.
3- **MEKANA-MENAA**: akele, uŋgom, lisigu, mbaŋgwe, metombolo, seki, tumbidi, shake, wumpfu and lendambomo.
4- **MEKONA-MAŋGOTE**: ikota, beŋga, shamayi, makoŋgwe, ndasa and bakola.
5- **MEMBE (OKANDE-TSOGO):** getsogo, gepinzi, kande, gebobe, gehimbaka, gebiya, ebongwe and kota-kota.
6- **MERYE**: gisira, gibarama, gibuŋgu, yipunu, yilumbu, yisangu, ŋgubi, **civili**, yirimba and yigama.
7- **METYE**: yinzebi, yitseŋgi, yiwele, yibili, liduma, liwanzi and yibingo.
8- **MEMBERE**: lembaama, lekaniŋi, lindumu, latege and latsitsege.
9- **MAKENA**: bekwil, shiwa (makina) and mwesa.
10- **BAKA**: baka.

The criteria used for this classification are mutual intelligibility (also referred to as intercomprehension) and the opening greeting formality "*I say that*", which the author is also using to name the language-unit. However, the author does not mention the criteria used for intercomprehension measurement.

A.2. **Jacquot's Gabonese languages groupings**

1-	Bube-Benga:	A30
2-	Ewondo:	A70
3-	Myene:	B10
4-	Kele:	B20
5-	Tsogo:	B30
6-	Sira:	B40
7-	Nzebi:	B50
8-	Mbede:	B60
9-	Teke:	B70
10-	**Civili:**	**H10**

Appendix B: Participants for Speech Recordings

Speech data manipulated in this work were recorded from the following four speakers.

	NAME	AGE	SEX	PROFESSION (at the time of recordings)
1	GMN	53	M	Port Attendant
2	RMB	73	M	Retired School Teacher
3	SBT	31	M	University Student
4	VM	35	F	School Teacher

The Following also assisted with recordings.

	NAME	AGE	SEX	PROFESSION (at the time of recordings)
1	AMN	45	M	School Teacher
2	CM	49	F	Unemployed
3	JMM	39	M	Civili Administrator

Appendix C: Corpus for Vowel Duration

/i/

1. iitu	*Our*	**notre**
2. iinu	*Your*	**votre**
3. mwiisi	*Smoke*	**Fumée**
4. mwiisi	*Smokes*	**Fumées**
5. mwiifi	*Thief*	**Voleur**
6. miifi	*Thieves*	**Voleurs**
7. mwiika	*Hair*	**Poil du corps**
8. miika	*Hair, coat*	**Poils du corps, Pelage**
9. ciika	*Seat*	**Siège, banc**
10. biika	*Seats*	**Sièges, bancs**
11. kwiisa	*To come to*	**Venir**
12. cibiinji	*Place*	**Lieu, endroit**
13. bibiinji	*Places*	**Lieux, endroits**
14. bwiisi	*Time*	**Temps**
15. bwiilu	*Night*	**Nuit**
16. mwiiba	*Xylopia aethiopica fruit*	**Manguier sauvage**
17. miiba	*Xylopia aethiopica fruits*	**Manguiers sauvages**
18. nliilu	*Nice fishing place*	**Lieu de bonne pêche**
19. mwiila	*River*	**Fleuve**
20. miila	*Rivers*	**Fleuves**
21. mwiili	*Intestine*	**Intestin**
22. miili	*Intestines*	**Intestins**
23. ciimu	*Something*	**Chose**
24. biimu	*Things*	**Choses**
25. ciima	*Thing*	**Chose**
26. biima	*Things*	**Choses**
27. kuziimbu	*To forget*	**Oublier**
28. kusiinga	*To agree*	**Accepter**
29. kuziinga	*To stay long*	**Mettre du temps, durer**
30. nsiinga	*Rope, string*	**Corde**
31. misiinga	*Ropes, strings*	**Cordes**
32. ndiinga	*dove*	**Colombe**
33. sindiinga	*doves*	**Colombes**
34. mbiinda	*Jars*	**Calebasse**
35. simbiinda	*Jars*	**Calebasses**
36. mwiinda	*Torche*	**Torche**
37. mpiinda	*Peanut*	**Arachide**
38. simpiinda	*Peanuts*	**Arachides**
39. cisiindu	*Trunk*	**Tronc**
40. bisiindu	*Trunks*	**Troncs**

41. n'siinga	*String*	**Ficelle**
42. misiinga	*String*	**Ficelles**
43. n'ziingu	*Battle, fight*	**Bataille, bagarre**
44. miziingu	*Battles, fights*	**Batailles, Bagarres**
45. ndiimbu	*Rubber*	**Caoutchouc**

/e/

46. libeena	*breast*	**sein**
47. mabeena	*breasts*	**seins**
48. kubeela	*To be ill*	**Etre malade**
49. kubweela	*To add*	**Ajouter**
50. likweela	*wedding, marriage*	**Mariage**
51. mweesa	*moonlight*	**Clair de lune**
52. mweeni	*Guest, foreigner*	**Etranger, Invité**
53. beeni	*Guests, foreigners*	**Etrangers, Invités**
54. nyeenzi	*Joy*	**Joie**
55. sinyeenzi	*Pleasure*	**Plaisir**
56. luseenda	*Thorn, prickle*	**Epine**
57. siseenda	*Thorn, prickle*	**Epines**
58. bunyeefa	*Beauty*	**Beauté**
59. cinyeefa	*Beautiful*	**Beau, belle**
60. syeefu	*Chief*	**Chef**
61. sisyeefu	*Chiefs*	**Chefs**
62. leelu	*Today*	**Aujourd'hui**
63. kuléési	*To show*	**Montrer**
64. kuleesi	*To lay*	**Faire coucher**
65. teeta	*Marrow*	**Courge**
66. sinteeta	*Marrows*	**Courges**
67. lideesu	*Marrow*	**Courge**
68. madeesu	*Marrows*	**Courges**
69. cikweesi	*Son-in-law*	**Gendre**
70. bikweesi	*Sons-in-law*	**Gendres**
71. n'cyeetu	*Woman*	**Femme**
72. bacyeetu	*Women*	**Femmes**
73. teemu	*Time, era*	**Epoque, temps**
74. lusyeemu	*Flash of lightning*	**Eclair**
75. sisyeemu	*Lightning*	**Eclairs**
76. mbeela	*Knife*	**Couteau**
77. simbeela	*Knifes*	**Couteaux**
78. n'teela	*Hunter*	**Chasseur**
79. bateela	*Hunters*	**Chasseurs**
80. cyeela	*Bait*	**Appât**
81. byeela	*Baits*	**Appâts**

82. lungweena	*Chameleon*	**Caméléon**
83. singweena	*Chameleons*	**Caméléons**
84. fayeeta	*Tailor*	**Tailleur**
85. sifayeeta	*Tailors*	**Tailleurs**
86. zeeta	Cooking *oil*	**Huile de cuisine**
87. mpeemu	*wind, air*	**Vent, air**
88. lyeenu	*Tooth*	**Dent**
89. meenu	*Teeth*	**Dents**
90. lyeesu	E*ye*	**Œil**
91. meesu	E*yes*	**Yeux**
92. vee	*Tranquil*	**Tranquille**
93. mbeembu	*Voice*	**Voix**
94. simbeembu	*Voices*	**Voix**
95. njeembu	*Bat*	**Chauve-souris**
96. sinjeembu	*Bats*	**Chauves-souris**
97. libeembi	*Pigeon*	**Pigeon**
98. mabeembi	*Pigeons*	**Pigeons**
99. lileenji	*Pumpkin*	**Citrouille**
100. maleenji	*Pumpkins*	**Citrouilles**
101. cineenga	*Scorpion*	**Scorpion**
102. bineenga	*Scorpions*	**Scorpions**
103. lyeenga	*Drop of blood*	**Goutte de sang**
104. meenga	*Blood*	**Sang**
105. n'seenga	*Sweet cane*	**Canne à sucre**
106. miseenga	*Sugar canes*	**Cannes à sucre**
107. seengu	*Hoe*	**Houe**
108. siseengu	*Hoes*	**Houes**
109. nceenzu	*Disease*	**Maladie**
110. sinceenzu	*Diseases*	**Maladies**
111. mbeenza	*Wound*	**Plaie, blessure**
112. simbeenza	*Wounds*	**Plaies, blessures**
113. n'leenji	*Hair*	**Poil de cheveu**
114. mileenji	*Hair*	**Cheveux**
115. cibeenyi	*Truth*	**Vérité**
116. ngeenza	*Thuth*	**Vérité**
117. n'seesa	*Stem broom*	**Balai à tiges**
118. miseesa	*stem brooms*	**Balais à tiges**
119. cyeseesa	*Light*	**Lumière**
120. byeseesa	*Lights*	**Lumières**

/a/

121.	aaku	*Your*	**Ton/Ta**
122.	aami	*My*	**Mon/Ma**
123.	aandi	*His/Her*	**Son/Sa**
124.	aawu	*Their*	**Leur**
125.	mbaasu	*Fire*	**Feu**
126.	cimbaasu	*Hot*	**Chaud**
127.	likaasu	*Kolanut*	**Noix de cola**
128.	makaasu	*Kolanuts*	**Noix de cola**
129.	mbaasi	*Friend*	**Ami**
130.	simbaasi	*Friends*	**Amis**
131.	mwaana	*Child*	**Enfant**
132.	baana	*Children*	**Enfants**
133.	nkaaka	*Grandparent*	**Grand-parent**
134.	sinkaaka	*Grandparents*	**Grand-parents**
135.	bwaali	*Twice* e	**Deux fois, à deux**
136.	lwaabi	*Strap*	**Courroie**
137.	cilwaala	*Sharp*	**Acéré/coupant/tranchant**
138.	bwaala	*Home, village*	**Village**
139.	maala	*Villages*	**Villages**
140.	maalu	*Legs*	**Jambes**
141.	kuvaalu	*Horse*	**Cheval**
142.	sikuvaalu	*Horses*	**Chevaux**
143.	lisafi	*Lung*	**Poumon**
144.	masafi	*Lungs*	**Poumons**
145.	libaawu	*Fever*	**Fièvre**
146.	mabaawu	*Fevers*	**Fièvres**
147.	bitaanu	*Five*	**Cinq**
148.	lusapaatu	*Shoe*	**Chaussure**
149.	sisapaatu	*Shoes*	**Chaussures**
150.	bwaatu	*Boat*	**Pirogue**
151.	maatu	*Boats*	**Pirogues**
152.	kubaala	*To remember*	**Se rappeler**
153.	bukaalu	*Expensive*	**Cher**
154.	saalu	*Salt*	**Sel**
155.	lyaani	*Maize*	**Maïs**
156.	maani	*Maize*	**Maïs**
157.	Nzaambi	*God*	**Dieu**
158.	lizaandu	*Market*	**Marché**
159.	mazaandu	*Markets*	**Marchés**
160.	likaanda	*Hand*	**Main**
161.	makaanda	*Hands*	**Mains**
162.	livaanda	*Branch*	**Branche**

163.	mavaanda	*Branches*	**Branches**
164.	ngaanda	*Outside*	**Dehors**
165.	lutaambi	*Foot*	**Pied**
166.	sintaambi	*Feet*	**Pieds**
167.	lubaandu	*Thinness*	**Maigreur**
168.	n'laandu	*Hill*	**Colline**
169.	milaandu	*Hills*	**Collines**
170.	ngaandu	*Caiman*	**Caïman**
171.	singaandu	*Caimans*	**Caïmans**
172.	civadaangu	*Duke*	**Canard**
173.	bivadaangu	*Dukes*	**Canards**
174.	lisaangu	*Liver*	**Foie**
175.	masaangu	*Livers*	**Foies**
176.	ngaanga	*Healer*	**Guérisseur**
177.	singaanga	*Healers*	**Guérisseurs**
178.	civaanga	*Henhouse*	**Poulailler**
179.	bivaanga	*Henhouses*	**Poulaillers**
180.	kaanga	*Guinea-fowl*	**Pintade**
181.	sikaanga	*Guinea-fowls*	**Pintades**
182.	ntaangu	*Sun*	**Soleil**
183.	ntaangu	*Temps, era*	**Epoque, temps**
184.	sintaangu	*Temps, eras*	**Epoques**
185.	n'taambu	*Trap*	**Piège**
186.	mitaambu	*Traps*	**Pièges**
187.	baantu	*Human beings, people*	**Etres humains**
188.	ngaanzi	*Roots*	**Racines**
189.	kaarasa	*Trouser*	**Pantalon**
190.	sikaarasa	*Trousers*	**Pantalons**
191.	taata	*Father*	**Père**
192.	mataata	*Fathers*	**Pères**
193.	maama	*Mother*	**Mère**
194.	bamaama	*Mothers*	**Mères**
195.	kuvaana	*To give*	**Donner**
196.	yaa	*I*	**Je**
197.	yaayi	*Oldest brother/sister*	**Aîné, Aînée**
198.	bayaayi	*Older brithers/sisters*	**Aînés**
199.	kwaartu	*Bedroom*	**Chambre**
200.	sikwaartu	*Bedrooms*	**Chambres**
201.	mwaanza	*Roof*	**Toit, toiture**
202.	myaanza	*Roofs*	**Toits**
203.	mwaanzu	*Advertisement, publicity*	**Annonce, révélation**
204.	myaanzu	*Advertisements, publicities*	**Annonces, révélations**

/o/

205.	oosu	*All*	**Tout, tous**
206.	yoonu	*Yesterday*	**Hier**
207.	moonyu	*Life*	**Vie**
208.	myoonyu	*Lives*	**Vies**
209.	n'cyoodu	*Sword*	**Epée**
210.	micyoodu	*Swords*	**Epées**
211.	liboola	*Basin*	**Cuvette**
212.	maboola	*Basins*	**Cuvettes**
213.	cikoola	*School*	**Ecole**
214.	bikoola	*Schools*	**Ecoles**
215.	byooli	*Two*	**Deux**
216.	kuvyooka	*To pass*	**Passer**
217.	loosu	*Rice*	**Riz**
218.	cicyoosi	*Cold*	**Froid**
219.	koomba	*younger brother/sister*	**Frère cadet, sœur cadette**
220.	sinkoomba	*younger brothers/sisters*	**Frères cadets, sœurs cadettes**
221.	kuvoonda	*To kill*	**Tuer**
222.	ngoonda	*Moon*	**Lune**
223.	singoonda	*Moons*	**Lunes**
224.	lukoondu	*Sickle*	**Faucille**
225.	sinkoondu	*Sickles*	**Faucilles**
226.	kuboonga	*To take from*	**Prendre**
227.	ciboonga	*Tortle*	**Tortue**
228.	biboonga	*Tortles*	**Tortues**
229.	noora	*Gold*	**Or**
230.	pokoongu	*Tiredness*	**Fatigue**
231.	ciloongu	*Medicine*	**Médicament**
232.	biloongu	*Medicines*	**Médicaments**
233.	liloondu	*Wharf*	**Débarcadère**
234.	buloongu	*World*	**Monde**
235.	liloongu	*People*	**Peuple**
236.	maloongu	*People*	**Peuples**
237.	moongu	*Mountain*	**Montagne**
238.	myoongu	*Mountains*	**Montagnes**
239.	litoongu	*Fish*	**Le Poisson**
240.	lyoonga	*Spear*	**Lance, sagaie**
241.	moonga	*Spears*	**Lances, sagaies**
242.	mboongu	*Money*	**Argent**
243.	simboongu	*Money*	**Argent**
244.	luloonga	*Plate, dish*	**Assiette**
245.	sindoonga	*Plates, dishes*	**Assiettes, vaisselle**
246.	citoombi	*Darkness*	**Obscurité**

247.	ngoombi	*Cow*	**Vache**
248.	singoombi	*Cows*	**Vaches**
249.	koombu	*Sheep*	**Brebis**
250.	sikoombu	*Sheeps*	**Brebis**
251.	ngoomfi	*Guitar, cithar*	**Guitare, cithare**
252.	singoomfi	*Guitars, cithar*	**Guitares, cithares**
253.	poonzi	*Basket*	**Panier, hotte**
254.	sipoonzi	*Baskets*	**Paniers, hottes**
255.	mboonza	*Hair*	**Chevelure**
256.	butoonzu	*Brains*	**Cervelle**
257.	n'poopi	*Frank*	**Pauvre**
258.	kooku	*Arms*	**Bras**
259.	myooku	*Arms*	**Bras**
260.	lusyoolu	*Scissors*	**Ciseaux**
261.	loosi	*Shop*	**Boutique**
262.	siloosi	*Shops*	**Boutiques**
263.	ndoosi	*Dream*	**Rêve**
264.	sindoosi	*Dreams*	**Rêves**
265.	voo	*Nothing*	**Rien**

/u/

266.	kuulu	*Leg*	**Jambe**
267.	suupu	*souper*	**Bouillon**
268.	sisuupu	*soupers*	**Bouillons**
269.	lupuutu	*Lie*	**Mensonge**
270.	mbuusa	*Net*	**Filet de pêche**
271.	simbuusa	*Nets*	**Filets de pêche**
272.	mbuungu	*Jar*	**Bocal**
273.	simbuungu	*Jars*	**Bocaux**
274.	buubwaayi	*Today*	**Aujourd'hui**
275.	muuntu	*Person, human being*	**Etre humain**
276.	mvuumbi	*Corpse, dead body*	**Cadavre**
277.	simvuumbi	*Corpse, dead body*	**Cadavres**
278.	nguumbi	*Partridge*	**Perdrix**
279.	singuumbi	*Partridges*	**Perdrix**
280.	cikuumbu	*Panther*	**Panthère**
281.	bikuumbu	*Panthers*	**Panthères**
282.	luumbu	*Song*	**Chant**
283.	nyuumbu	*Songs*	**Chants**
284.	nguumba	*Porcupine*	**Porc-épic**
285.	singuumba	*Porcupines*	**Porcs-épics**
286.	n'kuumba	*Navel*	**Nombril**
287.	mikuumba	*Navels*	**Nombrils**

288.	nzuunji	*Bile*	**Bile**
289.	sinzuunji	*Biles*	**Biles**
290.	mbuunji	*Mould*	**Moisissure**
291.	m'buunji	*Fog, mist*	**Brouillard**
292.	mpuungu	*Gorilla*	**Gorille**
293.	simpuungu	*Gorillas*	**Gorilles**
294.	nduungu	*Drum*	**Tambour**
295.	sinduungu	*Drums*	**Tambours**
296.	nzuungu	*Cooking-pot*	**Marmite**
297.	nzuungu	*Cooking-pots*	**Marmites**
298.	kuungu	*Copper, brass*	**Cuivre**
299.	cyuumbu	*Tin, pewter*	**Etain**
300.	byuumbu	*Pewter objects*	**Objets en étain**
301.	nyuumbu	*Baboon*	**Babouin**
302.	sinyuumbu	*Baboons*	**Babouins**
303.	maduungu	*Testicles*	**Testicules**
304.	liduunga	*Cloud*	**Nuage**
305.	maduunga	*Clouds*	**Nuages**
306.	ciluunzi	*Spirit*	**Esprit**
307.	biluunzi	*Spirits*	**Esprits**
308.	nfuunzi	*Guinea-fowl*	**Pintade**
309.	sinfuunzi	*Guinea-fowls*	**Pintades**
310.	nkuumbi	*Palm rat*	**Rat palmiste**
311.	sinkuumbi	*Palm rats*	**Rats palmistes**
312.	suunga	*Tobacco*	**Tabac**
313.	n'luunga	*Ring*	**Anneau**
314.	miluunga	*Rings*	**Anneaux**
315.	n'luunda	*Fruit*	**Fruit**
316.	miluunda	*Fruits*	**Fruits**
317.	muunyi	*Day*	**Jour, chaleur**
318.	myuuni	*Suns*	**Temps ensoleillés, soleils**

Appendix D: Minimal Pairs Based on Vowel Duration

/i/

CIVILI	ENGLISH	FRENCH
1. **Biima**	*Things*	**Choses**
2. Bima	*Groan* (imp.)	**Gémis** (imp.)
3. **Ciika**	*Seat, bed*	**Siège, lit**
4. Cika	*Support* (imp.), *Jam* (imp.)	**Soutiens** (imp.), **bloque** (imp.)
5. **Ciliili**	*manger*	**Mangeoir**
6. Cilili	*Lip*	**Lèvre**
7. **Citiiti**	*Herb*	**Herbe**
8. Cititi	*Drawer*	**Tiroir**
9. **Mbiila**	*Type, kind*	**Type, genre**
10. Mbila	*Call*	**Appel**
11. **Mbiisi**	*Cook me sth* (imp.)	**Fais moi cuire** (imp.)
12. Mbisi	*Meat*	**Viande**
13. **Miiti**	*I say*	**Je dis**
14. Miti	*Trees*	**Arbres**
15. **N'liilu**	*Nice fishing place*	**Lieu de bonne pêche**
16. N'lilu	*The way of eating*	**La manière de manger**

/e/

CIVILI	ENGLISH	FRENCH
17. **Ceesa**	*Luke*	**Chance**
18. Cesa	*Sneeze*	**Eternuement**
19. **Mbeela**	*Knife*	**Couteau**
20. Mbela	*Wrong*	**Tort**
21. **Mbeela**	*The way to do things*	**La manière de faire**
22. Mbela	*The fact to be wrong*	**Tort**
23. **Meesa**	*Table*	**Table**
24. Mesa	*Other*	**Autre**
25. **N'teela**	*Hunter*	**Chasseur**
26. N'tela	*Height*	**Taille**
27. **Neena**	*Defecate* (imp.)	**Défèque** (imp)
28. Nena	*Older mother*	**Grand Maman**
29. **Teela**	*Mischievousness*	**Espièglerie**
30. Tela	*TV*	**Télévision**

/a/

CIVILI	ENGLISH	FRENCH
31. **Baana**	*Children*	**Enfants**
32. Bana	*Four*	**Quatre**
33. **Cibaamba**	*White person*	**Blanc** (être humain)

34. Cibamba	*Home carboy*	**Dame-Jeanne**
35. **Libaaku**	*Fever*	**Fièvre**
36. Libaku	*Clash, stumble*	**Heurt, faux pas**
37. **Maatu**	*Boats*	**Pirogues**
38. Matu	*ears*	**Oreilles**
39. **Mataata**	*Fathers*	**Pères**
40. Matata	*Shaking*	**Tremblote**
41. **Mbaasi**	*Friend*	**Ami**
42. Mbasi	*Tomorrow*	**Demain**
43. **N'kaaka**	*Grandparent*	**Grand-parent**
44. N'kaka	*Barrage, barrier*	**Barrage**
45. **N'saafu**	*Change* (imp.)	**Change** (imp.)
46. N'safu	*Kind of tree*	**Atangatier**
47. **Saala**	*Sitting room*	**Salon**
48. Sala	*Work* (imp.)	**Travaille** (imp.)
49. **Saalu**	*Salt*	**Sel**
50. Salu	*Sitting room*	**Salon**

/o/

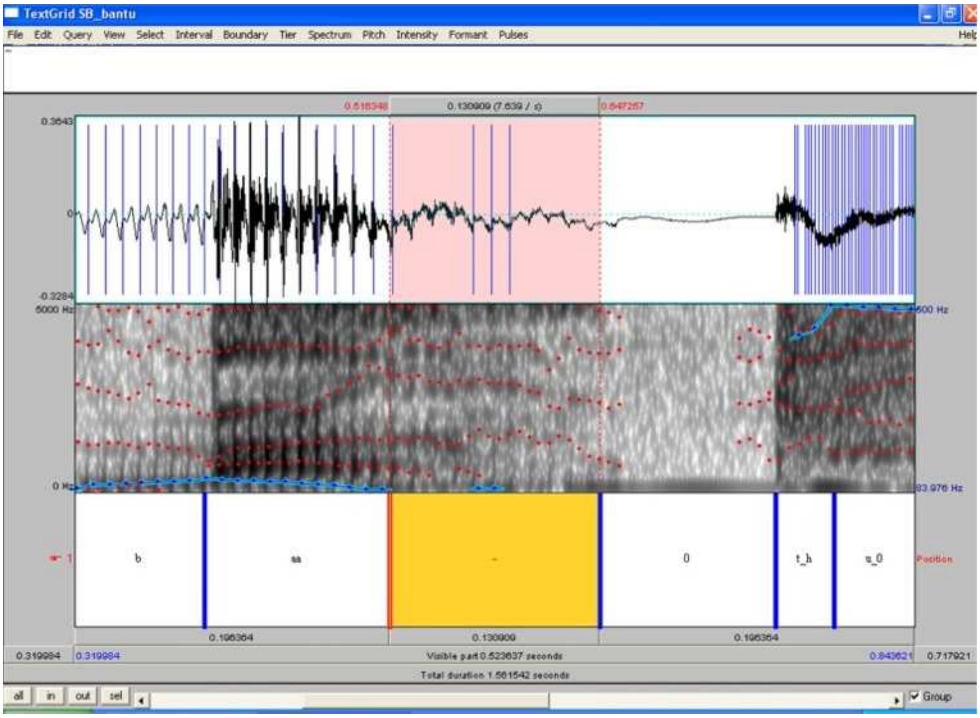
CIVILI	ENGLISH	FRENCH
51. **Libooka**	*So much death*	**Décès en grand nombre**
52. Liboka	*Holy wood*	**Bois sacré**
53. **Kutoosi**	*To make something end up/succeed*	**Faire aboutir**
54. Kutosi	*To make something bigger*	**Faire grossir**
55. **Loosu**	*Rice*	**Riz**
56. Losu	*Dirtiness*	**Saleté**
57. **Moona**	*New*	**Nouveau**
58. Mona	*Look (imp.)*	**Vois** (imp.)
59. **N'tootu**	*Tube, pipe*	**Tube**
60. N'totu	*Earth*	**Terre**
61. **Soola**	*Choose (imp.)*	**Choisis** (imp)
62. Sola	*Field*	**Plantation**

/u/

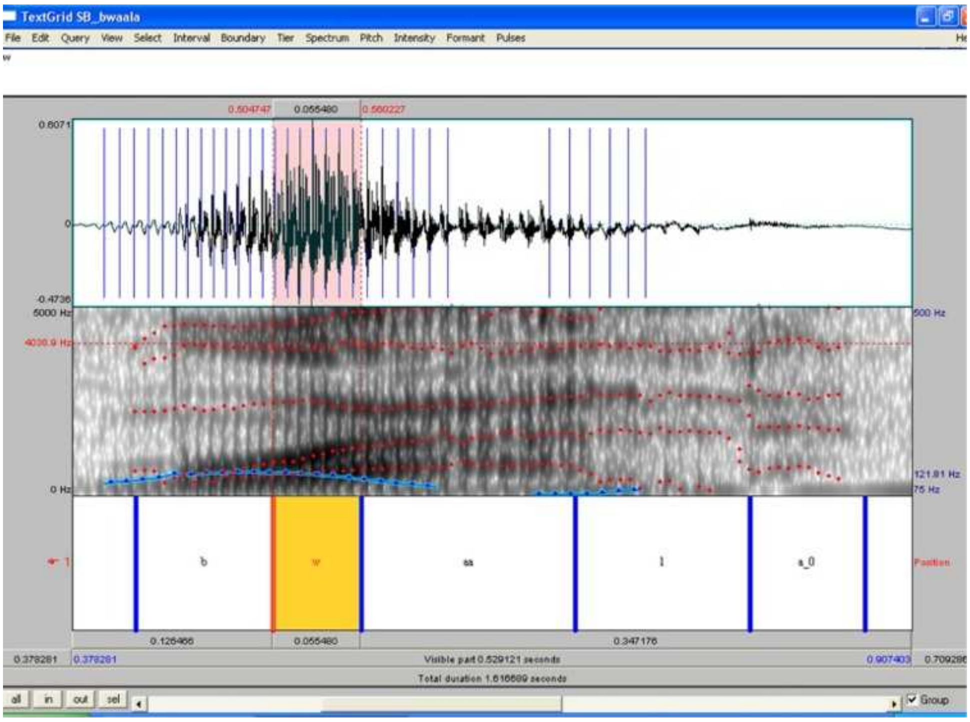
CIVILI	ENGLISH	FRENCH
63. **Mbuusa**	*Net*	**Filet de pêche**
64. Mbusa	*Back*	**Dos**
65. **Nduungu**	*Drum*	**Tamtam**
66. Ndungu	*Tree name*	**Nom d'arbre**

Appendix E: Samples of TextGrids of Test Words

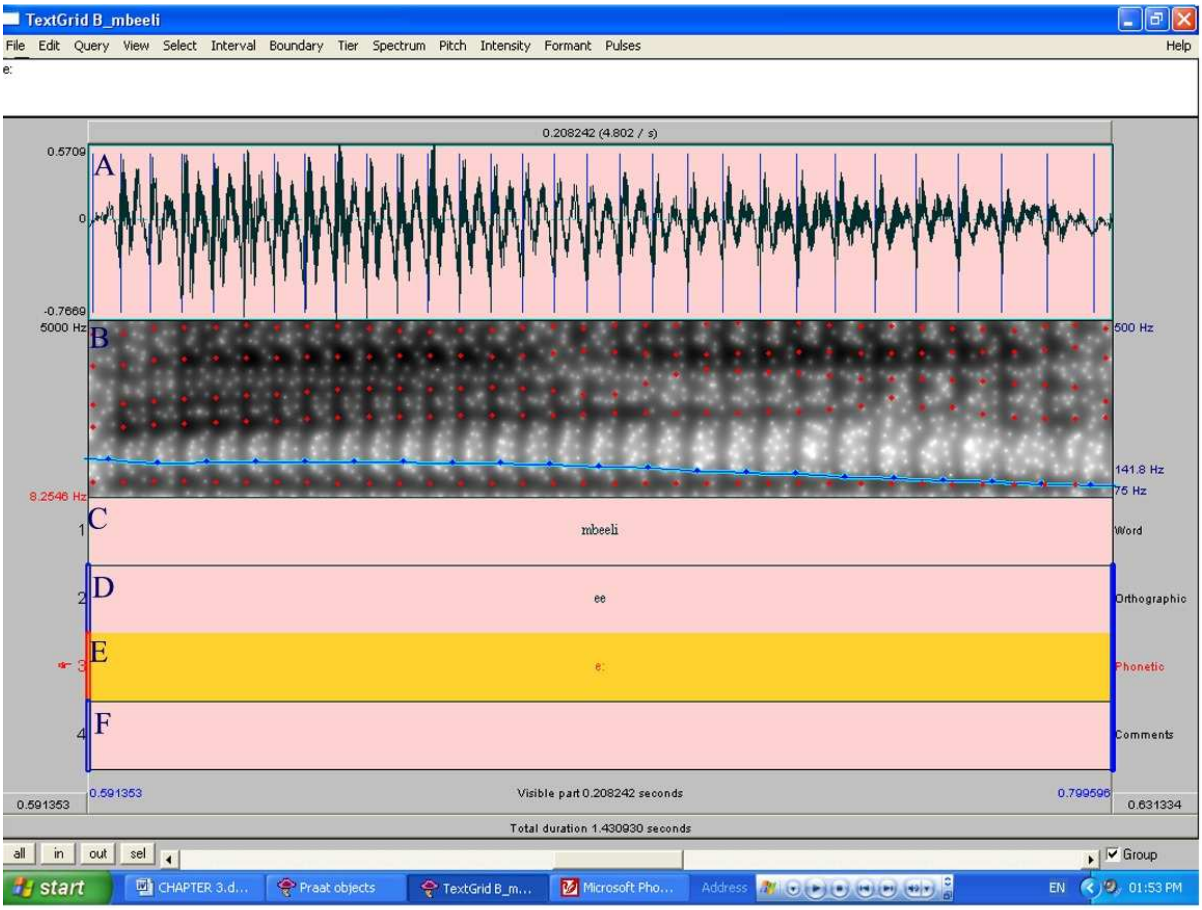
SB_bantu



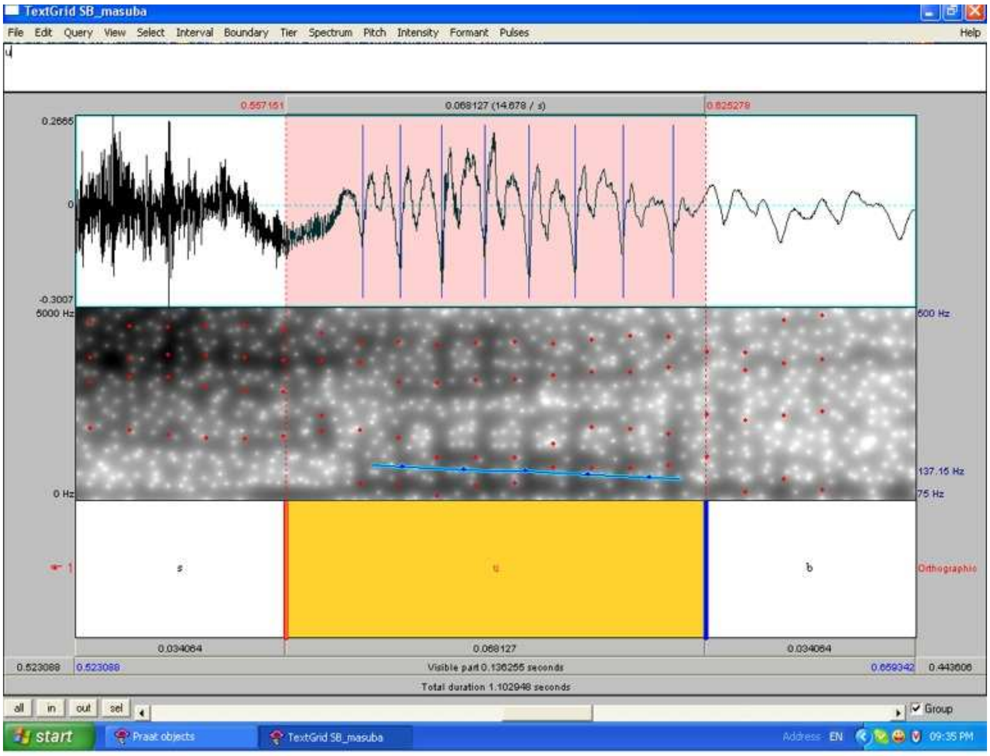
SB_bwaala



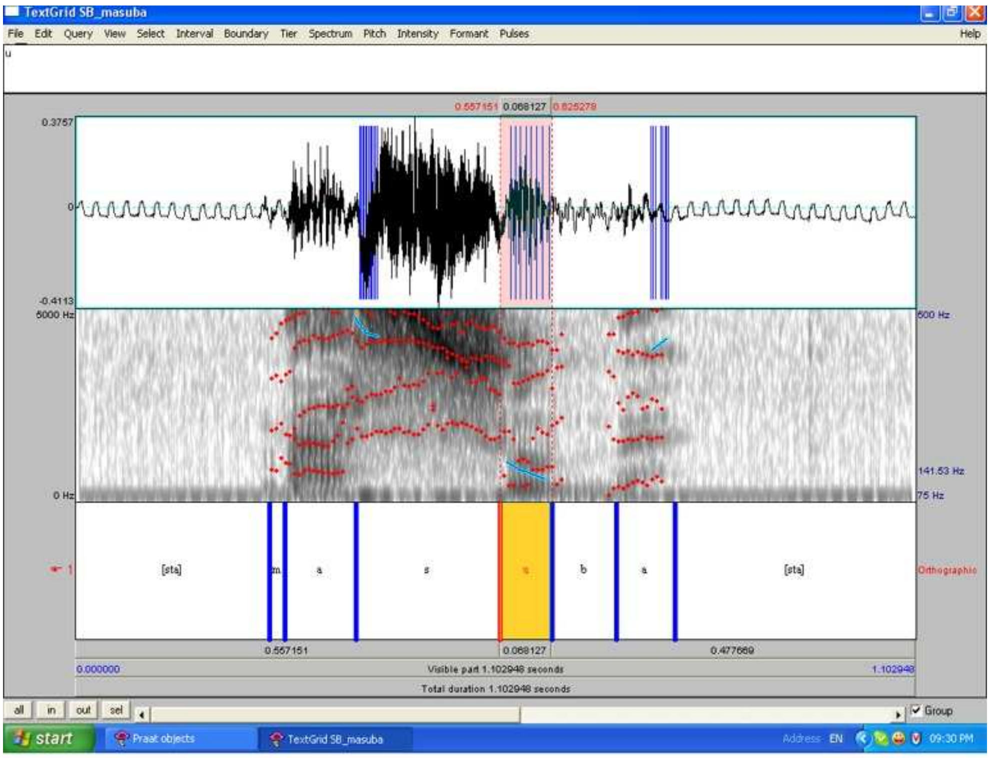
SB_mbeeli


TextGrid B_mbeeli
0.208242 (4.802 / s)
0.5709
0
-0.7669
5000 Hz
500 Hz
141.8 Hz
75 Hz
mbeeli
Word
ee
Orthographic
e:
Phonetic
Comments
0.591353
Visible part 0.208242 seconds
0.799596
0.631334
Total duration 1.430930 seconds

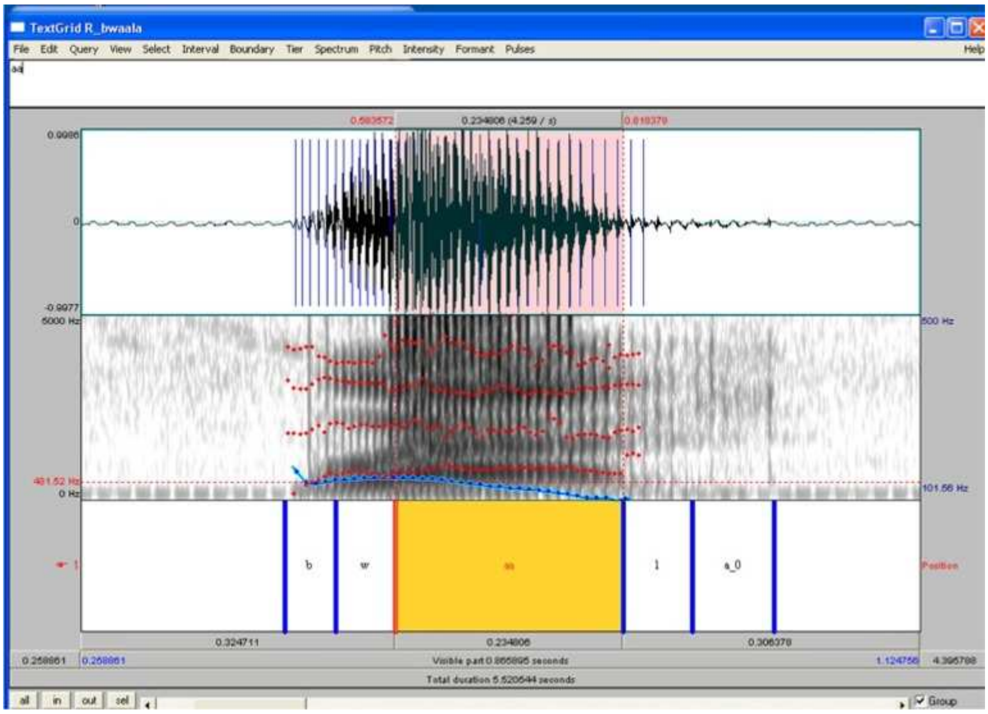
SB_masuba (u)



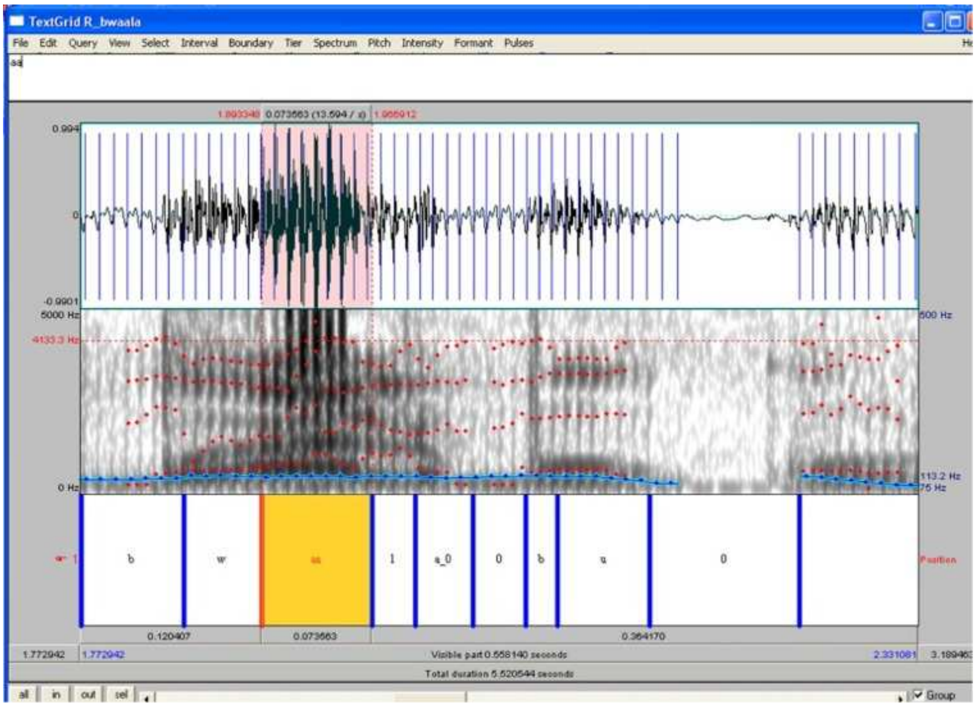
SB_masuba



R_bwaala (Isolation)



R_bwaala (sentence)



Appendix F: Duration Measurements

Positions:
- i. Isol: isolation
- ii. Subj: subject position in a phrase or sentence
- iii. Obj: object position in a phrase or sentence

Contexts:
- a. C_NC: when the vowel is followed by a pre-nasal segment
- b. CG_C: when the vowel follows a consonant-glide sequence
- c. C_N: when the vowel is followed by a single nasal consonant
- d. C_C: when the vowel follows a normal stop consonant
- e. C_L: when the vowel follows a liquid consonant

Duration is given is seconds.

Table F.1: Measurement results (duration) for /i/ sounding long in various contexts and positions.

/i/ sounding long													
		Speaker 1			Speaker 2			Speaker 3			Speaker 4		
		Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj
C_NC:	Mbiinda	0.249	0.159	0.198	0.235	0.162	0.195	0.219	0.114	0.121	0.249	0.240	0.259
	Mpiinda	0.211	0.139	0.196	0.210	0.136	0.186	0.177	0.147	0.121	0.233	0.223	0.253
	Misiinga	0.212	0.136	0.228	0.259	0.144	0.220	0.160	0.126	0.138	0.242	0.252	0.242
	Ndiimbu	0.194	0.146	0.200	0.204	0.158	0.228	0.202	0.241	0.146	0.243	0.245	0.240
CG_C:	Bwiilu	0.210	0.075	0.212	0.201	0.120	0.168	0.152	0.153	0.111	0.160	0.230	0.222
	Mwiifi	0.120	0.102	0.109	0.159	0.149	0.166	0.195	0.073	0.095	0.176	0.206	0.210
	Mwiila	0.218	0.222	0.235	0.212	0.224	0.235	0.216	0.218	0.226	0.223	0.220	0.224
	Mwiili	0.095	0.058	0.081	0.118	0.096	0.127	0.082	0.046	0.065	0.147	0.137	0.139
C_N:	ciima	0.210	0.105	0.189	0.183	0.102	0.168	0.201	0.099	0.105	0.205	0.243	0.241
C_C:	Biika	0.218	0.166	0.180	0.189	0.113	0.173	0.196	0.106	0.167	0.226	0.161	0.176
	Miika	0.214	0.127	0.190	0.176	0.149	0.166	0.204	0.141	0.151	0.220	0.200	0.229
C_L:	Miila	0.255	0.176	0.190	0.217	0.116	0.164	0.232	0.149	0.135	0.247	0.242	0.245

Table F.2: Measurement results (duration) for /e/ sounding long in various contexts and positions.

/e/ sounding long													
		Speaker 1			Speaker 2			Speaker 3			Speaker 4		
		Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj
C_NC:	Ciseengini	0.098	0.089	0.072	0.111	0.088	0.084	0.095	0.066	0.086	0.118	0.110	0.108
	Meenga	0.223	0.228	0.180	0.272	0.214	0.123	0.191	0.221	0.148	0.172	0.162	0.170
	Sinyeenza	0.203	0.210	0.204	0.212	0.142	0.109	0.127	0.127	0.125	0.202	0.200	0.201
	Siseenda	0.152	0.189	0.117	0.188	0.143	0.152	0.173	0.132	0.186	0.257	0.245	0.250
CG_C:	Lyeesu	0.156	0.137	0.130	0.158	0.104	0.149	0.091	0.128	0.064	0.090	0.100	0.092
	Mweesa	0.110	0.110	0.099	0.135	0.088	0.122	0.105	0.052	0.113	0.177	0.178	0.175
	Lifwesikini	0.065	0.049	0.060	0.037	0.059	0.054	0.056	0.039	0.040	0.073	0.093	0.094
C_N:	Mabeena	0.208	0.144	0.129	0.161	0.108	0.113	0.161	0.171	0.124	0.171	0.111	0.162
	Mpeemu	0.181	0.151	0.156	0.144	0.135	0.147	0.163	0.121	0.186	0.228	0.238	0.225

C_C:	Fayeeta	0.166	0.175	0.151	0.112	0.111	0.108	0.107	0.124	0.088	0.155	0.148	0.150
	N'ceetu	0.162	0.127	0.117	0.192	0.149	0.138	0.134	0.108	0.085	0.208	0.210	0.212
C_L:	Mbeela	0.223	0.194	0.232	0.252	0.160	0.209	0.143	0.123	0.123	0.212	0.222	0.220
	N'teela	0.203	0.141	0.207	0.202	0.127	0.161	0.164	0.163	0.172	0.224	0.220	0.226

Table F.3: Measurement results (duration) for /a/ sounding long in various contexts and positions.

/a/ sounding long													
		Speaker 1			**Speaker 2**			**Speaker 3**			**Speaker 4**		
		Isol	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**
C_NC:	Baantu	0.224	0.139	0.209	0.219	0.099	0.104	0.181	0.198	0.147	0.228	0.230	0.229
	Livaanda	0.242	0.147	0.227	0.248	0.107	0.191	0.153	0.126	0.122	0.238	0.233	0.239
	Mikaanda	0.230	0.163	0.131	0.231	0.164	0.187	0.190	0.141	0.117	0.257	0.260	0.259
	N'laangu	0.167	0.187	0.191	0.135	0.164	0.187	0.203	0.164	0.187	0.193	0.190	0.196
	Singaanzi	0.225	0.209	0.182	0.225	0.101	0.129	0.215	0.154	0.138	0.240	0.230	0.232
CG_C:	Bwaala	0.186	0.119	0.184	0.216	0.073	0.167	0.175	0.113	0.095	0.153	0.160	0.158
	Mwaali	0.147	0.140	0.144	0.143	0.144	0.146	0.106	0.096	0.125	0.220	0.219	0.218
C_N:	Baami	0.140	0.144	0.143	0.144	0.143	0.146	0.140	0.155	0.147	0.230	0.215	0.227
	Baana	0.232	0.153	0.225	0.275	0.155	0.214	0.200	0.172	0.186	0.224	0.225	0.229
C_C:	Baatu	0.192	0.185	0.187	0.220	0.215	0.226	0.181	0.133	0.159	0.209	0.205	0.207
	Mbaasi	0.190	0.132	0.133	0.205	0.085	0.086	0.160	0.180	0.133	0.221	0.219	0.223
	Mbaasu	0.210	0.142	0.183	0.178	0.105	0.188	0.163	0.142	0.154	0.265	0.235	0.240
	N'traafu	0.144	0.134	0.096	0.143	0.124	0.134	0.190	0.155	0.167	0.160	0.155	0.166
C_L:	Maalu	0.256	0.194	0.162	0.233	0.171	0.155	0.212	0.213	0.124	0.235	0.258	0.238
	Saalu	0.211	0.180	0.203	0.205	0.116	0.109	0.188	0.160	0.163	0.240	0.232	0.236

Table F.4: Measurement results (duration) for /o/ sounding long in various contexts and positions.

/o/ sounding long													
		Speaker 1			**Speaker 2**			**Speaker 3**			**Speaker 4**		
		Isol	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**
C_NC:	Ciboonga	0.185	0.179	0.191	0.155	0.150	0.140	0.233	0.176	0.134	0.226	0.230	0.229
	Lindoomba	0.086	0.128	0.096	0.088	0.089	0.085	0.113	0.125	0.091	0.155	0.160	0.157
	Mboonza	0.227	0.116	0.179	0.176	0.112	0.130	0.193	0.277	0.137	0.286	0.288	0.296
	Moonga	0.200	0.209	0.164	0.197	0.147	0.147	0.249	0.274	0.204	0.273	0.271	0.273
	Moongu	0.251	0.155	0.194	0.192	0.170	0.158	0.241	0.228	0.170	0.269	0.263	0.261
	Ngoondi	0.227	0.143	0.138	0.194	0.101	0.128	0.194	0.177	0.187	0.261	0.265	0.266
	Nkoombu	0.178	0.137	0.151	0.165	0.129	0.127	0.184	0.121	0.165	0.290	0.288	0.293
	Singoongulu	0.165	0.141	0.107	0.179	0.125	0.086	0.197	0.142	0.149	0.166	0.160	0.163
CG_C:	Lyoonga	0.179	0.152	0.168	0.139	0.147	0.116	0.165	0.155	0.148	0.249	0.220	0.222
	Myooku	0.164	0.158	0.089	0.110	0.115	0.074	0.106	0.112	0.075	0.222	0.214	0.200
	Myoongu	0.182	0.168	0.136	0.141	0.113	0.097	0.190	0.172	0.120	0.245	0.239	0.149
C_C:	Kooku	0.205	0.162	0.169	0.159	0.152	0.153	0.194	0.148	0.139	0.199	0.189	0.200
	Loosu	0.189	0.111	0.160	0.183	0.100	0.158	0.192	0.210	0.191	0.265	0.260	0.270
C_L:	Liboola	0.201	0.140	0.130	0.150	0.105	0.113	0.161	0.168	0.124	0.171	0.121	0.163
	Lilasoola	0.208	0.144	0.129	0.161	0.118	0.123	0.171	0.131	0.161	0.169	0.111	0.162

Table F.5: Measurement results (duration) for /u/ sounding long in various contexts and positions.

/u/ sounding long													
		Speaker 1			Speaker 2			Speaker 3			Speaker 4		
		Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj
C_NC:	Cifuundu	0.179	0.181	0.150	0.215	0.149	0.187	0.133	0.128	0.136	0.219	0.210	0.216
	Maduunga	0.133	0.121	0.094	0.179	0.113	0.167	0.169	0.118	0.146	0.207	0.205	0.208
	Makuungulu	0.160	0.145	0.162	0.168	0.088	0.082	0.088	0.097	0.130	0.173	0.179	0.177
	Muuntu	0.134	0.115	0.144	0.258	0.176	0.134	0.188	0.130	0.149	0.176	0.178	0.176
	Nduungu	0.149	0.162	0.147	0.194	0.188	0.190	0.140	0.139	0.129	0.271	0.275	0.277
	N'kuumba	0.157	0.133	0.133	0.147	0.132	0.123	0.191	0.116	0.167	0.115	0.112	0.119
C_N:	Muuni	0.183	0.122	0.143	0.201	0.094	0.171	0.134	0.121	0.166	0.210	0.214	0.218
C_C:	Libuufu	0.121	0.109	0.132	0.140	0.110	0.139	0.094	0.088	0.115	0.213	0.210	0.213
	Lupuutu	0.122	0.120	0.131	0.195	0.139	0.153	0.158	0.110	0.124	0.207	0.203	0.205
	Mbuusa	0.134	0.110	0.077	0.189	0.083	0.099	0.151	0.134	0.133	0.228	0.222	0.225
	Suupu	0.148	0.096	0.107	0.167	0.147	0.059	0.152	0.111	0.119	0.190	0.195	0.197
	Suusi	0.150	0.130	0.129	0.130	0.122	0.119	0.191	0.141	0.115	0.180	0.185	0.187
C_L:	Kuulu	0.172	0.125	0.114	0.190	0.100	0.161	0.135	0.130	0.135	0.202	0.207	0.200

Table F.6: Measurement results (duration) for /i/ sounding short in various contexts and positions.

/i/ sounding short													
		Speaker 1			Speaker 2			Speaker 3			Speaker 4		
		Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj
C_N:	Bina	0.077	0.057	0.088	0.090	0.056	0.078	0.099	0.058	0.064	0.111	0.101	0.099
	Lizina	0.060	0.044	0.056	0.078	0.052	0.068	0.085	0.071	0.081	0.112	0.121	0.118
C_C:	Liyilu (n)	0.081	0.077	0.082	0.094	0.082	0.069	0.085	0.071	0.047	0.190	0.201	0.199
	Liyilu (s)	0.091	0.077	0.081	0.079	0.050	0.076	0.078	0.068	0.073	0.142	0.142	0.144
	Mbisi	0.065	0.039	0.043	0.074	0.051	0.061	0.076	0.071	0.047	0.128	0.108	0.112
	Ndibu	0.098	0.053	0.077	0.080	0.086	0.078	0.090	0.081	0.077	0.121	0.119	0.120
	Ndika	0.082	0.074	0.096	0.099	0.081	0.084	0.075	0.076	0.065	0.118	0.113	0.119
C_L:	Micila	0.055	0.039	0.045	0.090	0.050	0.052	0.069	0.057	0.064	0.101	0.091	0.100
	Mili	0.080	0.060	0.077	0.095	0.088	0.081	0.088	0.082	0.078	0.141	0.139	0.142

Table F.7: Measurement results (duration) for /e/ sounding short in various contexts and positions.

/e/ sounding short													
		Speaker 1			Speaker 2			Speaker 3			Speaker 4		
		Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj
C_N:	Cimenu	0.076	0.097	0.089	0.091	0.064	0.090	0.088	0.070	0.078	0.125	0.120	0.223
	Limema	0.099	0.097	0.098	0.089	0.092	0.089	0.103	0.100	0.098	0.128	0.125	0.124
C_C:	Cidefu	0.089	0.101	0.079	0.095	0.067	0.084	0.081	0.064	0.076	0.113	0.110	0.111
	Citeba	0.077	0.057	0.080	0.069	0.049	0.051	0.078	0.035	0.057	0.123	0.122	0.136
	Libeta	0.098	0.097	0.101	0.083	0.072	0.061	0.085	0.080	0.065	0.118	0.119	0.121
	Lisefu	0.057	0.065	0.067	0.082	0.086	0.054	0.073	0.051	0.042	0.119	0.121	0.122
	Mivesa	0.088	0.069	0.076	0.078	0.060	0.070	0.075	0.052	0.065	0.114	0.112	0.120
	Ndebu	0.101	0.106	0.089	0.107	0.077	0.068	0.086	0.062	0.057	0.135	0.130	0.133
	Sincefu	0.064	0.073	0.086	0.073	0.057	0.082	0.059	0.075	0.059	0.126	0.125	0.127
C_L:	N'tela	0.098	0.044	0.079	0.087	0.057	0.072	0.078	0.063	0.057	0.127	0.125	0.128
	Mabelu	0.084	0.070	0.084	0.086	0.071	0.088	0.089	0.072	0.084	0.122	0.122	0.124

Table F.8: Measurement results (duration) for /a/ sounding short in various contexts and positions.

/a/ sounding short													
		Speaker 1			Speaker 2			Speaker 3			Speaker 4		
		Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj
C_N:	N'manka	0.090	0.055	0.067	0.091	0.069	0.67	0.089	0.095	0.097	0.123	0.120	0.125
C_C:	Babakala	0.050	0.065	0.067	0.080	0.095	0.097	0.095	0.086	0.075	0.128	0.119	0.123
	Citafi	0.088	0.070	0.095	0.070	0.058	0.065	0.080	0.085	0.087	0.125	0.130	0.133
	Livafi	0.087	0.080	0.086	0.087	0.057	0.063	0.096	0.085	0.072	0.132	0.129	0.130
	Masi	0.096	0.088	0.086	0.089	0.057	0.067	0.085	0.081	0.088	0.145	0.138	0.138
	Mataku	0.093	0.071	0.062	0.109	0.087	0.055	0.091	0.066	0.066	0.134	0.130	0.138
	Matu	0.070	0.056	0.067	0.060	0.055	0.070	0.107	0.081	0.070	0.140	0.129	0.135
	Ndaka	0.095	0.062	0.072	0.084	0.049	0.097	0.117	0.076	0.089	0.152	0.150	0.161
	mbasi	0.098	0.070	0.079	0.082	0.055	0.068	0.079	0.070	0.058	0.168	0.166	0.160
C_L:	Makala	0.066	0.056	0.070	0.095	0.060	0.070	0.079	0.062	0.072	0.145	0.142	0.140
	Livala	0.098	0.093	0.079	0.091	0.096	0.084	0.108	0.097	0.076	0.162	0.160	0159
	Kuvalu	0.097	0.077	0.079	0.091	0.089	0.097	0.099	0.089	0.093	0.150	0.147	0.151
	Sisala	0.098	0.068	0.089	0.104	0.089	0.061	0.107	0.087	0.066	0.181	0.180	0.183

Table F.9: Measurement results (duration) for /o/ sounding short in various contexts and positions.

/o/ sounding short													
		Speaker 1			Speaker 2			Speaker 3			Speaker 4		
		Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj	Isol	Subj	Obj
C_N:	Soni	0.105	0.099	0.081	0.100	0.087	0.059	0.080	0.100	0.096	0.170	0.171	0.179
C_C:	Cibofu (c)	0.094	0.094	0.079	0.091	0.097	0.065	0.083	0.084	0.065	0.115	0.110	0.120
	Cibofu (m)	0.064	0.081	0.084	0.077	0.090	0.089	0.080	0.079	0.071	0.151	0.150	0.149
	Losu	0.090	0.081	0.071	0.095	0.090	0.069	0.083	0.069	0.082	0.147	0.130	0.136
	Lusoku	0.081	0.076	0.085	0.076	0.070	0.085	0.084	0.061	0.077	0.156	0.151	0.169
	Minoka	0.107	0.086	0.103	0.096	0.090	0.084	0.101	0.088	0.079	0.161	0.149	0.160
	N'totu	0.093	0.073	0.074	0.074	0.060	0.071	0.101	0.086	0.085	0.146	0.140	0.145
	Nyoka	0.089	0.075	0.092	0.088	0.053	0.064	0.064	0.070	0.077	0.122	0.120	0.131
	Simbota	0.088	0.071	0.074	0.077	0.071	0.083	0.099	0.081	0.077	0.153	0.134	0.145
	Tusoku	0.071	0.080	0.085	0.064	0.075	0.075	0.097	0.070	0.094	0.144	0.153	0.145
C_L:	Tolu	0.100	0.100	0.073	0.101	0.097	0.069	0.095	0.096	0.087	0.153	0.158	0.151

Table F.10: Measurement results (duration) for /u/ sounding short in various contexts and positions.

/u/ sounding short													
		Speaker 1			**Speaker 2**			**Speaker 3**			**Speaker 4**		
		Isol	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**	**Isol**	**Subj**	**Obj**
C_N:	Banuni	0.078	0.057	0.065	0.087	0.058	0.070	0.090	0.089	0.078	0.142	0.143	0.146
	Cin**u**nu	0.085	0.071	0.076	0.101	0.088	0.103	0.089	0.081	0.089	0.144	0.119	0.135
	Civ**u**mu	0.067	0.060	0.070	0.087	0.070	0.090	0.055	0.058	0.088	0.139	0.144	0.130
	M**u**nu	0.076	0.070	0.076	0.145	0.064	0.102	0.057	0.076	0.076	0.174	0.177	0.178
	N'nuni	0.071	0.079	0.080	0.070	0.061	0.079	0.091	0.089	0.079	0.142	0.144	0.145
	N'suni	0.101	0.081	0.099	0.091	0.100	0.090	0.099	0.080	0.082	0.118	0.116	0.119
	Sinuni	0.076	0.080	0.085	0.082	0.071	0.082	0.080	0.077	0.065	0.123	0.128	0.126
C_C:	K**u**tu	0.075	0.070	0.076	0.079	0.047	0.077	0.080	0.055	0.089	0.106	0.099	0.102
	Lisus**u**ku	0.044	0.060	0.059	0.059	0.068	0.064	0.070	0.056	0.057	0.124	0.122	0.134
	Masuba	0.087	0.052	0.081	0.071	0.070	0.072	0.050	0.064	0.067	0.111	0.112	0.112
	Mbusa	0.084	0.052	0.071	0.098	0.050	0.068	0.029	0.055	0.074	0.169	0.160	0.166
	N'pusa	0.061	0.069	0.067	0.056	0.062	0.071	0.065	0.060	0.067	0.136	0.137	0.132
C_L:	Cib**u**lu	0.092	0.071	0.072	0.070	0.057	0.078	0.097	0.058	0.082	0.120	0.118	0.122
	Mbula	0.077	0.069	0.087	0.090	0.063	0.067	0.079	0.075	0.100	0.100	0.101	0.103
	Mvula	0.075	0.066	0.084	0.099	0.065	0.099	0.082	0.045	0.051	0.097	0.095	0.100
	Makuung**u**lu	0.055	0.050	0.060	0.050	0.057	0.058	0.052	0.044	0.062	0.103	0.103	0.102

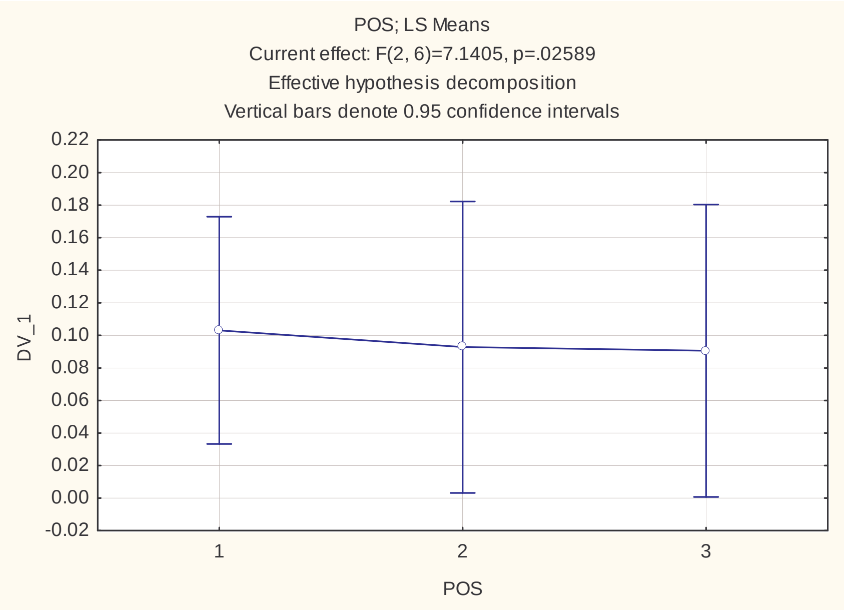
Appendix G: Statistical Results of VD Measurements

1 a

1.1 Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw)

Effect	Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	0.328066	1	0.328066	40.35393	0.007892
Error	0.024389	3	0.008130		
CONTEXT	0.000983	2	0.000492	1.93140	0.225141
Error	0.001527	6	0.000254		
POS	0.001075	2	0.000538	7.14051	0.025893
Error	0.000452	6	0.000075		
CONTEXT*POS	0.000041	4	0.000010	0.26055	0.897603
Error	0.000473	12	0.000039		
dependent variables:	a(C_C)(ISOLATION)				
	a(C_C)(OBJECT)				
	a(C_C)(SUBJECT)				
	a(C_L)(ISOLATION)				
	a(C_L)(OBJECT)				
	a(C_L)(SUBJECT)				
	a(C_N)(ISOLATION)				
	a(C_N)(OBJECT)				
	a(C_N)(SUBJECT)				

1.2 POS; LS Means



1.3 POS; LS Means (Spreadsheet13 in results.stw)

	POS; LS Means (Spreadsheet13 in results.stw) Current effect: F(2, 6)=7.1405, p=.02589 Effective hypothesis decomposition					
Cell No.	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.103083	0.021937	0.033270	0.172896	4
2	2	0.092760	0.028136	0.003219	0.182302	4
3	3	0.090542	0.028235	0.000686	0.180397	4

1.4 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

	Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw) Approximate Probabilities for Post Hoc Tests Error: Within MSE = .00008, df = 6.0000			
Cell No.	POS	{1} .10308	{2} .09276	{3} .09054
1	1		0.060627	0.028430
2	2	0.060627		0.811773
3	3	0.028430	0.811773	

1.5 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

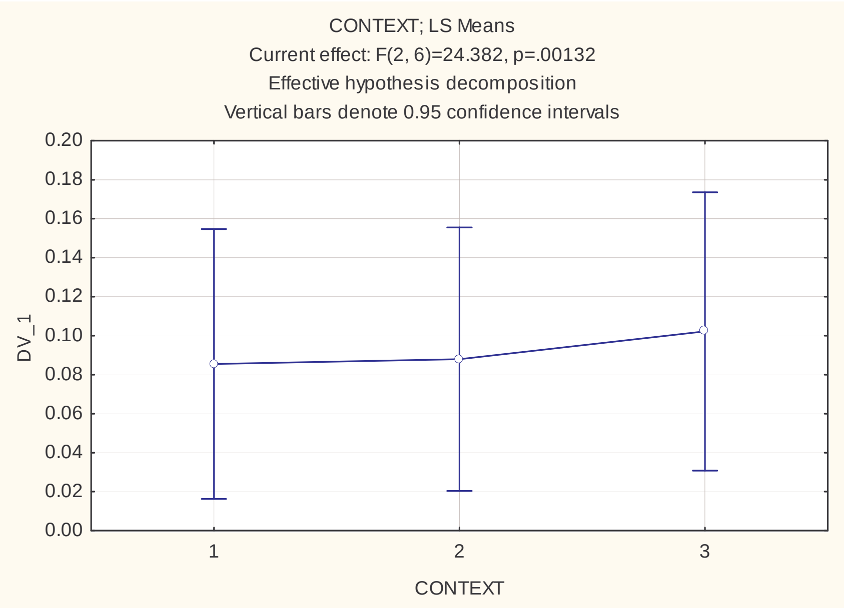
	Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw Homogenous Groups, alpha = .05000 Error: Within MSE = .00008, df = 6.0000			
Cell No.	POS	DV_1 Mean	1	2
3	3	0.090542	****	
2	2	0.092760	****	****
1	1	0.103083		****

2 e

2.1 Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw)

	Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition				
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	0.303890	1	0.303890	54.02254	0.005205
Error	0.016876	3	0.005625		
CONTEXT	0.001959	2	0.000979	24.38240	0.001315
Error	0.000241	6	0.000040		
POS	0.000812	2	0.000406	3.05168	0.121825
Error	0.000799	6	0.000133		
CONTEXT*POS	0.000575	4	0.000144	1.66010	0.223320
Error	0.001039	12	0.000087		
dependent varial	e(C_C)(ISOLATION)				
	e(C_C)(OBJECT)				
	e(C_C)(SUBJECT)				
	e(C_L)(ISOLATION)				
	e(C_L)(OBJECT)				
	e(C_L)(SUBJECT)				
	e(C_N)(ISOLATION)				
	e(C_N)(OBJECT)				
	e(C_N)(SUBJECT)				

2.2 CONTEXT; LS Means



2.3 CONTEXT; LS Means (Spreadsheet13 in results.stw)

	CONTEXT; LS Means (Spreadsheet13 in results.stw) Current effect: F(2, 6)=24.382, p=.00132 Effective hypothesis decomposition					
Cell No.	CONTEXT	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.085464	0.021742	0.016271	0.154658	4
2	2	0.087958	0.021225	0.020410	0.155507	4
3	3	0.102208	0.022431	0.030823	0.173593	4

2.4 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

	Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw) Approximate Probabilities for Post Hoc Tests Error: Within MSE = .00004, df = 6.0000			
Cell No.	CONTEXT	{1} .08546	{2} .08796	{3} .10221
1	1		0.623824	0.001755
2	2	0.623824		0.003778
3	3	0.001755	0.003778	

2.5 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

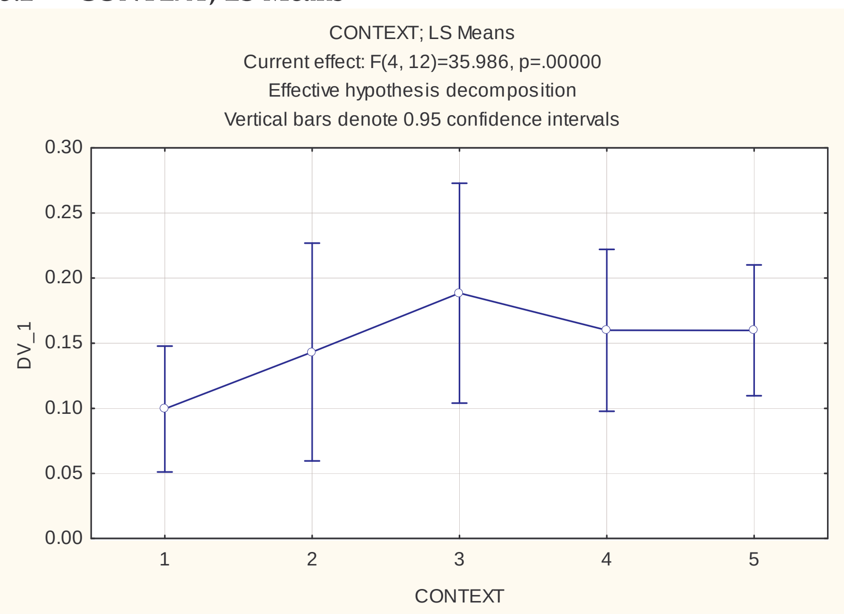
	Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw Homogenous Groups, alpha = .05000 Error: Within MSE = .00004, df = 6.0000			
Cell No.	CONTEXT	DV_1 Mean	1	2
1	1	0.085464	****	
2	2	0.087958	****	
3	3	0.102208		****

3 ee

3.1 Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw)

Effect	Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	1.353527	1	1.353527	178.0409	0.000910
Error	0.022807	3	0.007602		
CONTEXT	0.051258	4	0.012814	35.9861	0.000001
Error	0.004273	12	0.000356		
POS	0.004729	2	0.002364	5.4271	0.045116
Error	0.002614	6	0.000436		
CONTEXT*POS	0.002747	8	0.000343	2.0977	0.076815
Error	0.003928	24	0.000164		
dependent variables:	ee(CG_C)(ISOLATION)				
	ee(CG_C)(OBJECT)				
	ee(CG_C)(SUBJECT)				
	ee(C_C)(ISOLATION)				
	ee(C_C)(OBJECT)				
	ee(C_C)(SUBJECT)				
	ee(C_L)(ISOLATION)				
	ee(C_L)(OBJECT)				
	ee(C_L)(SUBJECT)				
	ee(C_N)(ISOLATION)				
	ee(C_N)(OBJECT)				
	ee(C_N)(SUBJECT)				
	ee(C_NC)(ISOLATION)				
	ee(C_NC)(OBJECT)				
	ee(C_NC)(SUBJECT)				

3.2 CONTEXT; LS Means



3.3 CONTEXT; LS Means (Spreadsheet13 in results.stw)

CONTEXT; LS Means (Spreadsheet13 in results.stw)
Current effect: F(4, 12)=35.986, p=.00000
Effective hypothesis decomposition

Cell No.	CONTEXT	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.099500	0.015188	0.051165	0.147835	4
2	2	0.143208	0.026282	0.059567	0.226849	4
3	3	0.188458	0.026544	0.103984	0.272933	4
4	4	0.159917	0.019537	0.097741	0.222093	4
5	5	0.159896	0.015779	0.109679	0.210113	4

3.4 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00036, df = 12.000

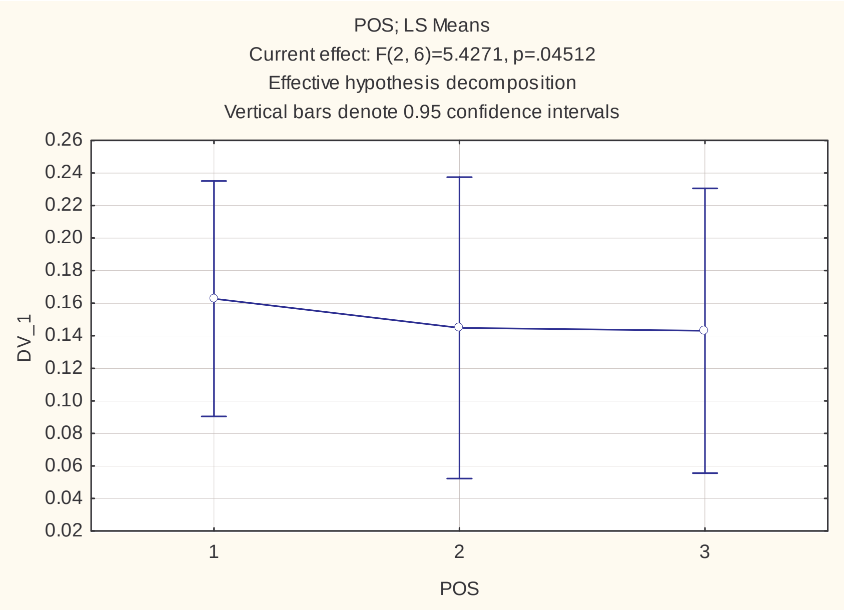
Cell No.	CONTEXT	{1} .09950	{2} .14321	{3} .18846	{4} .15992	{5} .15990
1	1		0.000925	0.000152	0.000181	0.000181
2	2	0.000925		0.000708	0.254812	0.255800
3	3	0.000152	0.000708		0.020712	0.020617
4	4	0.000181	0.254812	0.020712		1.000000
5	5	0.000181	0.255800	0.020617	1.000000	

3.5 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Homogenous Groups, alpha = .05000
Error: Within MSE = .00036, df = 12.000

Cell No.	CONTEXT	DV_1 Mean	1	2	3
1	1	0.099500		****	
2	2	0.143208	****		
5	5	0.159896	****		
4	4	0.159917	****		
3	3	0.188458			****

3.6 POS; LS Means



3.7 POS; LS Means (Spreadsheet13 in results.stw)

POS; LS Means (Spreadsheet13 in results.stw)
Current effect: F(2, 6)=5.4271, p=.04512
Effective hypothesis decomposition

Cell No.	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.16270ε	0.022722	0.090397	0.23502C	4
2	2	0.14482ς	0.02909ε	0.052227	0.237431	4
3	3	0.14305C	0.027485	0.05558C	0.23052C	4

3.8 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00044, df = 6.0000

Cell No.	POS	{1} .16271	{2} .14483	{3} .14305
1	1		0.07843ε	0.05599З
2	2	0.07843ε		0.96108ς
3	3	0.05599З	0.96108ς	

3.9 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Homogenous Groups, alpha = .05000
Error: Within MSE = .00044, df = 6.0000

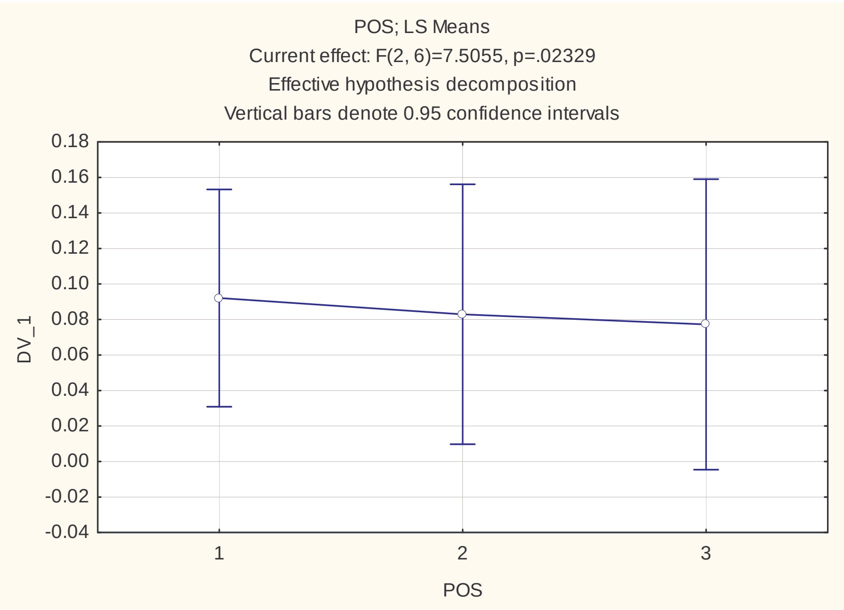
Cell No.	POS	DV_1 Mean	1
3	3	0.14305C	****
2	2	0.14482ς	****
1	1	0.16270ε	****

4 i

4.1 Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw)

Effect	Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	0.254554	1	0.254554	42.00586	0.007456
Error	0.018180	3	0.006060		
CONTEXT	0.000704	2	0.000352	2.12186	0.200946
Error	0.000995	6	0.000166		
POS	0.001339	2	0.000669	7.50552	0.023287
Error	0.000535	6	0.000089		
CONTEXT*POS	0.000117	4	0.000029	1.19143	0.363751
Error	0.000295	12	0.000025		
dependent variables:	i(C_C)(ISOLATION)				
	i(C_C)(OBJECT)				
	i(C_C)(SUBJECT)				
	i(C_L)(ISOLATION)				
	i(C_L)(OBJECT)				
	i(C_L)(SUBJECT)				
	i(C_N)(ISOLATION)				
	i(C_N)(OBJECT)				
	i(C_N)(SUBJECT)				

4.2 POS; LS Means



4.3 POS; LS Means (Spreadsheet13 in results.stw)

POS; LS Means (Spreadsheet13 in results.stw)
Current effect: F(2, 6)=7.5055, p=.02329
Effective hypothesis decomposition

Cell No.	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.092058	0.019215	0.030908	0.153209	4
2	2	0.082958	0.023002	0.009756	0.156160	4
3	3	0.077250	0.025715	-0.004588	0.159088	4

4.4 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00009, df = 6.0000

Cell No.	POS	{1} .09206	{2} .08296	{3} .07725
1	1		0.122116	0.020131
2	2	0.122116		0.363636
3	3	0.020131	0.363636	

4.5 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Homogenous Groups, alpha = .05000
Error: Within MSE = .00009, df = 6.0000

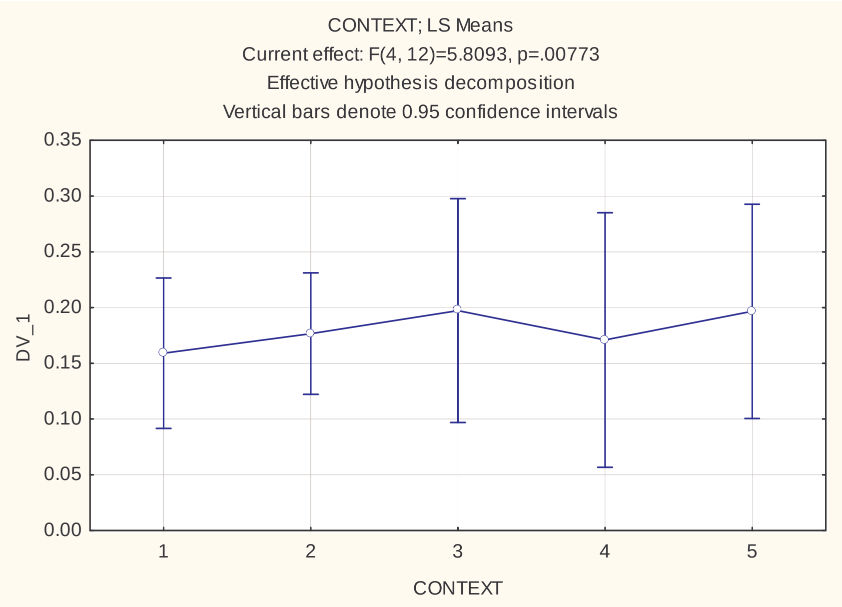
Cell No.	POS	DV_1 Mean	1	2
3	3	0.077250	****	
2	2	0.082958	****	****
1	1	0.092058		****

5 ii

5.1 Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw)

Effect	Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	1.946521	1	1.946521	144.7154	0.001236
Error	0.040352	3	0.013451		
CONTEXT	0.013281	4	0.003320	5.8093	0.007732
Error	0.006858	12	0.000572		
POS	0.026497	2	0.013248	5.5119	0.043781
Error	0.014422	6	0.002404		
CONTEXT*POS	0.004137	8	0.000517	2.3939	0.046887
Error	0.005185	24	0.000216		
dependent varia	ii(CG_C)(ISOLATION				
	ii(CG_C)(OBJECT)				
	ii(CG_C)(SUBJECT)				
	ii(C_C)(ISOLATION				
	ii(C_C)(OBJECT)				
	ii(C_C)(SUBJECT)				
	ii(C_L)(ISOLATION				
	ii(C_L)(OBJECT)				
	ii(C_L)(SUBJECT)				
	ii(C_N)(ISOLATION				
	ii(C_N)(OBJECT)				
	ii(C_N)(SUBJECT)				
	ii(C_NC)(ISOLATION				
	ii(C_NC)(OBJECT)				
	ii(C_NC)(SUBJECT)				

5.2 CONTEXT; LS Means



5.3 CONTEXT; LS Means (Spreadsheet13 in results.stw)

CONTEXT; LS Means (Spreadsheet13 in results.stw)
Current effect: F(4, 12)=5.8093, p=.00773
Effective hypothesis decomposition

Cell No.	CONTEXT	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.159125	0.021201	0.091655	0.226595	4
2	2	0.176583	0.017117	0.122111	0.231056	4
3	3	0.197333	0.031537	0.096967	0.297700	4
4	4	0.170917	0.035870	0.056761	0.285072	4
5	5	0.196625	0.030174	0.100599	0.292651	4

5.4 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00057, df = 12.000

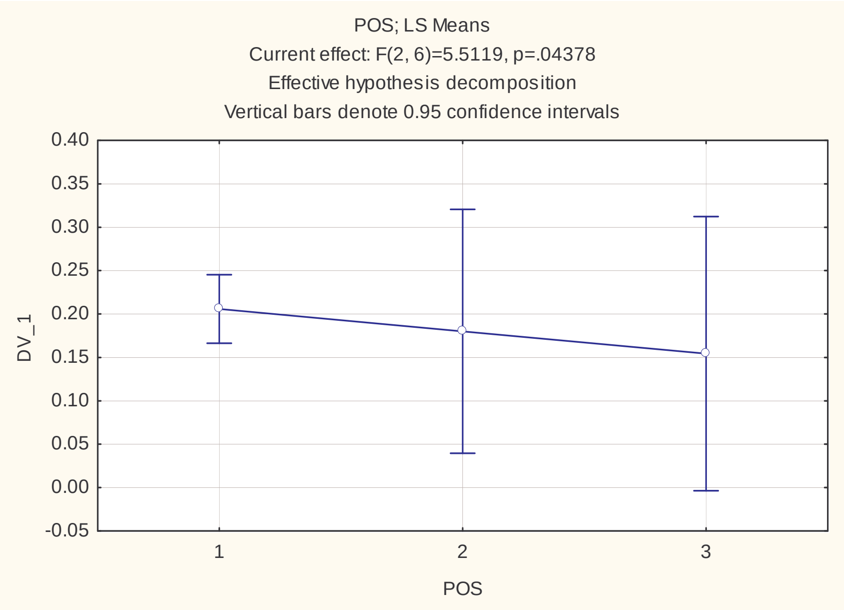
Cell No.	CONTEXT	{1} .15913	{2} .17658	{3} .19733	{4} .17092	{5} .19662
1	1		0.422372	0.014468	0.747200	0.016372
2	2	0.422372		0.270861	0.975545	0.299667
3	3	0.014468	0.270861		0.111465	0.999993
4	4	0.747200	0.975545	0.111465		0.125332
5	5	0.016372	0.299667	0.999993	0.125332	

5.5 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Homogenous Groups, alpha = .05000
Error: Within MSE = .00057, df = 12.000

Cell No.	CONTEXT	DV_1 Mean	1	2
1	1	0.159125		****
4	4	0.170917	****	****
2	2	0.176583	****	****
5	5	0.196625	****	
3	3	0.197333	****	

5.6 POS; LS Means



5.7 POS; LS Means (Spreadsheet13 in results.stw)

POS; LS Means (Spreadsheet13 in results.stw)
Current effect: F(2, 6)=5.5119, p=.04378
Effective hypothesis decomposition

Cell No.	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.205862	0.012410	0.166370	0.245355	4
2	2	0.180100	0.044130	0.039658	0.320542	4
3	3	0.154388	0.049629	-0.003553	0.312328	4

5.8 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00240, df = 6.0000

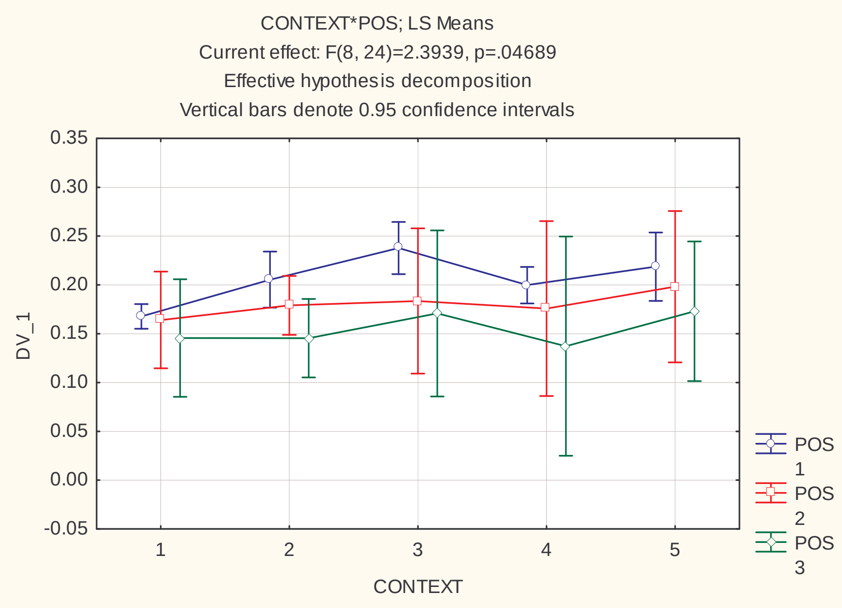
Cell No.	POS	{1} .20586	{2} .18010	{3} .15439
1	1		0.293526	0.036926
2	2	0.293526		0.294670
3	3	0.036926	0.294670	

5.9 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Homogenous Groups, alpha = .05000
Error: Within MSE = .00240, df = 6.0000

Cell No.	POS	DV_1 Mean	1	2
3	3	0.154388	****	
2	2	0.180100	****	****
1	1	0.205862		****

5.10 CONTEXT*POS; LS Means



5.11 CONTEXT*POS; LS Means (Spreadsheet13 in results.stw)

Cell No.	CONTEXT*POS; LS Means (Spreadsheet13 in results.stw) Current effect: F(8, 24)=2.3939, p=.04689 Effective hypothesis decomposition CONTEXT	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	1	0.167750	0.00398	0.155074	0.180426	4
2	1	2	0.164063	0.015573	0.11450	0.213622	4
3	1	3	0.145563	0.018910	0.085382	0.205743	4
4	2	1	0.205375	0.009017	0.176679	0.234071	4
5	2	2	0.179000	0.009480	0.148830	0.209170	4
6	2	3	0.145375	0.012650	0.105118	0.185632	4
7	3	1	0.237750	0.008400	0.211017	0.264483	4
8	3	2	0.183500	0.023376	0.109109	0.257891	4
9	3	3	0.170750	0.026731	0.085679	0.255821	4
10	4	1	0.199750	0.005879	0.181040	0.218460	4
11	4	2	0.175750	0.028135	0.086213	0.265287	4
12	4	3	0.137250	0.035271	0.025001	0.249499	4
13	5	1	0.218687	0.011021	0.183612	0.253763	4
14	5	2	0.198188	0.024348	0.120700	0.275675	4
15	5	3	0.173000	0.022468	0.101495	0.244505	4

5.12 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00022, df = 24.000

Cell No.	CONTEXT	POS	{1} .16775	{2} .16406	{3} .14556	{4} .20537	{5} .17900	{6} .14538	{7} .23775	{8} .1835
1	1	1		1.000000	0.702408	0.067427	0.998072	0.691461	0.000176	0.961
2	1	2	1.000000		0.884420	0.031404	0.974422	0.877183	0.000156	0.845
3	1	3	0.702408	0.884420		0.000588	0.150340	1.000000	0.000145	0.063
4	2	1	0.067427	0.031404	0.000588		0.452137	0.000569	0.181534	0.720
5	2	2	0.998072	0.974422	0.150340	0.452137		0.145320	0.000714	1.000
6	2	3	0.691461	0.877183	1.000000	0.000569	0.145320		0.000145	0.060
7	3	1	0.000176	0.000156	0.000145	0.181534	0.000714	0.000145		0.001
8	3	2	0.961400	0.845760	0.063314	0.720410	1.000000	0.060952	0.001802	
9	3	3	1.000000	0.999995	0.521993	0.120848	0.999936	0.510802	0.000221	0.993
10	4	1	0.193701	0.098731	0.001827	0.999999	0.782086	0.001754	0.062517	0.951
11	4	2	0.999955	0.997165	0.261587	0.285723	1.000000	0.253870	0.000407	0.999
12	4	3	0.248816	0.427408	0.999930	0.000204	0.028609	0.999946	0.000145	0.010
13	5	1	0.003751	0.001662	0.000158	0.990354	0.044209	0.000157	0.861951	0.108
14	5	2	0.251334	0.132612	0.002571	0.999988	0.856660	0.002467	0.045373	0.977
15	5	3	1.000000	0.999838	0.393194	0.181534	0.999999	0.383213	0.000275	0.999

5.13 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Homogenous Groups, alpha = .05000 (Non-Exhaustive Search)
Error: Within MSE = .00022, df = 24.000

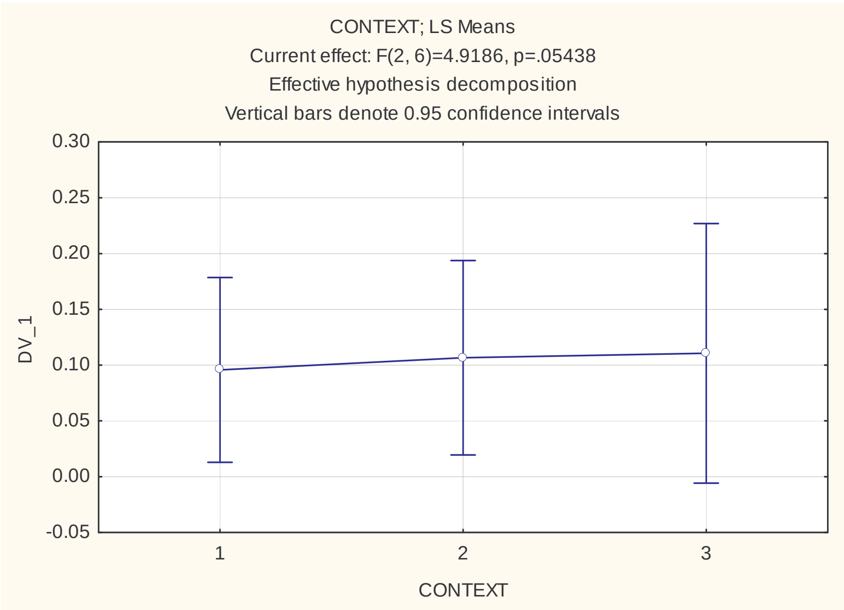
Cell No.	CONTEXT	POS	DV_1 Mean	1	2	3	4	5	6
12	4	3	0.137250	****					
6	2	3	0.145375	****	****				
3	1	3	0.145563	****	****				
2	1	2	0.164063	****	****	****			
1	1	1	0.167750	****	****	****	****		
9	3	3	0.170750	****	****	****	****		
15	5	3	0.173000	****	****	****	****		
11	4	2	0.175750	****	****	****	****		
5	2	2	0.179000		****	****	****		
8	3	2	0.183500		****	****	****	****	
14	5	2	0.198188			****	****	****	
10	4	1	0.199750			****	****	****	****
4	2	1	0.205375				****	****	****
13	5	1	0.218687					****	****
7	3	1	0.237750						****

6 o

6.1 Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw)

Effect	Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	0.392062	1	0.392062	36.43472	0.009117
Error	0.032282	3	0.010761		
CONTEXT	0.001403	2	0.000701	4.91858	0.054378
Error	0.000856	6	0.000143		
POS	0.000727	2	0.000363	2.26178	0.185339
Error	0.000964	6	0.000161		
CONTEXT*POS	0.000456	4	0.000114	2.18448	0.132446
Error	0.000626	12	0.000052		
dependent varial	ɔ(C_C)(ISOLATION)				
	o(C_C)(OBJECT)				
	o(C_C)(SUBJECT)				
	ɔ(C_L)(ISOLATION)				
	o(C_L)(OBJECT)				
	o(C_L)(SUBJECT)				
	ɔ(C_N)(ISOLATION)				
	o(C_N)(OBJECT)				
	o(C_N)(SUBJECT)				

6.2 CONTEXT; LS Means



6.3 CONTEXT; LS Means (Spreadsheet13 in results.stw)

CONTEXT; LS Means (Spreadsheet13 in results.stw)
Current effect: F(2, 6)=4.9186, p=.05438
Effective hypothesis decomposition

Cell No.	CONTEXT	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.095824	0.026025	0.013002	0.178646	4
2	2	0.106667	0.027359	0.019599	0.193734	4
3	3	0.110583	0.036547	-0.005726	0.226892	4

6.4 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00014, df = 6.0000

Cell No.	CONTEXT	{1} .09582	{2} .10667	{3} .11058
1	1		0.145320	0.052715
2	2	0.145320		0.714914
3	3	0.052715	0.714914	

6.5 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Homogenous Groups, alpha = .05000
Error: Within MSE = .00014, df = 6.0000

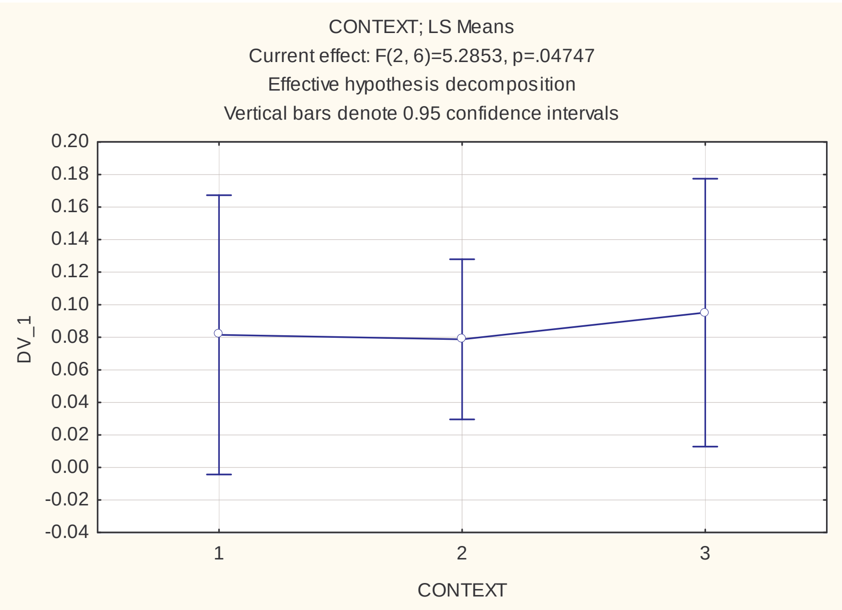
Cell No.	CONTEXT	DV_1 Mean	1
1	1	0.095824	****
2	2	0.106667	****
3	3	0.110583	****

7 u

7.1 Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw)

Effect	Repeated Measures Analysis of Variance (Spreadsheet13 in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	0.260866	1	0.260866	42.12411	0.007426
Error	0.018578	3	0.006193		
CONTEXT	0.001862	2	0.000931	5.28526	0.047473
Error	0.001057	6	0.000176		
POS	0.000667	2	0.000334	10.18048	0.011792
Error	0.000197	6	0.000033		
CONTEXT*POS	0.000055	4	0.000014	1.00507	0.442586
Error	0.000165	12	0.000014		
dependent variables:	ı(C_C)(ISOLATION)				
	u(C_C)(OBJECT)				
	u(C_C)(SUBJECT)				
	ı(C_L)(ISOLATION)				
	u(C_L)(OBJECT)				
	u(C_L)(SUBJECT)				
	ı(C_N)(ISOLATION)				
	u(C_N)(OBJECT)				
	u(C_N)(SUBJECT)				

7.2 CONTEXT; LS Means



7.3 CONTEXT; LS Means (Spreadsheet13 in results.stw)

CONTEXT; LS Means (Spreadsheet13 in results.stw)
Current effect: F(2, 6)=5.2853, p=.04747
Effective hypothesis decomposition

Cell No.	CONTEXT	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.081500	0.026977	-0.004352	0.167352	4
2	2	0.078708	0.015476	0.029457	0.127960	4
3	3	0.095167	0.025865	0.012852	0.177481	4

7.4 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00018, df = 6.0000

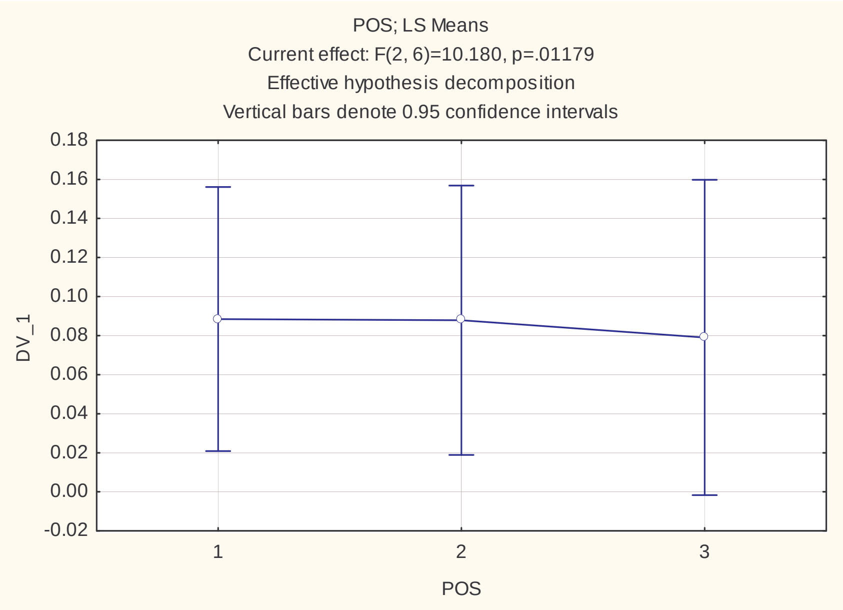
Cell No.	CONTEXT	{1} .08150	{2} .07871	{3} .09517
1	1		0.867004	0.099346
2	2	0.867004		0.052044
3	3	0.099346	0.052044	

7.5 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Homogenous Groups, alpha = .05000
Error: Within MSE = .00018, df = 6.0000

Cell No.	CONTEXT	DV_1 Mean	1
2	2	0.078708	****
1	1	0.081500	****
3	3	0.095167	****

7.6 POS; LS Means



7.7 POS; LS Means (Spreadsheet13 in results.stw)

POS; LS Means (Spreadsheet13 in results.stw)
Current effect: F(2, 6)=10.180, p=.01179
Effective hypothesis decomposition

Cell No.	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.088465	0.021243	0.020862	0.156069	4
2	2	0.087862	0.021666	0.018912	0.156811	4
3	3	0.079048	0.025376	-0.001709	0.159804	4

7.8 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00003, df = 6.0000

Cell No.	POS	{1} .08847	{2} .08786	{3} .07905
1	1		0.964193	0.016304
2	2	0.964193		0.021766
3	3	0.016304	0.021766	

7.9 Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw)

Tukey HSD test; variable DV_1 (Spreadsheet13 in results.stw
Homogenous Groups, alpha = .05000
Error: Within MSE = .00003, df = 6.0000

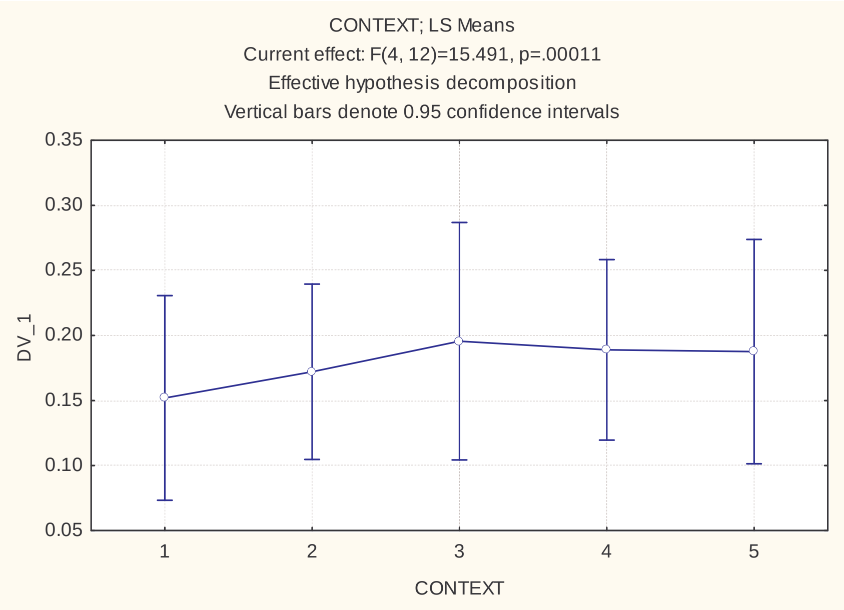
Cell No.	POS	DV_1 Mean	1	2
3	3	0.079048		****
2	2	0.087862	****	
1	1	0.088465	****	

8 aa

8.1 Repeated Measures Analysis of Variance (aa oo uu in results.stw)

Effect	Repeated Measures Analysis of Variance (aa oo uu in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition SS	Degr. of Freedom	MS	F	p
Intercept	1.927314	1	1.927314	168.7547	0.000985
Error	0.034262	3	0.011421		
CONTEXT	0.014720	4	0.003680	15.4911	0.000110
Error	0.002851	12	0.000238		
POS	0.011146	2	0.005573	4.9595	0.053543
Error	0.006742	6	0.001124		
CONTEXT*POS	0.002807	8	0.000351	4.5144	0.001890
Error	0.001865	24	0.000078		
dependent variables:	aa(CG_C)(ISOLATION)				
	aa(CG_C)(OBJECT)				
	aa(CG_C)(SUBJECT)				
	aa(C_C)(ISOLATION)				
	aa(C_C)(OBJECT)				
	aa(C_C)(SUBJECT)				
	aa(C_L)(ISOLATION)				
	aa(C_L)(OBJECT)				
	aa(C_L)(SUBJECT)				
	aa(C_N)(ISOLATION)				
	aa(C_N)(OBJECT)				
	aa(C_N)(SUBJECT)				
	aa(C_NC)(ISOLATION)				
	aa(C_NC)(OBJECT)				
	aa(C_NC)(SUBJECT)				

8.2 CONTEXT; LS Means



8.3 CONTEXT; LS Means (aa oo uu in results.stw)

CONTEXT; LS Means (aa oo uu in results.stw)
Current effect: F(4, 12)=15.491, p=.00011
Effective hypothesis decomposition

Cell No.	CONTEXT	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.151958	0.024728	0.073263	0.230654	4
2	2	0.172063	0.021189	0.104630	0.239495	4
3	3	0.195583	0.028683	0.104302	0.286865	4
4	4	0.188958	0.021816	0.119529	0.258387	4
5	5	0.187567	0.027086	0.101366	0.273767	4

8.4 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00024, df = 12.000

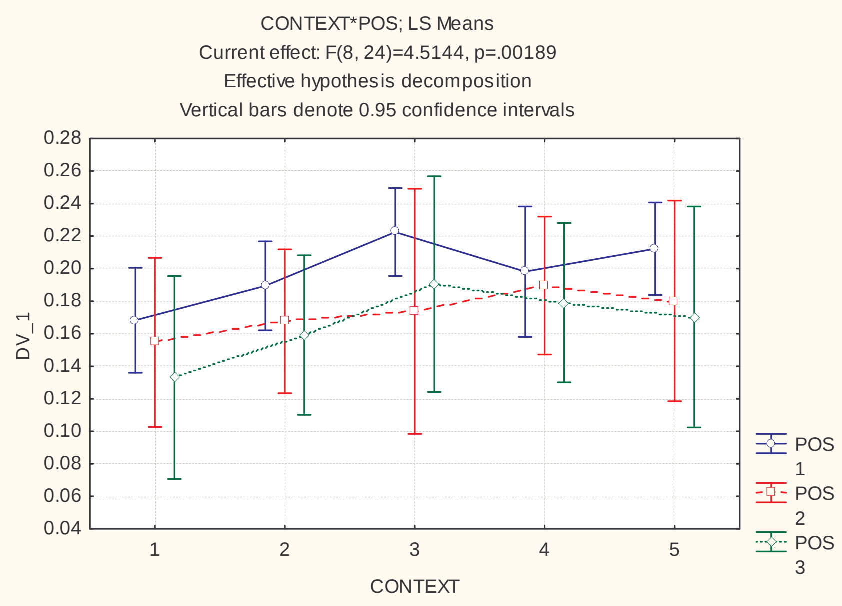
Cell No.	CONTEXT	{1} .15196	{2} .17206	{3} .19558	{4} .18896	{5} .18757
1	1		0.049448	0.000262	0.000702	0.000950
2	2	0.049448		0.019557	0.115413	0.163887
3	3	0.000262	0.019557		0.826321	0.710923
4	4	0.000702	0.115413	0.826321		0.999420
5	5	0.000950	0.163887	0.710923	0.999420	

8.5 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Homogenous Groups, alpha = .05000
Error: Within MSE = .00024, df = 12.000

Cell No.	CONTEXT	DV_1 Mean	1	2	3
1	1	0.151958			****
2	2	0.172063	****		
5	5	0.187567	****	****	
4	4	0.188958	****	****	
3	3	0.195583		****	

8.6 CONTEXT*POS; LS Means



8.7 CONTEXT*POS; LS Means (aa oo uu in results.stw)

CONTEXT*POS; LS Means (aa oo uu in results.stw)
Current effect: F(8, 24)=4.5144, p=.00189
Effective hypothesis decomposition

Cell No.	CONTEXT	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	1	0.168250	0.010136	0.135994	0.200506	4
2	1	2	0.154625	0.016321	0.102683	0.206567	4
3	1	3	0.133000	0.019615	0.070576	0.195424	4
4	2	1	0.189437	0.008580	0.162134	0.216741	4
5	2	2	0.167625	0.013908	0.123362	0.211888	4
6	2	3	0.159125	0.015421	0.110050	0.208200	4
7	3	1	0.222500	0.008488	0.195488	0.249512	4
8	3	2	0.173750	0.023691	0.098354	0.249146	4
9	3	3	0.190500	0.020832	0.124204	0.256796	4
10	4	1	0.198125	0.012587	0.158068	0.238182	4
11	4	2	0.189625	0.013328	0.147209	0.232041	4
12	4	3	0.179125	0.015401	0.130113	0.228137	4
13	5	1	0.212200	0.008930	0.183780	0.240620	4
14	5	2	0.180200	0.019386	0.118505	0.241895	4
15	5	3	0.170300	0.021337	0.102396	0.238204	4

8.8 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00008, df = 24.000

Cell No.	CONTEXT	POS	{1} .16825	{2} .15463	{3} .13300	{4} .18944	{5} .16763	{6} .15912	{7} .22250	{8 .17
1	1	1		0.671374	0.000712	0.105931	1.000000	0.970449	0.000145	0.99
2	1	2	0.671374		0.092008	0.000819	0.731878	0.999979	0.000145	0.19
3	1	3	0.000712	0.092008		0.000145	0.000871	0.019366	0.000145	0.00
4	2	1	0.105931	0.000819	0.000145		0.086570	0.004102	0.001496	0.46
5	2	2	1.000000	0.731878	0.000871	0.086570		0.983405	0.000145	0.99
6	2	3	0.970449	0.999979	0.019366	0.004102	0.983405		0.000145	0.57
7	3	1	0.000145	0.000145	0.000145	0.001496	0.000145	0.000145		0.00
8	3	2	0.999784	0.197590	0.000206	0.464889	0.999298	0.570607	0.000146	
9	3	3	0.074973	0.000589	0.000145	1.000000	0.060818	0.002761	0.002193	0.36
10	4	1	0.004837	0.000161	0.000145	0.980097	0.003826	0.000267	0.036237	0.03
11	4	2	0.099730	0.000771	0.000145	1.000000	0.081418	0.003826	0.001599	0.44
12	4	3	0.897949	0.034678	0.000149	0.927778	0.857316	0.152927	0.000161	0.99
13	5	1	0.000158	0.000145	0.000145	0.063175	0.000154	0.000145	0.928367	0.00
14	5	2	0.823436	0.023625	0.000147	0.967493	0.770775	0.109776	0.000172	0.99
15	5	3	1.000000	0.466094	0.000396	0.196887	1.000000	0.879416	0.000145	0.99

8.9 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Homogenous Groups, alpha = .05000 (Non-Exhaustive Search)
Error: Within MSE = .00008, df = 24.000

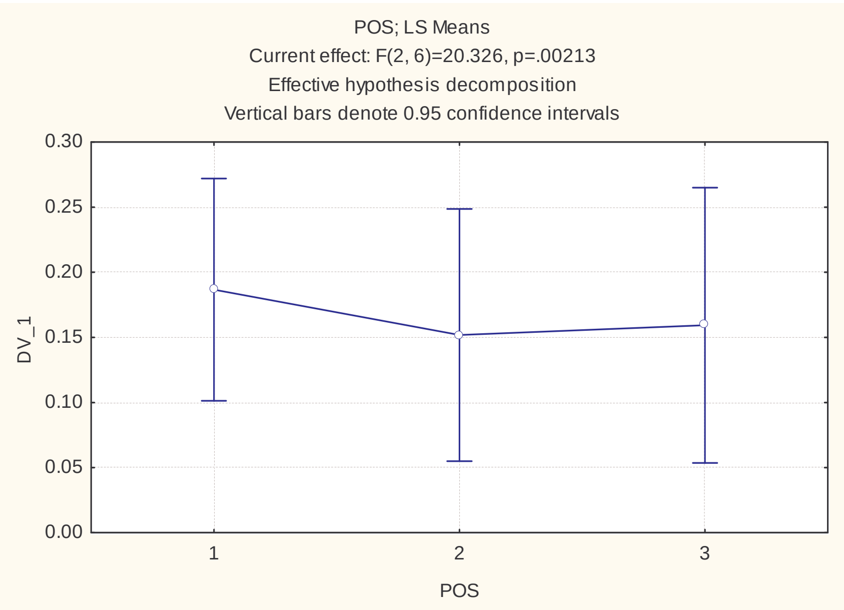
Cell No.	CONTEXT	POS	DV_1 Mean	1	2	3	4	5	6	7
3	1	3	0.133000	****						
2	1	2	0.154625	****	****					
6	2	3	0.159125		****	****				
5	2	2	0.167625		****	****	****			
1	1	1	0.168250		****	****	****			
15	5	3	0.170300		****	****	****			
8	3	2	0.173750		****	****	****			
12	4	3	0.179125			****	****	****		
14	5	2	0.180200			****	****	****		
4	2	1	0.189437				****	****	****	
11	4	2	0.189625				****	****	****	
9	3	3	0.190500				****	****	****	
10	4	1	0.198125					****	****	
13	5	1	0.212200						****	****
7	3	1	0.222500							****

9 oo

9.1 Repeated Measures Analysis of Variance (aa oo uu in results.stw)

Effect	SS	Degr. of Freedom	MS	F	p
	Repeated Measures Analysis of Variance (aa oo uu in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition				
Intercept	1.321208	1	1.321208	126.2049	0.001512
Error	0.031406	3	0.010469		
CONTEXT	0.009794	3	0.003265	2.8592	0.096771
Error	0.010276	9	0.001142		
POS	0.010742	2	0.005371	20.3263	0.002127
Error	0.001585	6	0.000264		
CONTEXT*POS	0.002079	6	0.000347	1.7411	0.168706
Error	0.003582	18	0.000199		
dependent variables:	oo(CG_C)(ISOLATION				
	oo(CG_C)(OBJECT				
	oo(CG_C)(SUBJECT				
	oo(C_C)(ISOLATION				
	oo(C_C)(OBJECT)				
	oo(C_C)(SUBJECT				
	oo(C_L)(ISOLATION				
	oo(C_L)(OBJECT)				
	oo(C_L)(SUBJECT				
	oo(C_NC)(ISOLATION				
	oo(C_NC)(OBJECT				
	oo(C_NC)(SUBJECT				

9.2 POS; LS Means



9.3 POS; LS Means (aa oo uu in results.stw)

POS; LS Means (aa oo uu in results.stw)
Current effect: F(2, 6)=20.326, p=.00213
Effective hypothesis decomposition

Cell No.	POS	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.186607	0.026822	0.101248	0.271966	4
2	2	0.151771	0.030436	0.054911	0.248631	4
3	3	0.159344	0.033220	0.053623	0.265065	4

9.4 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00026, df = 6.0000

Cell No.	POS	{1} .18661	{2} .15177	{3} .15934
1	1		0.002386	0.007731
2	2	0.002386		0.437015
3	3	0.007731	0.437015	

9.5 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Homogenous Groups, alpha = .05000
Error: Within MSE = .00026, df = 6.0000

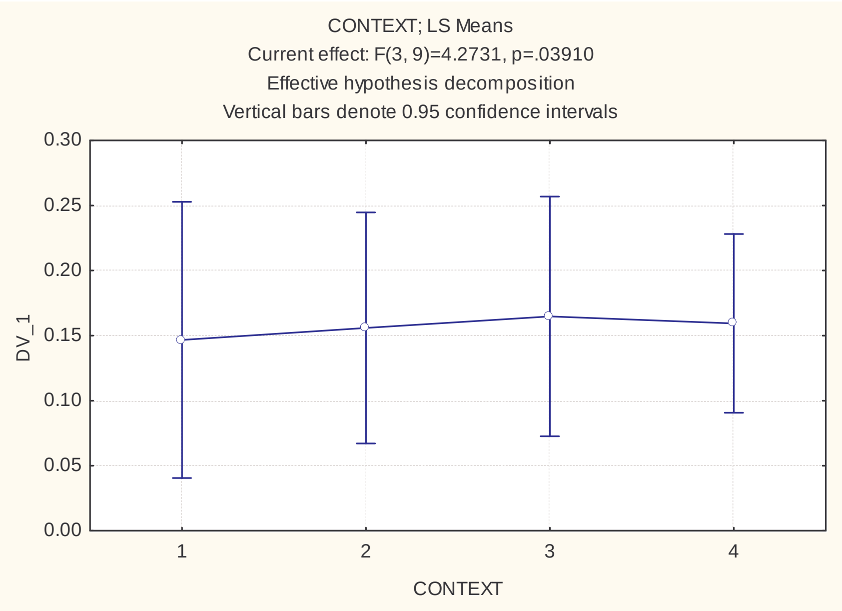
Cell No.	POS	DV_1 Mean	1	2
2	2	0.151771	****	
3	3	0.159344	****	
1	1	0.186607		****

10 uu

10.1 Repeated Measures Analysis of Variance (aa oo uu in results.stw)

	Repeated Measures Analysis of Variance (aa oo uu in results.stw) Sigma-restricted parameterization Effective hypothesis decomposition				
Effect	SS	Degr. of Freedom	MS	F	p
Intercept	1.178530	1	1.178530	95.90459	0.002263
Error	0.036866	3	0.012289		
CONTEXT	0.002068	3	0.000689	4.27311	0.039104
Error	0.001452	9	0.000161		
POS	0.008011	2	0.004006	3.50036	0.098299
Error	0.006866	6	0.001144		
CONTEXT*POS	0.001616	6	0.000269	1.41060	0.264282
Error	0.003436	18	0.000191		
dependent variables:	uu(C_C)(ISOLATION				
	uu(C_C)(OBJECT)				
	uu(C_C)(SUBJECT				
	uu(C_L)(ISOLATION				
	uu(C_L)(OBJECT)				
	uu(C_L)(SUBJECT				
	uu(C_N)(ISOLATION				
	uu(C_N)(OBJECT				
	uu(C_N)(SUBJECT				
	uu(C_NC)(ISOLATION				
	uu(C_NC)(OBJECT				
	uu(C_NC)(SUBJECT				

10.2 CONTEXT; LS Means



10.3 CONTEXT; LS Means (aa oo uu in results.stw)

CONTEXT; LS Means (aa oo uu in results.stw)
Current effect: F(3, 9)=4.2731, p=.03910
Effective hypothesis decomposition

Cell No.	CONTEXT	DV_1 Mean	DV_1 Std.Err.	DV_1 -95.00%	DV_1 +95.00%	N
1	1	0.146717	0.033341	0.040612	0.252821	4
2	2	0.155917	0.02791C	0.067095	0.244739	4
3	3	0.16475C	0.028931	0.072678	0.256822	4
4	4	0.159389	0.021576	0.090723	0.228055	4

10.4 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Approximate Probabilities for Post Hoc Tests
Error: Within MSE = .00016, df = 9.0000

Cell No.	CONTEXT	{1} .14672	{2} .15592	{3} .16475	{4} .15939
1	1		0.344306	0.029393	0.137455
2	2	0.344306		0.375712	0.905993
3	3	0.029393	0.375712		0.734996
4	4	0.137455	0.905993	0.734996	

10.5 Tukey HSD test; variable DV_1 (aa oo uu in results.stw)

Tukey HSD test; variable DV_1 (aa oo uu in results.stw)
Homogenous Groups, alpha = .05000
Error: Within MSE = .00016, df = 9.0000

Cell No.	CONTEXT	DV_1 Mean	1	2
1	1	0.146717	****	
2	2	0.155917	****	****
4	4	0.159389	****	****
3	3	0.16475C		****

Appendix H: List of Words Recorded for Stimulation

Perception Test I

Vowel /a/

	Testing A
Pair1:	sala vs. saala
Pair2:	mbasi vs. mbaasi
Pair3:	n'safu vs. n'saafu
Pair4:	cibamba vs. cibaamba
Pair5:	salu vs. saalu

Vowel /e/

	Testing A
Pair1:	tela vs. teela
Pair2:	mbela vs. mbeela
Pair3:	kutela vs. kuteela
Pair4:	nena vs. neena
Pair5:	cilesi vs. cileesi

Vowel /i/

	Testing A
Pair1:	bima vs.biima
Pair2:	cika vs. ciika
Pair3:	kutina vs. kutiina
Pair4:	n'lilu vs. n'liilu
Pair5:	miti vs. miiti

Vowel /o/

	Testing A
Pair1:	kubola vs. kuboola
Pair2:	kukoka vs. kukooka
Pair3:	kukota vs. kukoota
Pair4:	sola vs. soola
Pair5:	losu vs. loosu

Vowel /u/

	Testing A
Pair1:	mbusa vs. mbuusa
Pair2:	kuputa vs. kupuuta
Pair3:	kututa vs. kutuuta
Pair4:	kubuka vs. kubuuka
Pair5:	ndungu vs. nduungu

Perception Test II

Vowel /a/

Pair1	baana "children"	bana "four"
Pair2	maatu "boats"	matu "ears"

Vowel /e/

Pair1	kubeela "to be ill"	kubela "to be wrong"
Pair2	ceesa "luke"	cesa "sneeze"

Vowel /i/

Pair1	ciliili "manger"	cilili "lip"
Pair2	citiiti "herb"	cititi "drawer"

Vowel /o/

Pair1	n'tootu "tube"	n'totu "earth"
Pair2	libooka "so much death"	liboka "holy wood"

Vowel /u/

Pair1	kutuuta "to crush"	kututa "to pull"
Pair2	mbuusa "net"	mbusa "back"

Perception Test III

Vowel /a/

Pair1	baana "children"	bana "four"
Pair2	maatu "boats"	matu "ears"

Vowel /e/

Pair1	kubeela "to be ill"	kubela "to be wrong"
Pair2	ceesa "luke"	cesa "sneeze"

Vowel /i/

Pair1	ciliili "manger"	cilili "lip"
Pair2	citiiti "herb"	cititi "drawer"

Vowel /o/

Pair1	n'tootu "tube"	n'totu "earth"
Pair2	libooka "so much death"	liboka "holy wood"

Vowel /u/

Pair1	kutuuta "to crush"	kututa "to pull"
Pair2	mbuusa "net"	mbusa "back"

Appendix I: Pages, Stimuli, Expected Responses and Answers

Perception Test I

Vowel /a/

Pages	Stimuli	Expected Responses		Answers		
		Meaning	Number on the pt page	% Correct	% Wrong	% Uncertain
1	Sala	*Travaille!*	2	35	49	15
2	Saala	*Salon*	1	69	20	11
3	Mbaasi	*Ami*	2	69	14	17
4	Mbasi	*Demain*	2	23	57	20
5	N'safu	*Atangatier*	1	55	9	35
6	N'saafu	*Change!*	1	74	8	18
7	Cibamba	*Dame-jeanne*	2	12	88	0
8	Cibaamba	*Homme blanc*	1	80	14	0
9	Salu	*Salon*	2	18	78	3
10	Saalu	*Sel*	2	65	20	15
PERCENTAGE MEANS				50	35.7	13.4

Table I.PT1a for vowel /a/

Vowel /e/

Pages	Stimuli	Expected Responses		Answers		
		Meaning	Number on pt the page	% Correct	% Wrong	% Uncertain
11	Tela	*Télévision*	1	48	15	37
12	Teela	*Espiéglerie*	2	11	85	5
13	Mbela	*Avoir tort*	2	23	69	8
14	Mbeela	*Couteau*	2	15	77	8
15	Kutela	*Appeler*	2	95	3	2
16	Kuteela	*Coudre*	1	71	17	12
17	Nena	*Grand-maman*	2	9	35	55
18	Neena	*Defèque!*	1	12	80	8
19	Cilesi	*Jeune*	1	91	5	5
20	Cileesi	*Montre-le*	1	31	40	29
PERCENTAGE MEANS				40.6	42.6	16.9

Table I.PT1e for vowel /e/

Vowel /i/

Pages	Stimuli	Expected Responses		Answers		
		Meaning	Number on the pt page	% Correct	% Wrong	% Uncertain
21	Bima	*Gémis!*	2	3	91	6
22	Biima	*Choses*	2	37	32	31
23	Cika	*Bloque!*	1	12	88	0
24	Ciika	*Lit*	1	14	82	5
25	Kutina	*Creuser*	2	17	63	20
26	Kutiina	*Fuir*	1	88	8	5
27	N'lilu	*Manière de manger*	1	48	38	14
28	N'liilu	*Lieu de bonne pêche*	2	42	35	23
29	Miti	*Arbres*	1	98	2	0
30	Miiti	*Je dis que*	1	29	68	3
PERCENTAGE MEANS				38.8	50.7	10.7

Table I.PT1i for vowel /i/

Vowel /o/

Pages	Stimuli	Expected Responses		Answers		
		Meaning	Number on the pt page	% Correct	% Wrong	% Uncertain
31	Kubola	*Pourrir*	2	60	31	9
32	Kuboola	*Ramasser*	1	86	11	3
33	Kukoka	*Drainer*	1	15	74	11
34	Kukooka	*Griller à la braise*	2	34	51	15
35	Kukota	*Entrer*	2	14	86	0
36	Kukoota	*Se rechauffer*	2	86	8	6
37	Sola	*Plantation*	2	92	6	2
38	Soola	*Choisis!*	2	23	65	12
39	Losu	*Saleté*	1	98	2	0
40	Loosu	*Riz*	2	8	80	12
PERCENTAGE MEANS				51.6	41.4	7.00

Table I.PT1o for vowel /o/

Vowel /u/

Pages	Stimuli	Expected Responses		Answers		
		Meaning	Number on the pt page	% Correct	% Wrong	% Uncertain
41	Mbusa	*Dos*	2	94	2	5
42	Mbuusa	*Filet de pêche*	1	78	12	9
43	Kuputa	*Emballer*	1	23	66	11
44	Kupuuta	*Mentir*	1	28	66	6
45	Kututa	*Tirer*	2	85	12	3
46	Kutuuta	*Piler*	2	12	83	5
47	Kubuka	*Soigner*	1	54	26	20
48	Kubuuka	*Bouger*	2	17	80	3
49	Ndungu	*Type d'arbre*	1	6	91	3
50	Nduungu	*Tam-tam*	1	17	69	14
PERCENTAGE MEANS				41.4	50.7	7.9

Table I.PT1u for vowel /u/

Perception Test II

Vowel /a/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
51	Bana Baana	*Différent*	2	52	42	6
52	Maatu Matu	*Différent*	2	57	37	6
PERCENTAGE MEANS				54.5	39.5	6.00

Table I.PT2a for vowel /a/

Vowel /e/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
53	Kubeela Kubela	*Différent*	2	58	38	3
54	Ceesa Cesa	*Différent*	2	60	22	18
PERCENTAGE MEANS				59.00	30.00	10.5

Table I.PT2e for vowel /e/

Vowel /i/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
55	Cilili Ciliili	*Différent*	2	**ABORTED PAGE RESULTS**		
56	Citiiti Cititi	*Différent*	2	57	40	3
PERCENTAGE MEANS				57.00	40.00	3.00

Table I.PT2i for vowel /i/

Vowel /o/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
57	N'tootu N'totu	*Différent*	2	65	32	3
58	Liboka Libooka	*Différent*	2	52	43	5
PERCENTAGE MEANS				58.5	37.5	4.00

Table I.PT2o for vowel /o/

Vowel /u/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
59	Kutuuta Kututa	*Différent*	2	75	23	2
60	Mbusa Mbuusa	*Différent*	2	83	17	0
PERCENTAGE MEANS				79.00	20.00	1.00

Table I.PT2u for vowel /u/

Perception Test III

Vowel /a/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
61	Baana Bana Bana	*Icône B (Deuxième)*	2	66	22	12
62	Maatu Matu Matu	*Icône B (Deuxième)*	2	12	83	5
PERCENTAGE MEANS				39.00	52.5	8.5

Table I.PT3a for vowel /a/

Vowel /e/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
63	Kubeela Kubela Kubeela	*Icône A (Premier)*	1	23	77	0
64	Ceesa Cesa Ceesa	*Icône A (Premier)*	1	80	11	9
PERCENTAGE MEANS				51.5	44.00	4.5

Table I.PT3e for vowel /e/

Vowel /i/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
65	Ciliili Cilili Cilili	*Icône B (Deuxième)*	2	88	11	2
66	Cititi Citiiti Citiiti	*Icône B (Deuxième)*	2	85	15	0
PERCENTAGE MEANS				86.5	13.00	1.00

Table I.PT3i for vowel /i/

Vowel /o/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
67	N'tootu N'totu N'totu	*Icône B (Deuxième)*	2	9	88	3
68	Libooka Liboka Liboka	*Icône B (Deuxième)*	2	85	14	2
PERCENTAGE MEANS				47.00	51.00	2.5

Table I.PT3u for vowel /o/

Vowel /u/

Pages	Stimuli	Expected Responses		Answers		
		Icon	Number on the pt page	% Correct	% Wrong	% Uncertain
69	Kututa Kutuuta Kututa	*Icône A (Premier)*	1	83	15	2
70	Mbuusa Mbusa Mbuusa	*Icône A (Premier)*	1	88	12	0
PERCENTAGE MEANS				85.5	13.5	1.00

Table I.PT3u for vowel /u/

Appendix J: Participants for Perception Experiment

SUBJ	NAME	AGE	SEX	PROFESSION (at the time of the experiment)
s1	SB	30	F	High School Teacher
s10	ENM	50	M	Mechanic Engineer
s11	LB	63	M	Retired Administration Officer
s12	JB	37	F	Unemployed
s13	NB	27	F	Unemployed
s14	GAT	47	M	Medical Doctor
s15	CET	32	M	Train Driver
s16	GRD	38	M	Marine
s17	JM	22	M	Student
s18	GS	36	F	House Keeper
s19	CMN	46	F	Unemployed
s2	RL	26	M	Student
s20	JPT	33	M	Engine Driver
s21	MDT	28	F	Student
s22	EFT	15	F	Student
s23	JMF	44	M	Finance Officer
s24	PB	30	F	Finance Officer
s25	PP	35	M	Forester
s26	LPT	23	F	Student
s27	AAM	32	F	Educator
s28	NE	26	F	Student
s29	LFN	16	M	High-school student
s3	ANM	56	M	Retired finance officer
s30	MAM	48	F	Unemployed
s31	PK	33	M	Engineer
s32	PL	37	F	Unemployed
s33	CMB	35	F	Nurse
s34	LPBK	24	F	Unemployed
s35	HCDK	18	M	High-school student
s37	GM	15	F	High-school student
s38	SN	17	M	High-school student
s39	HM	16	F	High-school student
s4	JM	54	M	Retired Military
s40	AGM	19	M	High-school student
s41	MYM	15	F	High-school student
s42	GGM	20	M	High-school student
s43	FT	15	M	High-school student
s44	JT	15	F	High-school student
s45	GRN	15	M	High-school student

s46	MN	18	M	High-school student
s47	PK	27	M	Logistics engineer
s48	CL	20	M	High-school student
s49	CN	16	M	High-school student
s5	JMB	42	M	Military
s50	FRPS	19	M	High-school student
s51	CAM	16	F	High-school student
s52	MNB	18	M	High-school student
s53	SLV	15	F	School student
s54	EOBM	17	F	High-scholl student
s55	HM	17	M	School student
s56	CJT	15	M	High-school student
s57	GB	26	F	Post Officer
s58	IGD	15	M	High-scool student
s59	PWMH	17	M	High-school student
s6	TM	29	M	Health Lab Officer
s60	DMN	15	M	High-school student
s61	JLN	15	M	High-school student
s62	SYT	19	F	Unemployed
s63	MSN	46	F	Pharmacist
s64	OMMM	16	F	High-school student
s65	SEV	19	F	High-school student
s66	FMKT	18	F	High-school student
s67	CM	32	F	Secretary
s68	HA	28	F	Businesswoman
s7	AM	24	M	Nurse
s8	AN	41	F	Unemployed
s9	FSBK	21	M	Student

Appendix K: Fieldwork Questionnaire

Questionnaire for details of mother-tongue speakers/listeners of Civili

1. Subject No. _____ 2. Gender_____ 3. Age_____
Numero sujet *Sexe* *Age*

4. Name and surname___________________________________
Prénom et Nom

5. Place of birth________________ 6. Place of habitation________________
Lieu de naissance *Lieu d'habitation*

6. Profession___________________
Profession

7. What is your mother's language?
Quelle est la langue de votre mère?
____

8. What is your father's language?
Quelle est la langue de votre père?
____

9. Other languages you can speak.
Les autres langues que vous pouvez parler.
____

10. Other languages you can understand.
Les autres langues que vous pouvez comprendre.
____

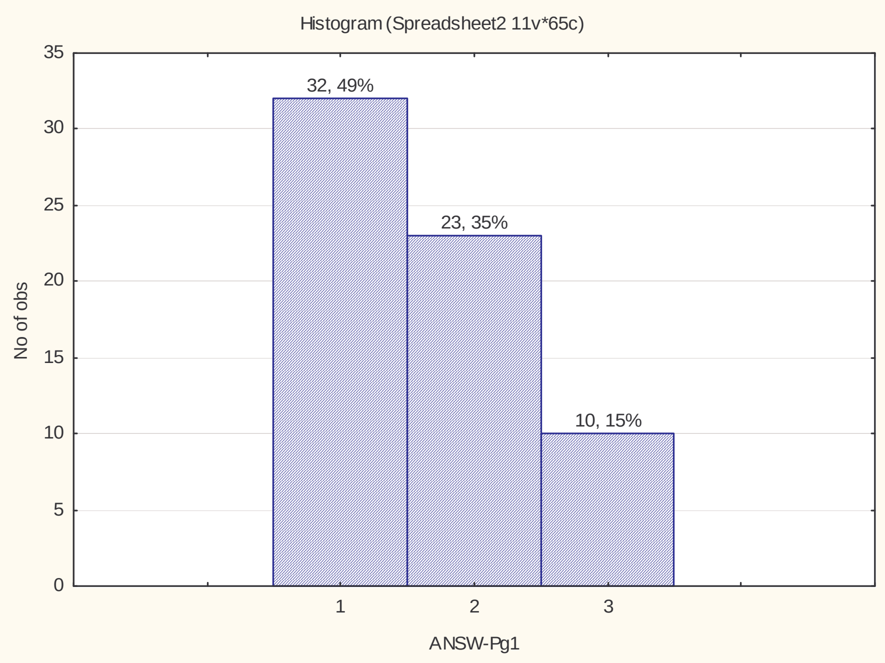
11. Can you write in Civili?
Pouvez vous écrire en Civili?
____

12. Can you read Civili?
Pouvez vous lire le vili?
____

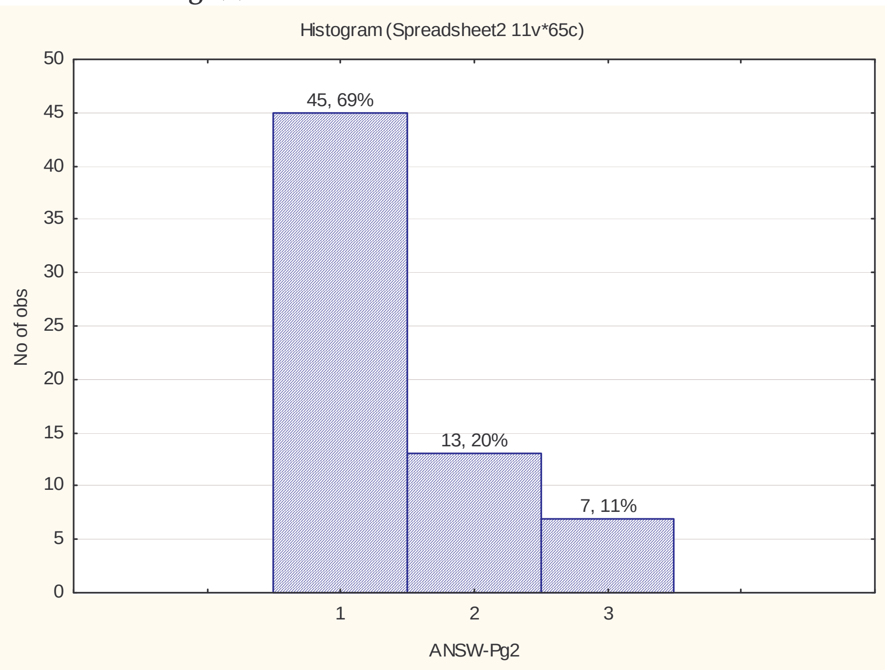
Appendix L: Perception Experiment Results

1 test1A

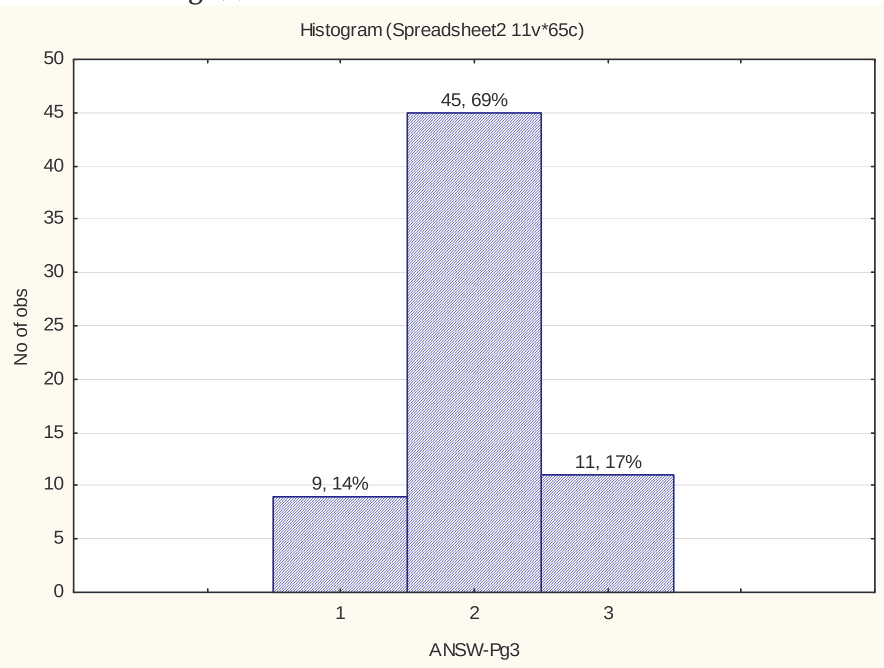
1.1 ANSW-Pg1(2)



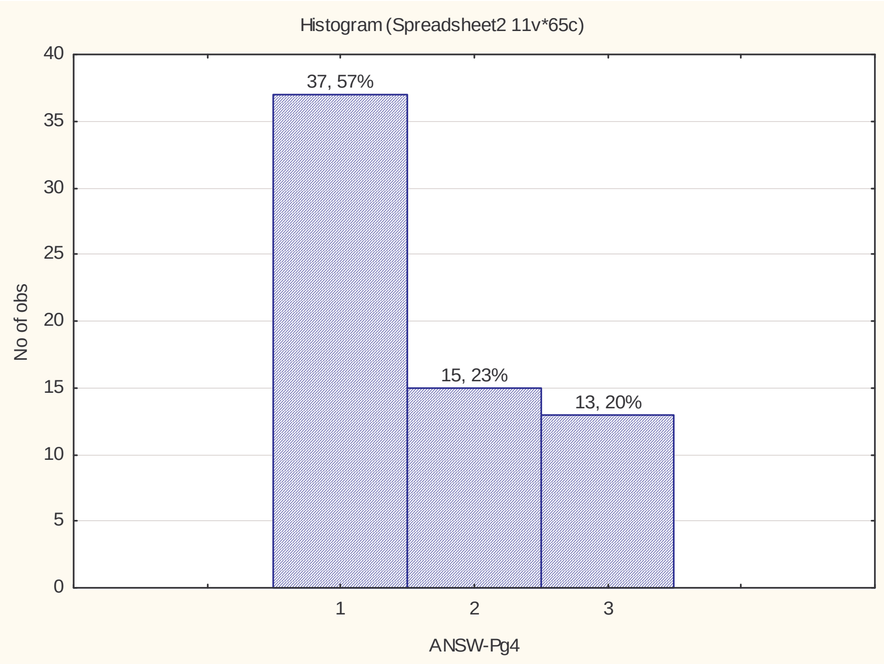
1.2 ANSW-Pg2(3)



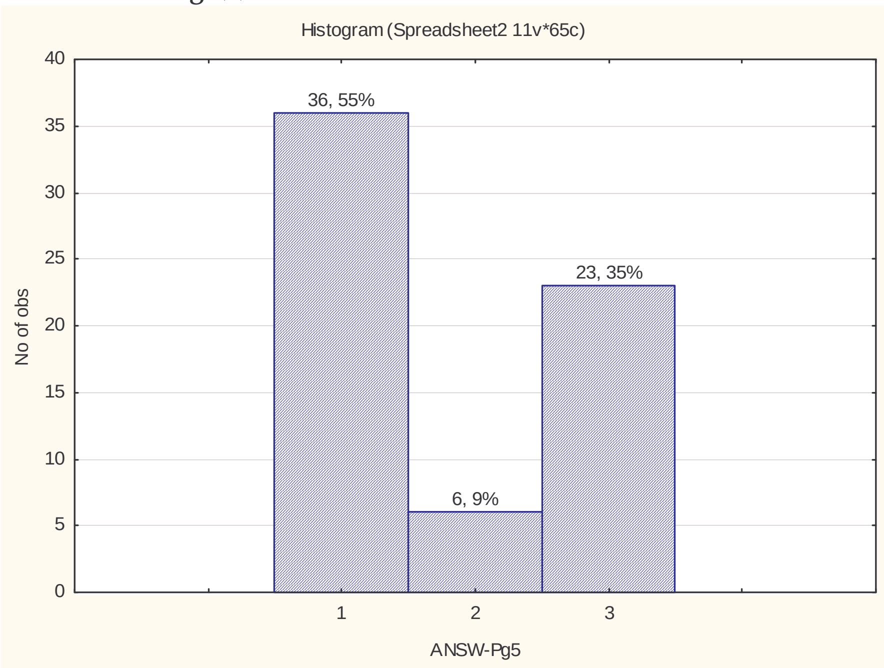
1.3 ANSW-Pg3(4)



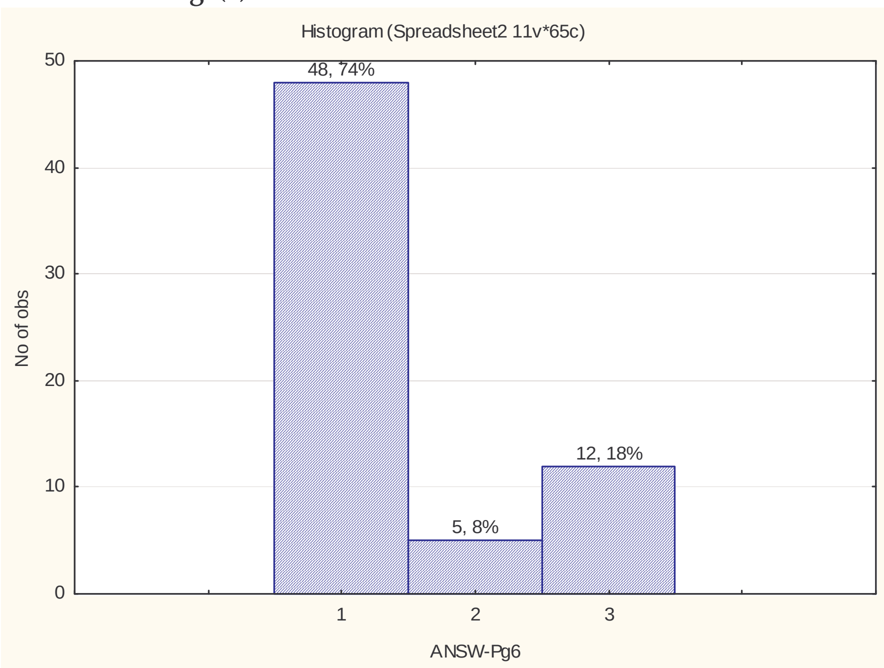
1.4 ANSW-Pg4(5)



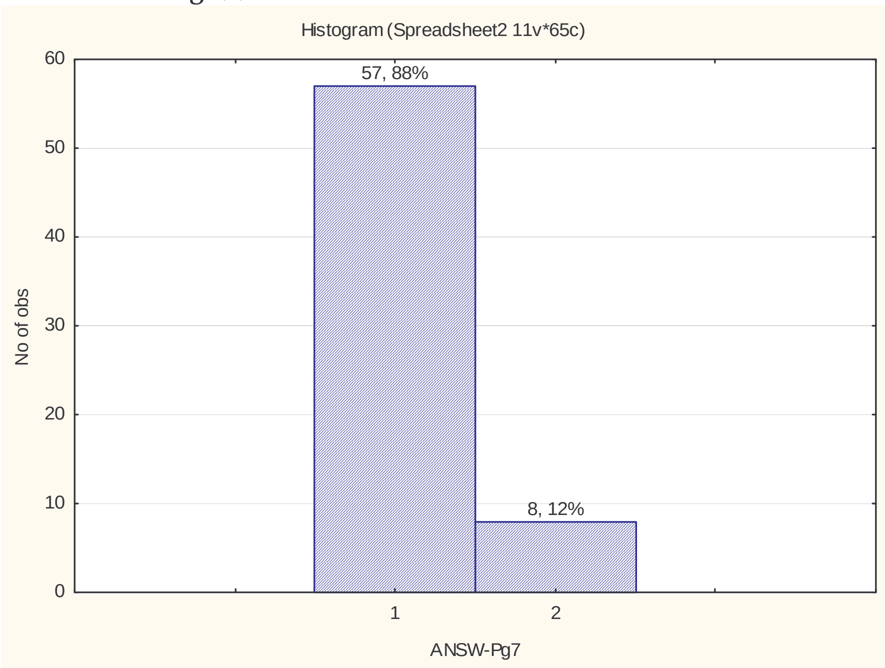
1.5 ANSW-Pg5(6)



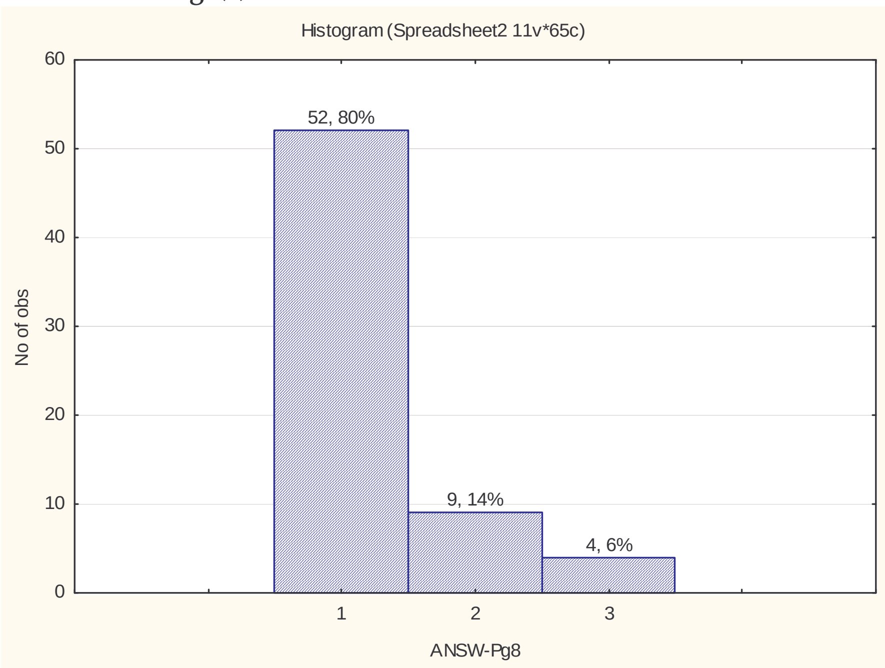
1.6 ANSW-Pg6(7)



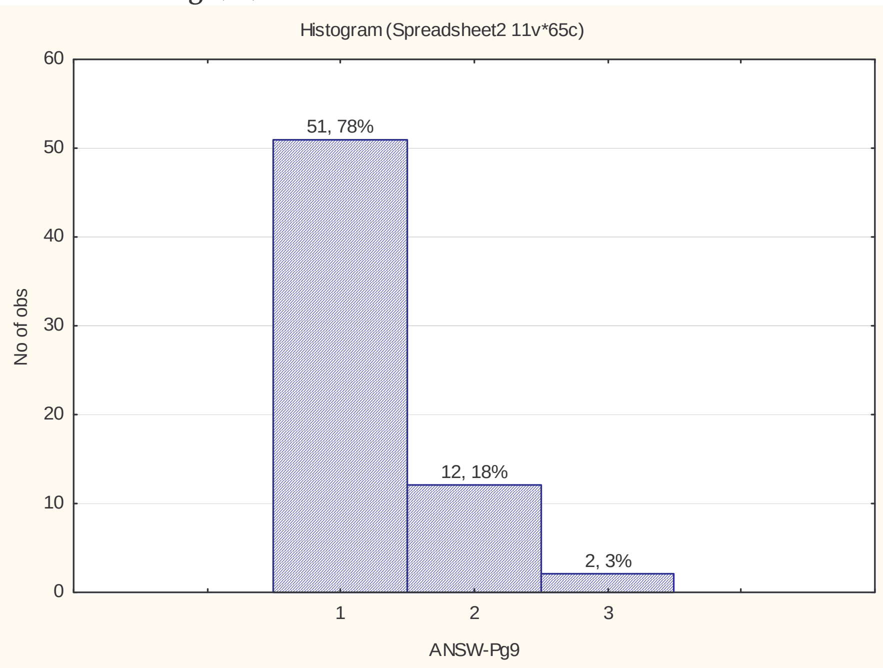
1.7 ANSW-Pg7(8)



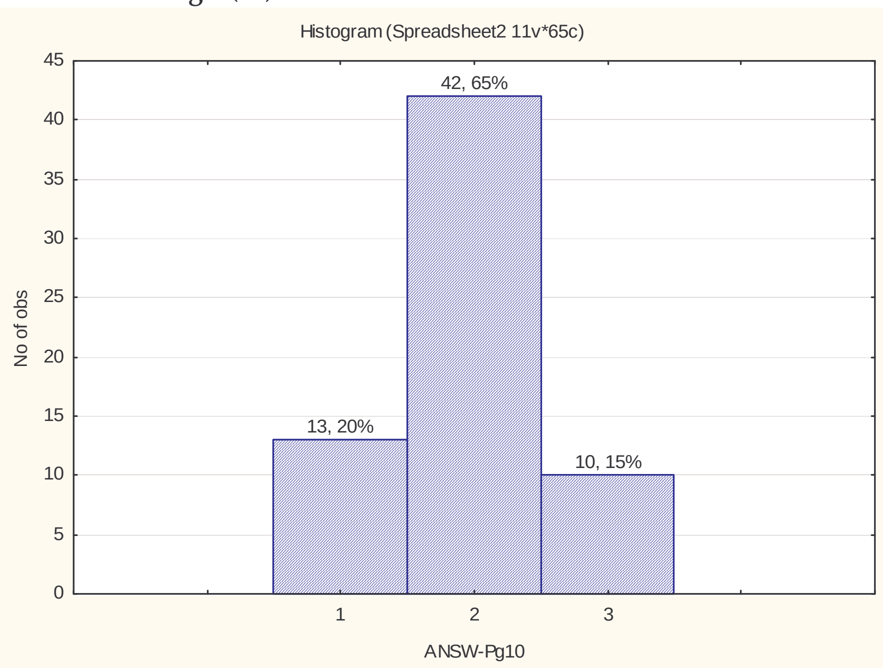
1.8 ANSW-Pg8(9)



1.9 ANSW-Pg9(10)

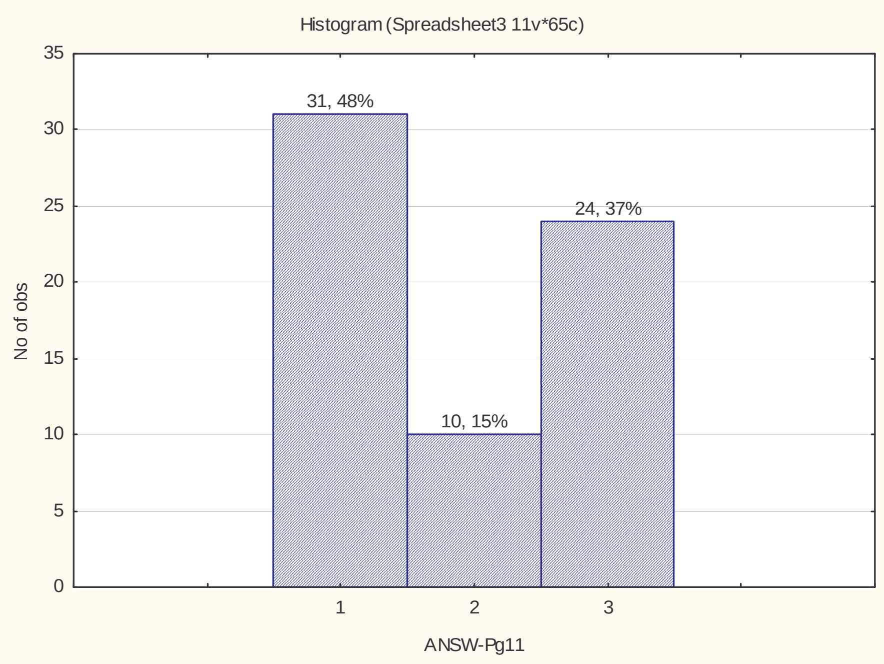


1.10 ANSW-Pg10(11)

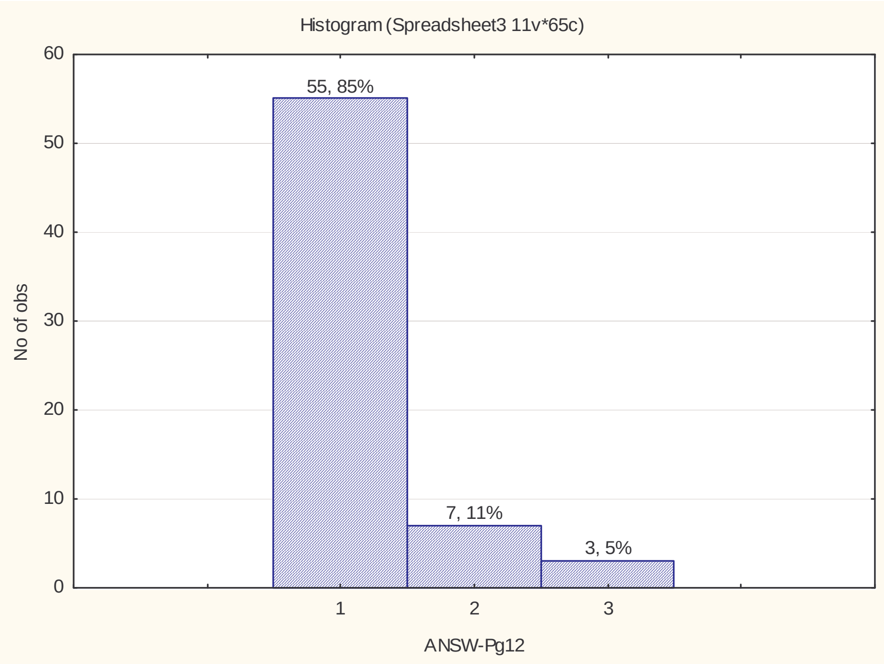


2 test1E

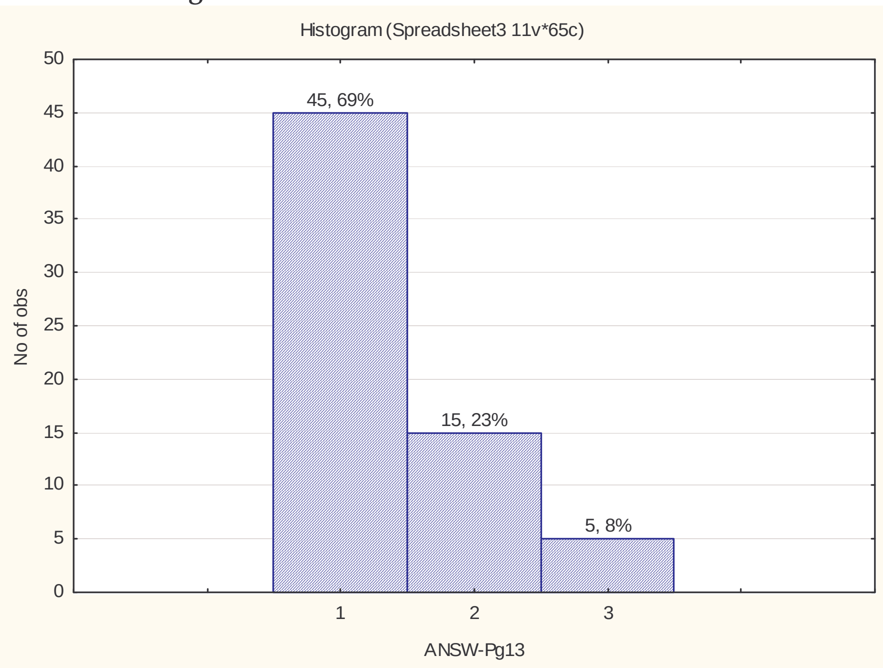
2.1 ANSW-Pg11



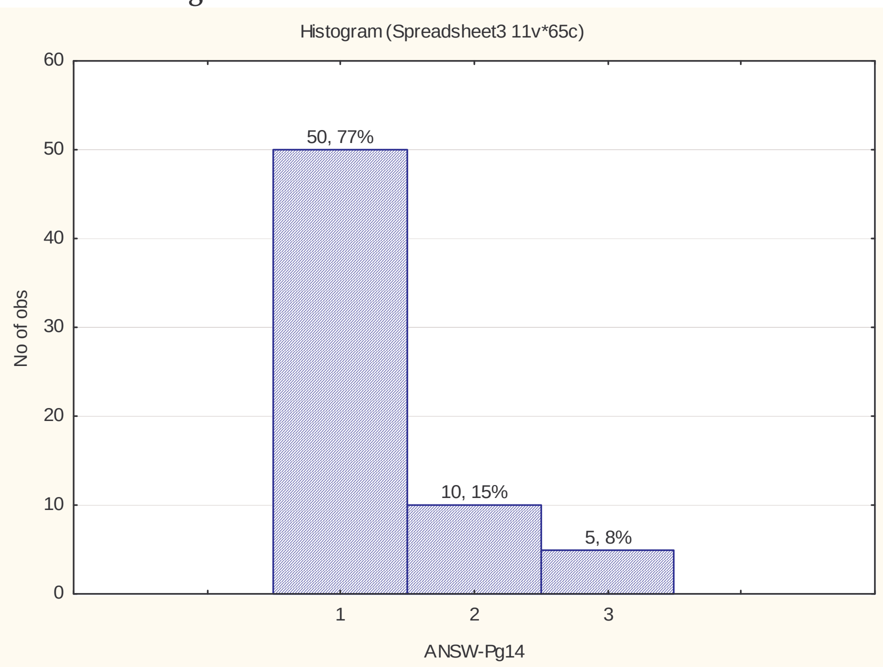
2.2 ANSW-Pg12



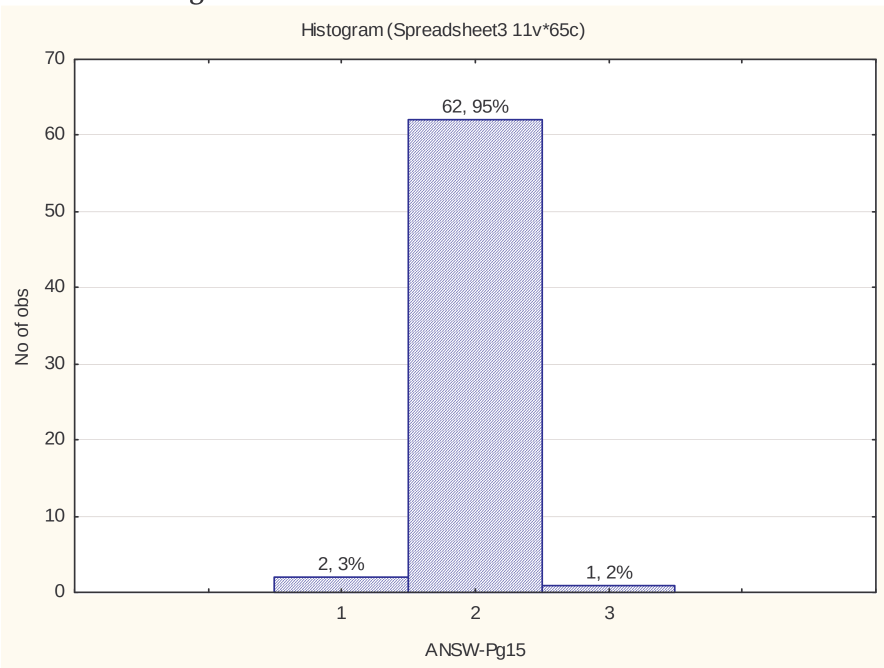
2.3 ANSW-Pg13



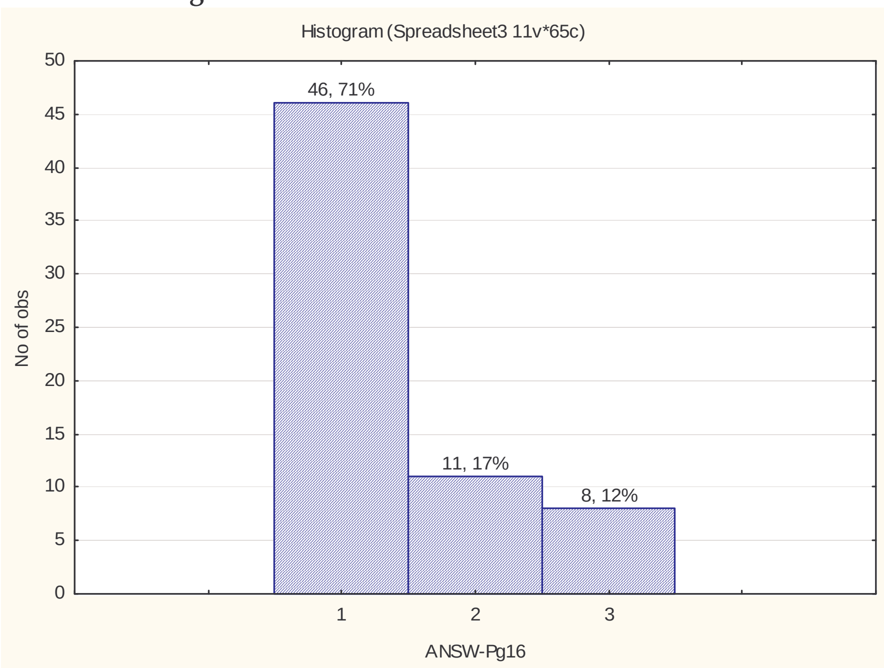
2.4 ANSW-Pg14



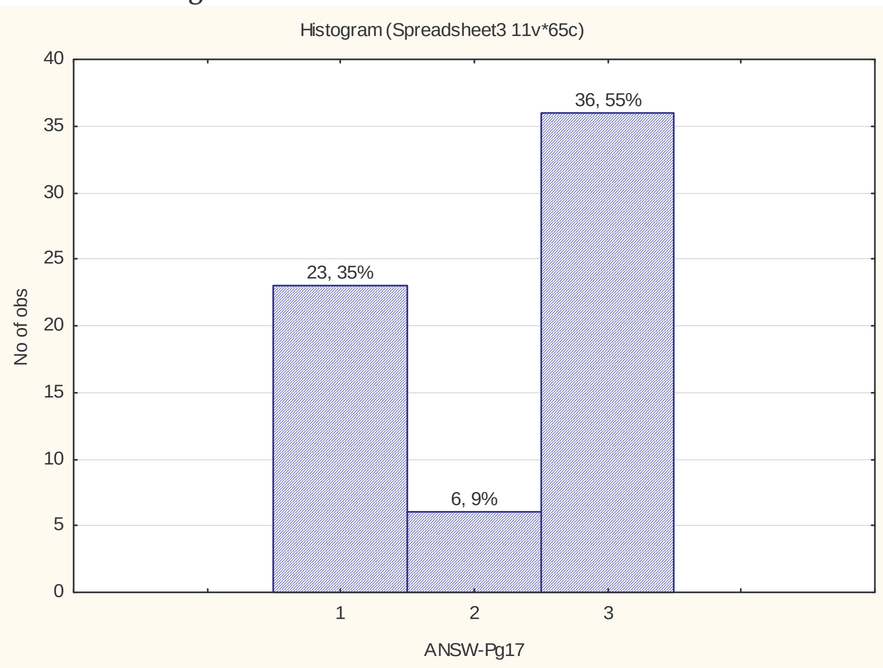
2.5 ANSW-Pg15



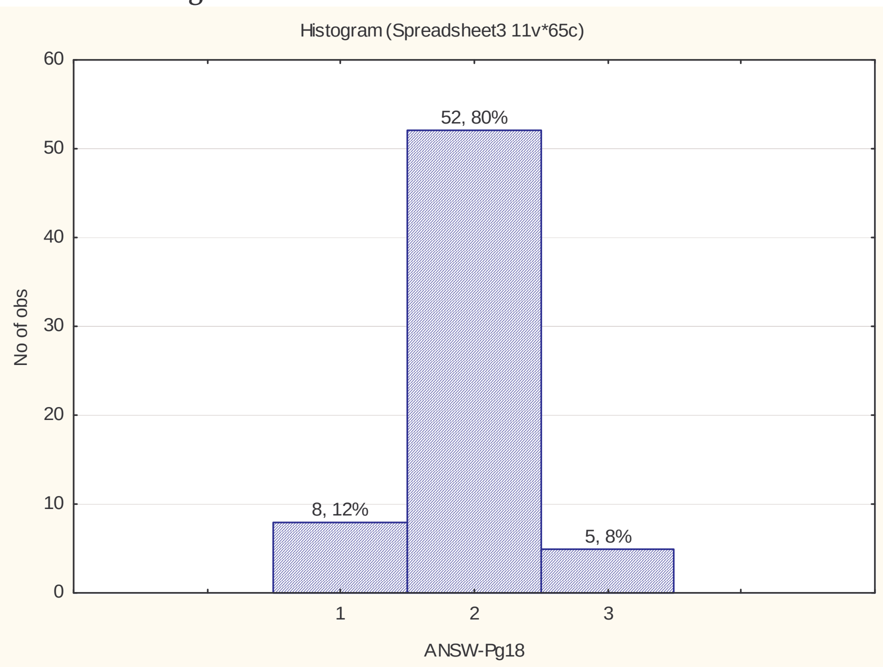
2.6 ANSW-Pg16



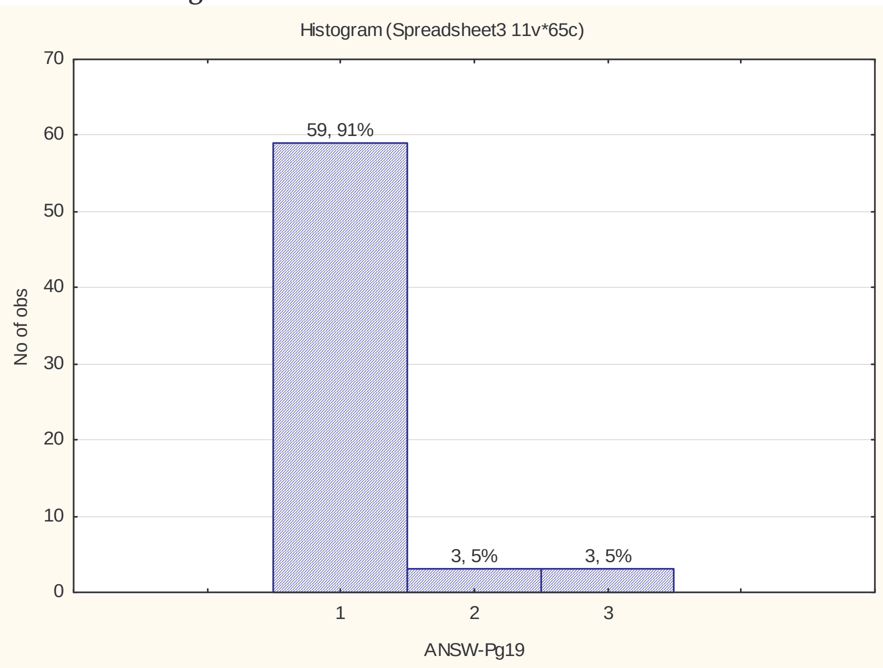
2.7 ANSW-Pg17



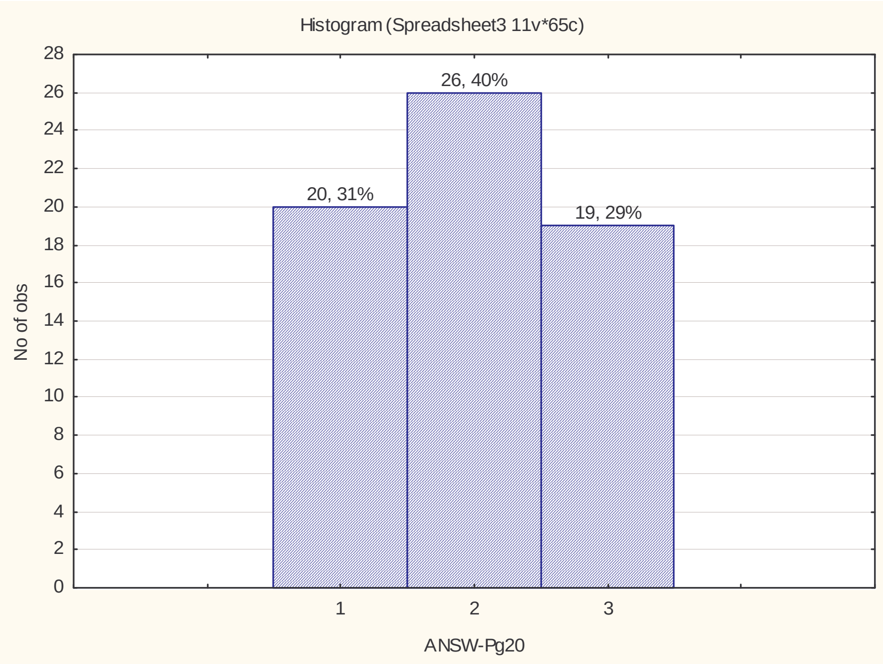
2.8 ANSW-Pg18



2.9 ANSW-Pg19

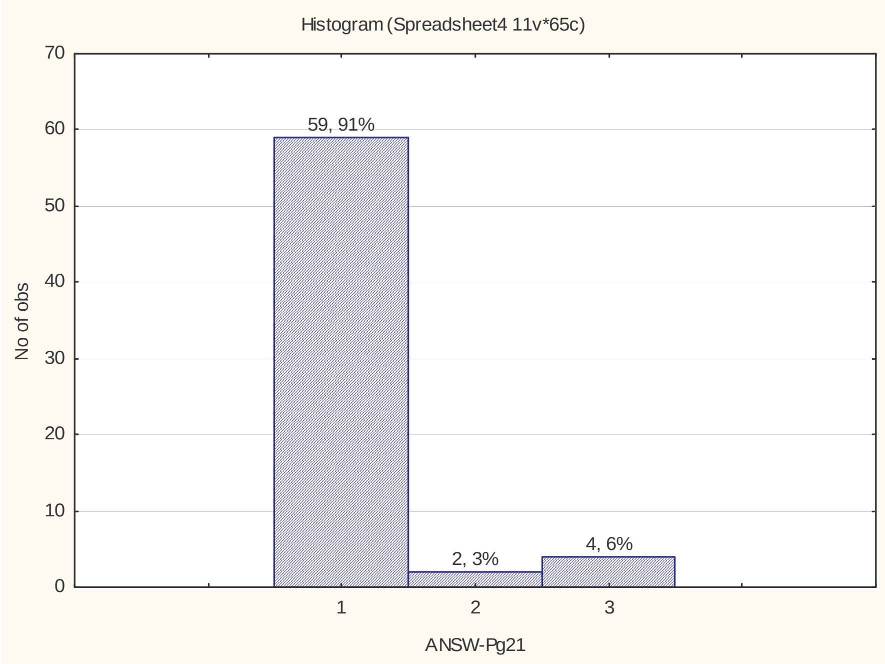


2.10 ANSW-Pg20

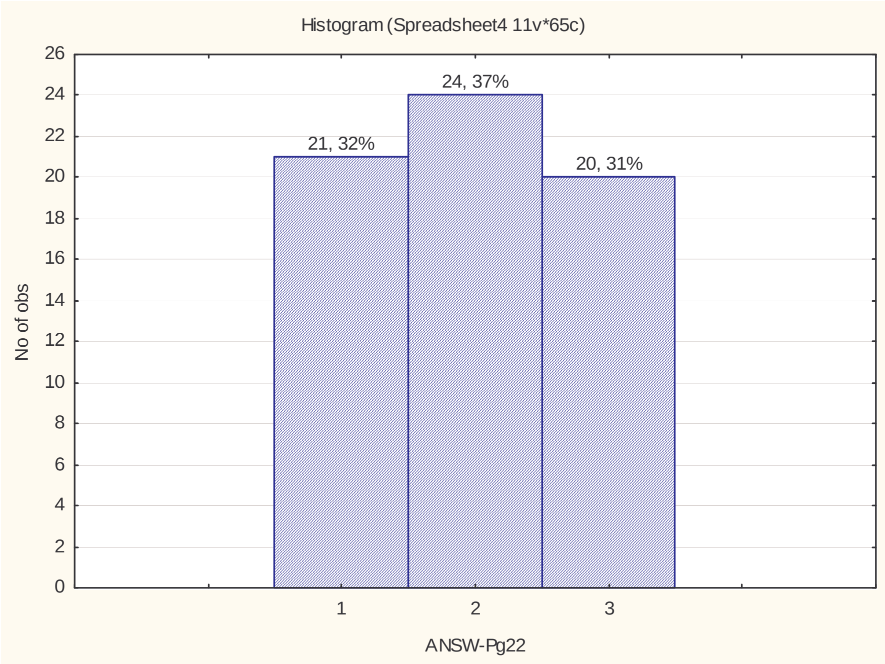


3 test1I

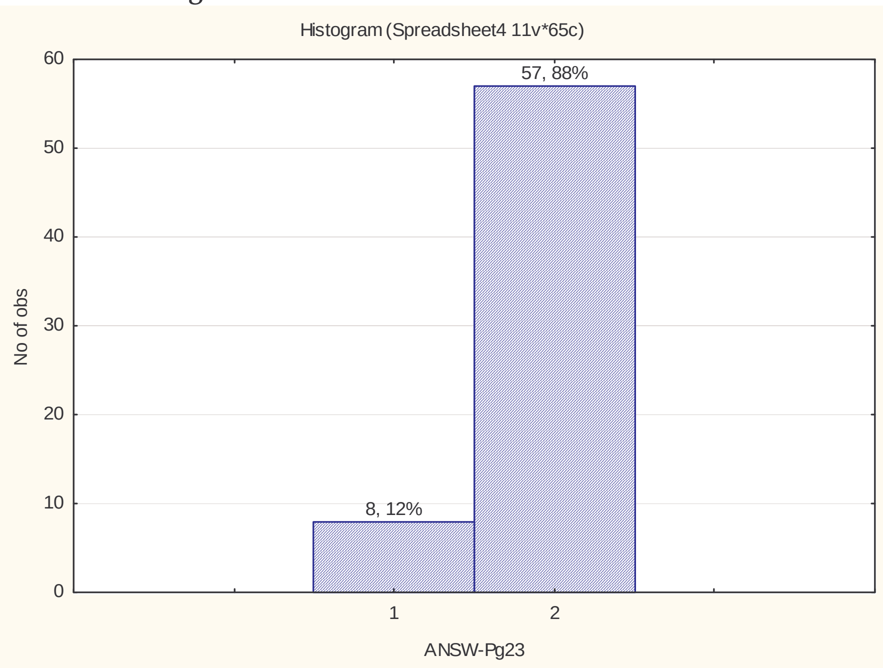
3.1 ANSW-Pg21



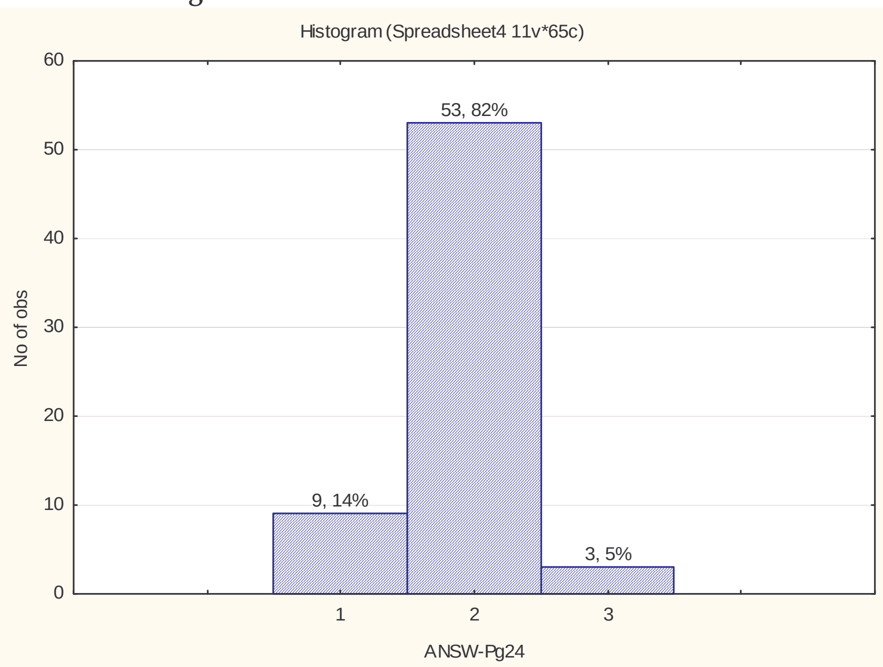
3.2 ANSW-Pg22



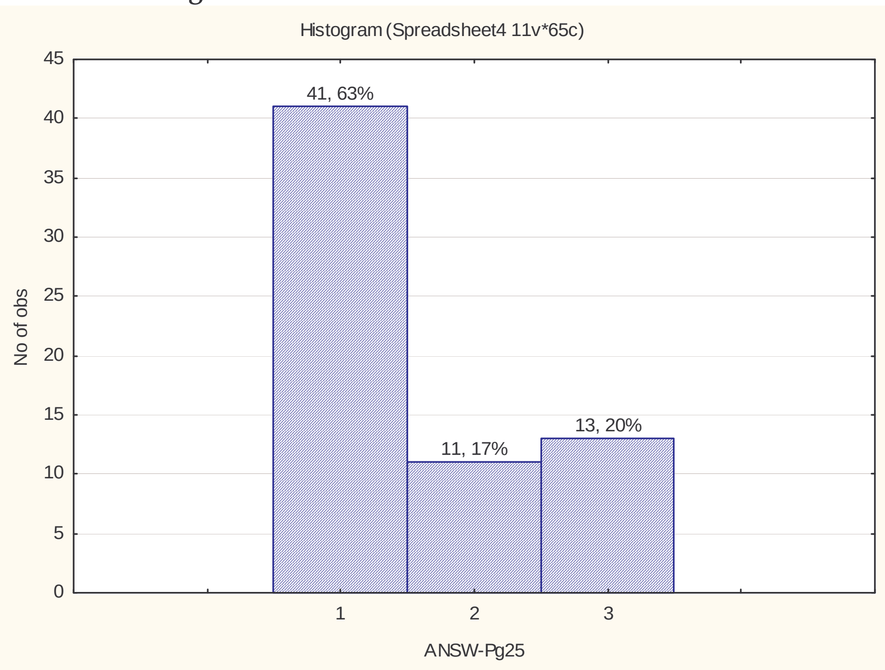
3.3 ANSW-Pg23



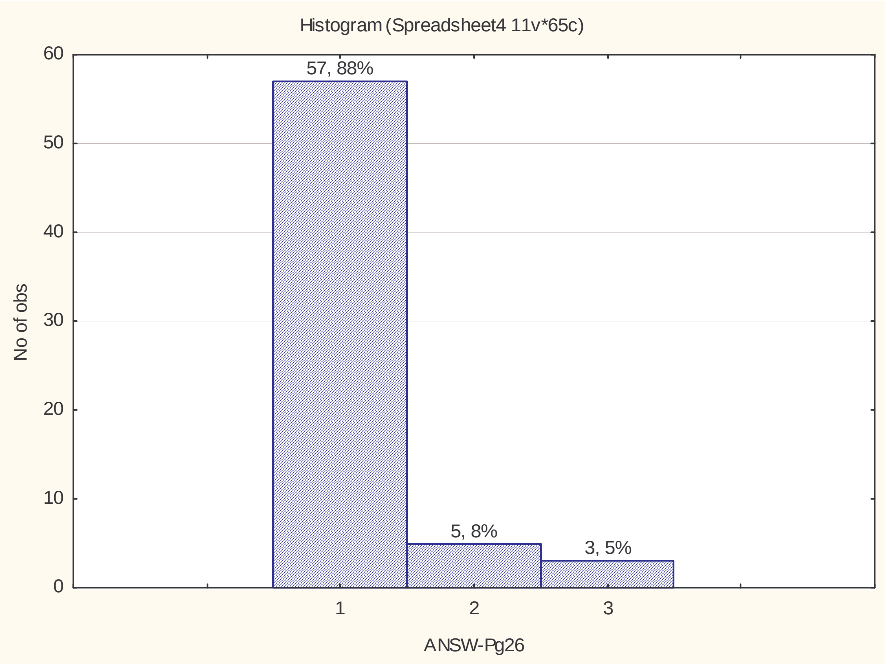
3.4 ANSW-Pg24



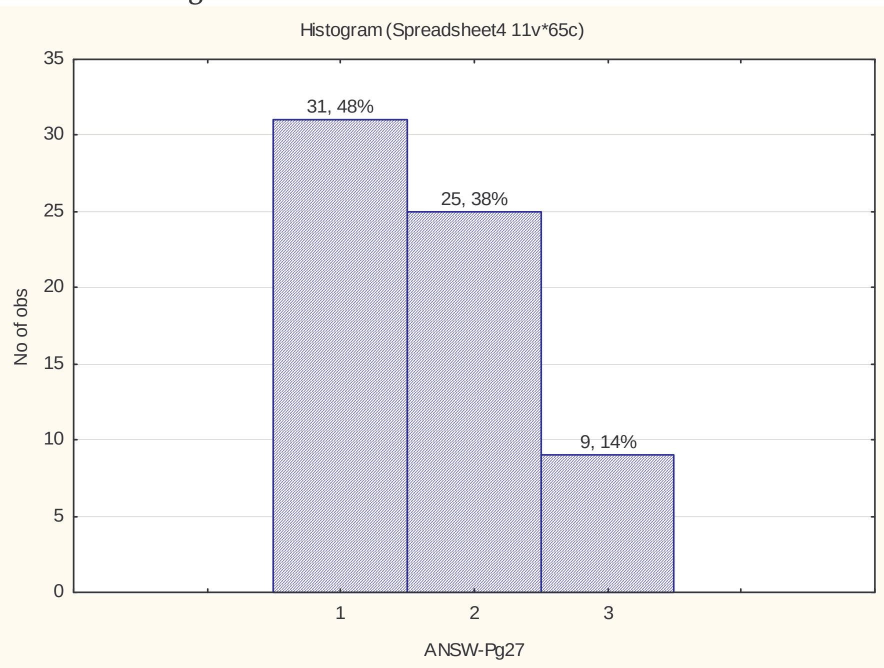
3.5 ANSW-Pg25



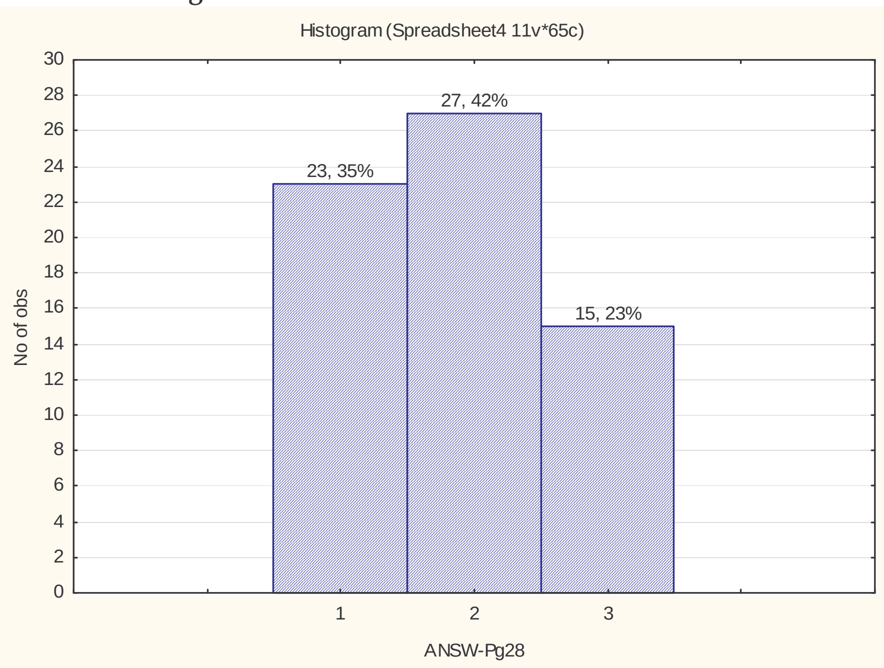
3.6 ANSW-Pg26



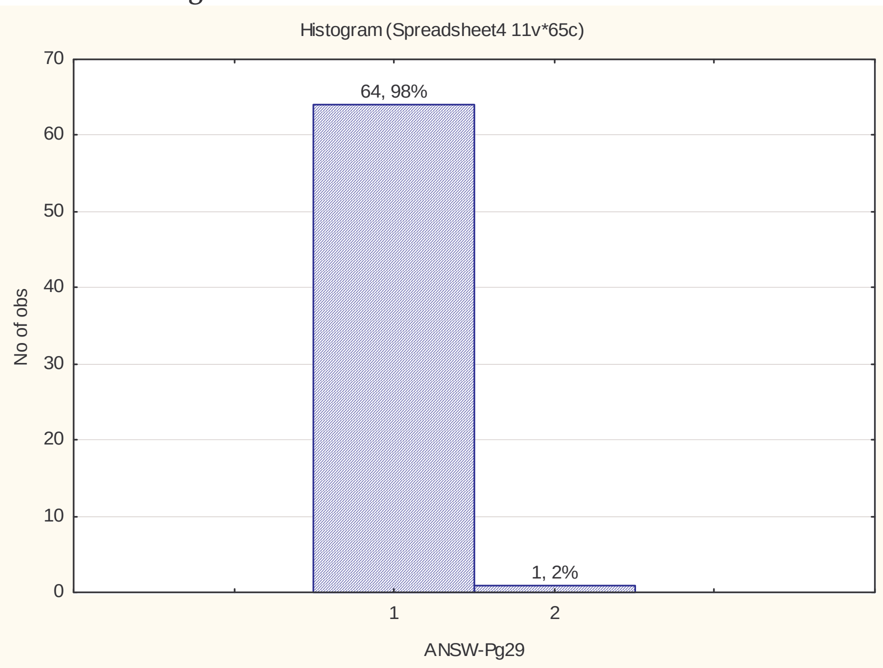
3.7 ANSW-Pg27



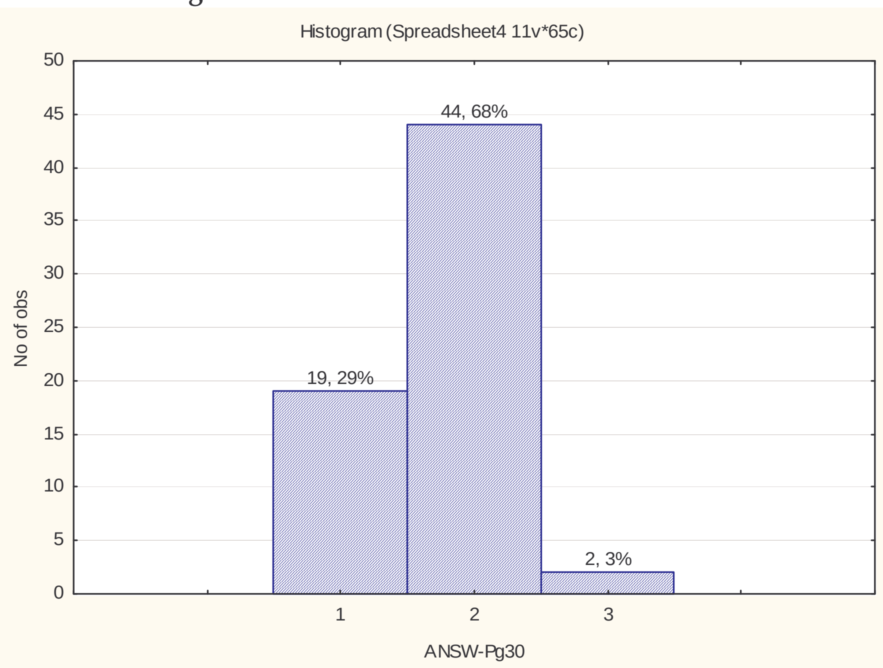
3.8 ANSW-Pg28



3.9 ANSW-Pg29

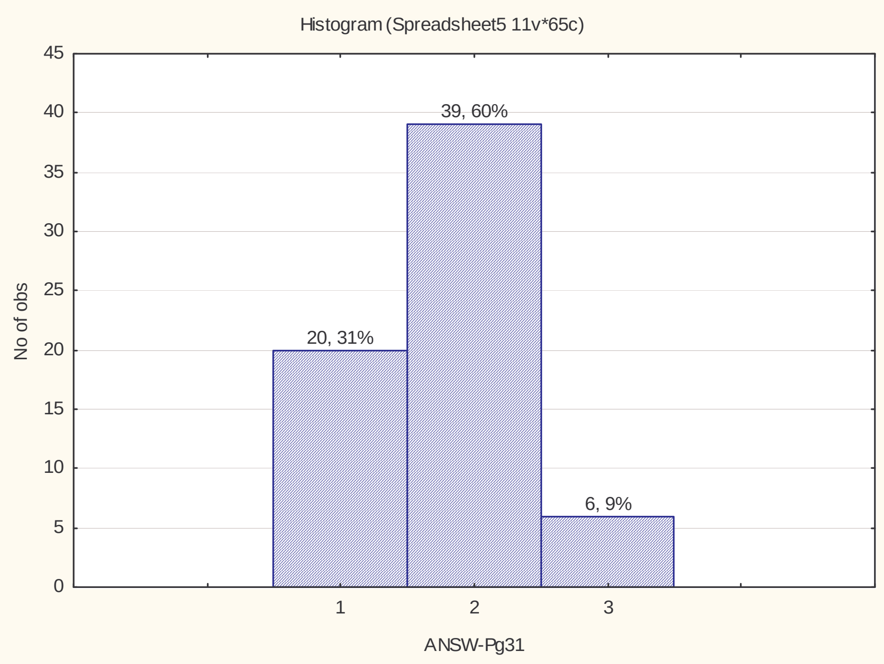


3.10 ANSW-Pg30

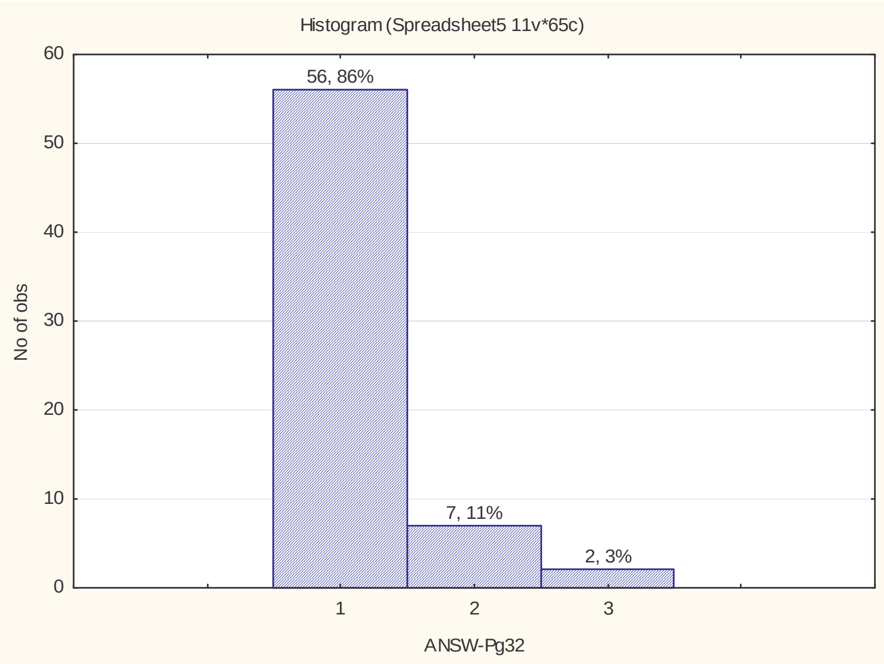


4 test1O

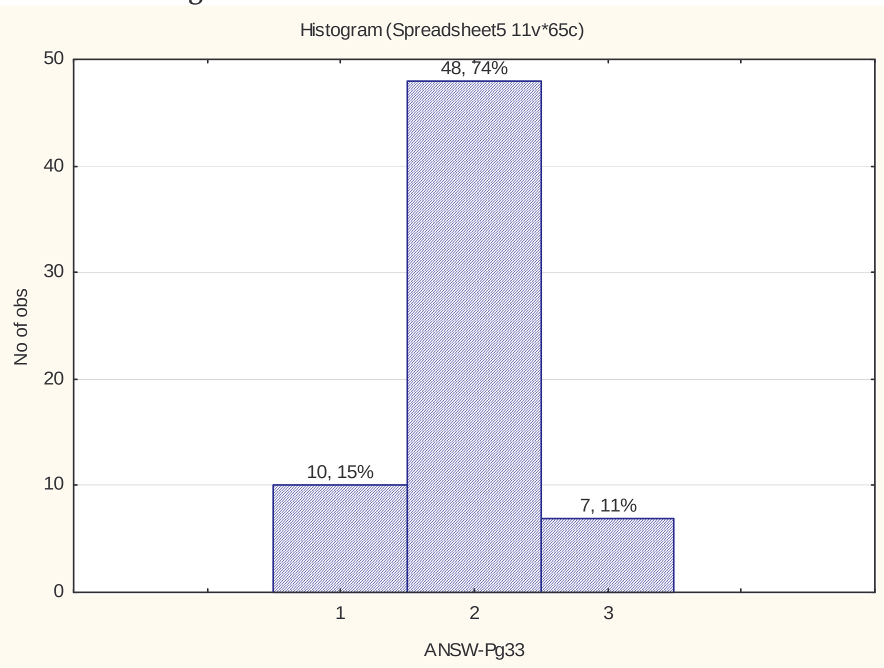
4.1 ANSW-Pg31



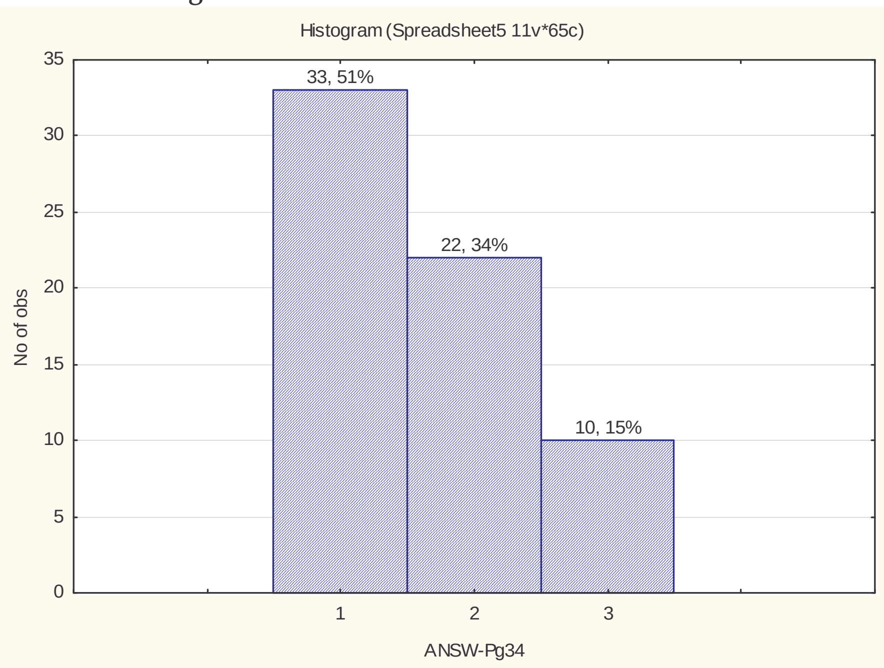
4.2 ANSW-Pg32



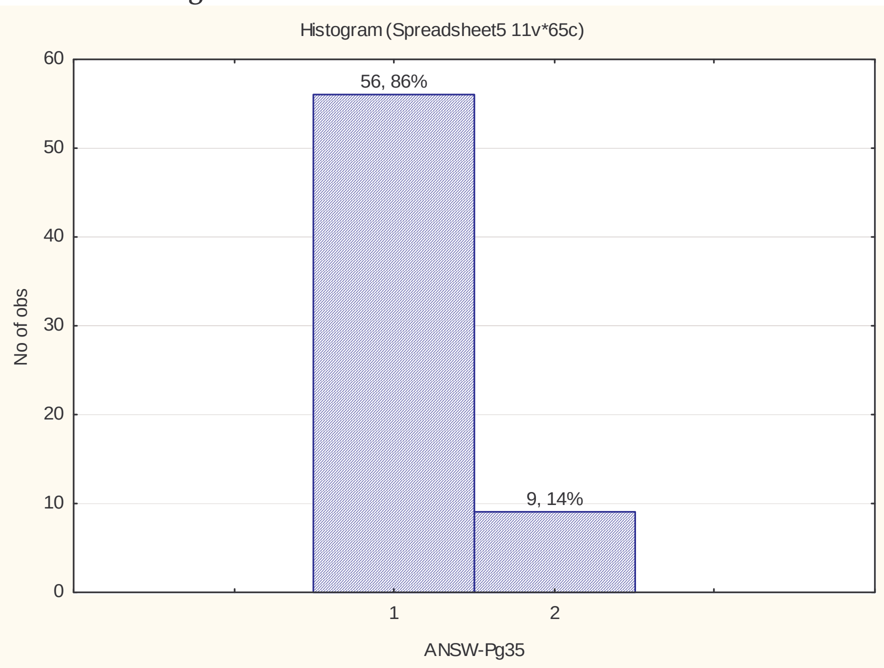
4.3 ANSW-Pg33



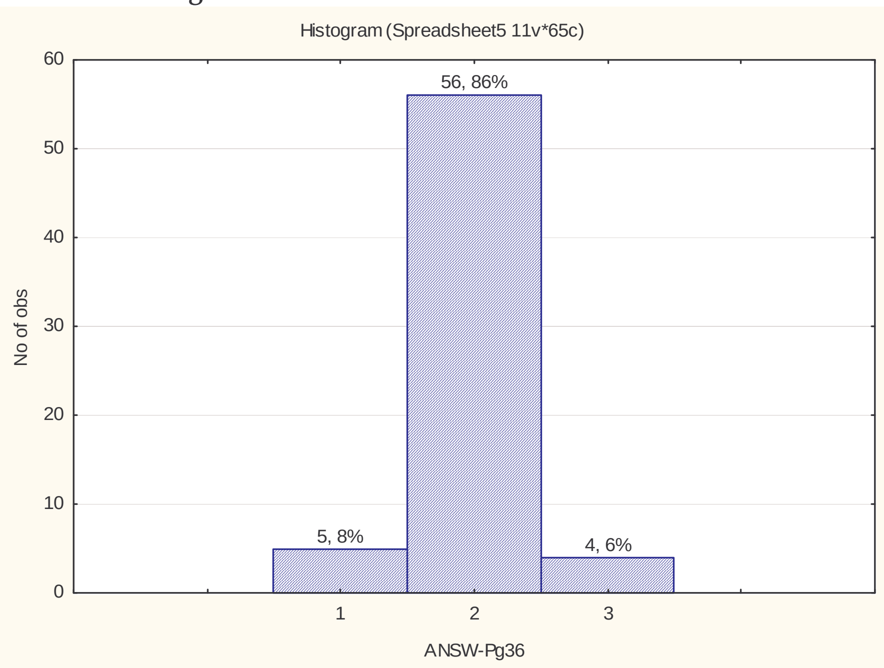
4.4 ANSW-Pg34



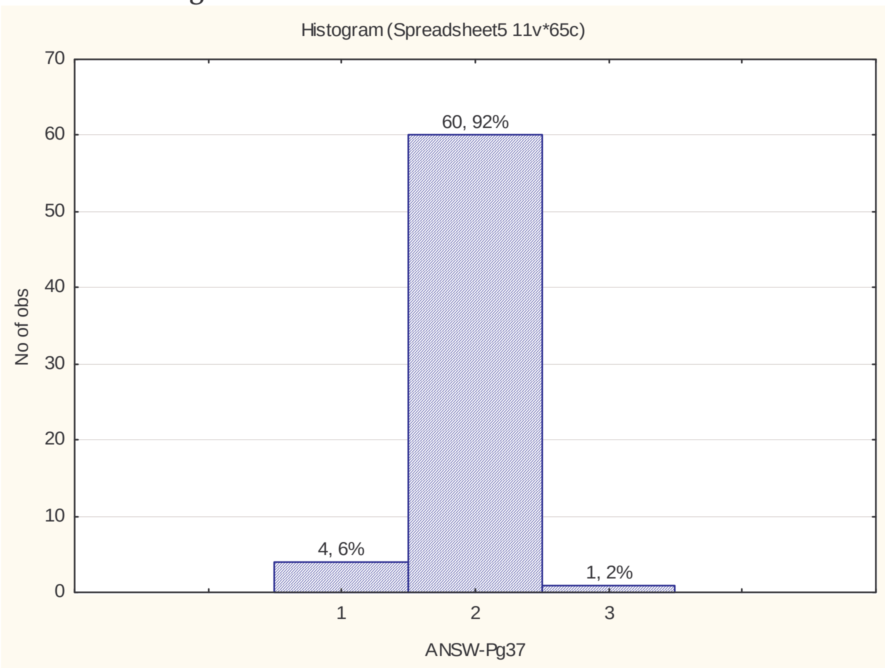
4.5 ANSW-Pg35



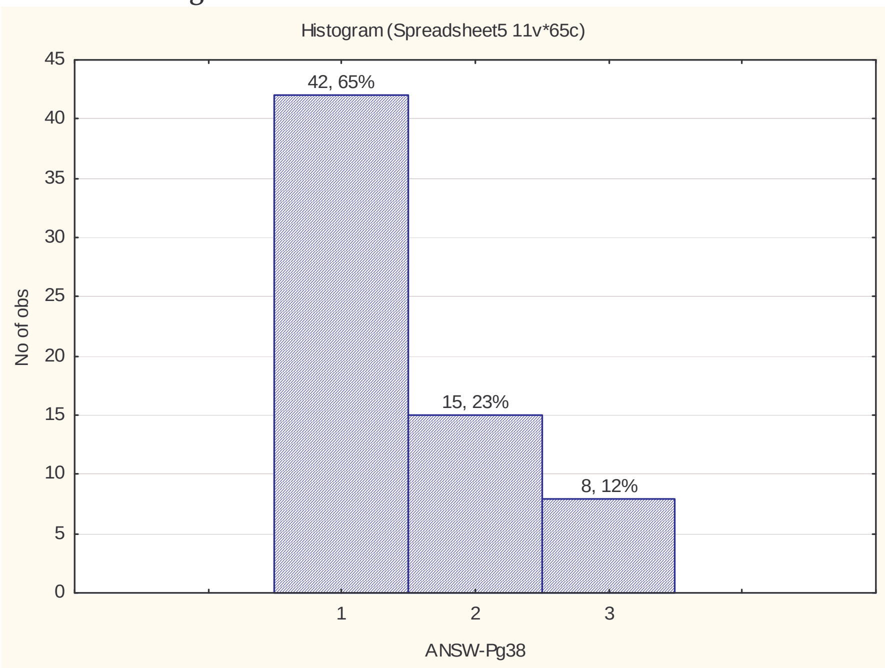
4.6 ANSW-Pg36



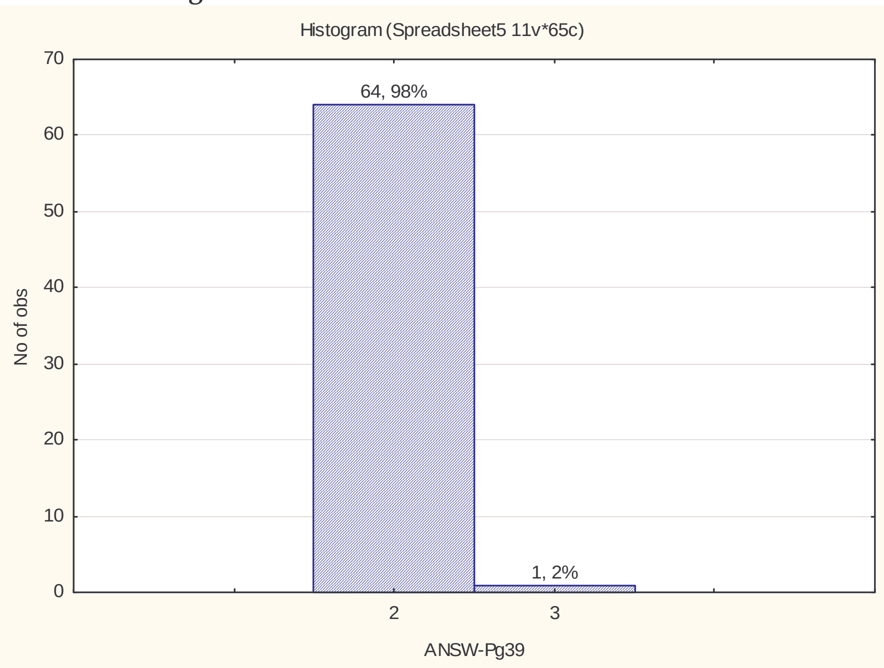
4.7 ANSW-Pg37



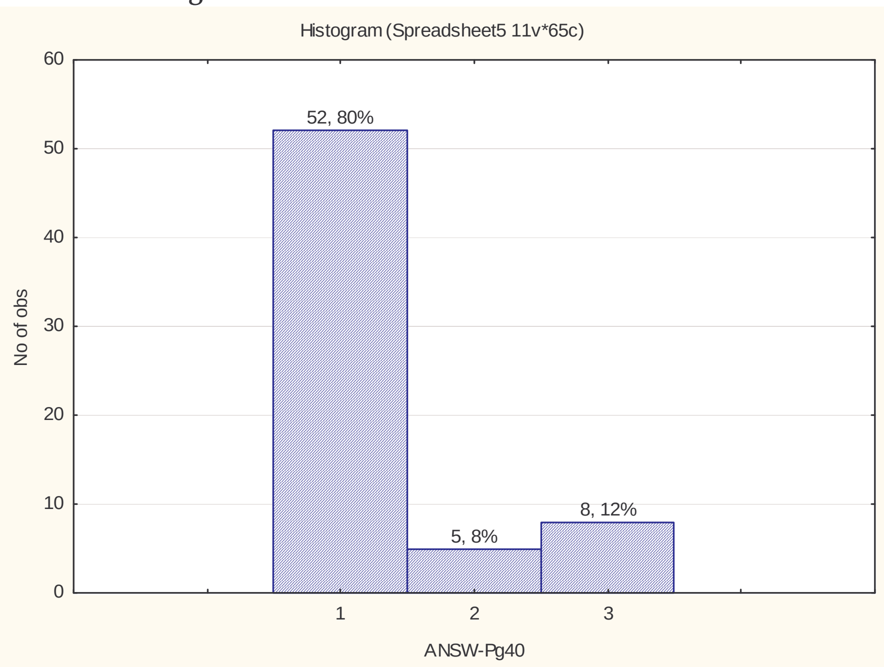
4.8 ANSW-Pg38



4.9 ANSW-Pg39

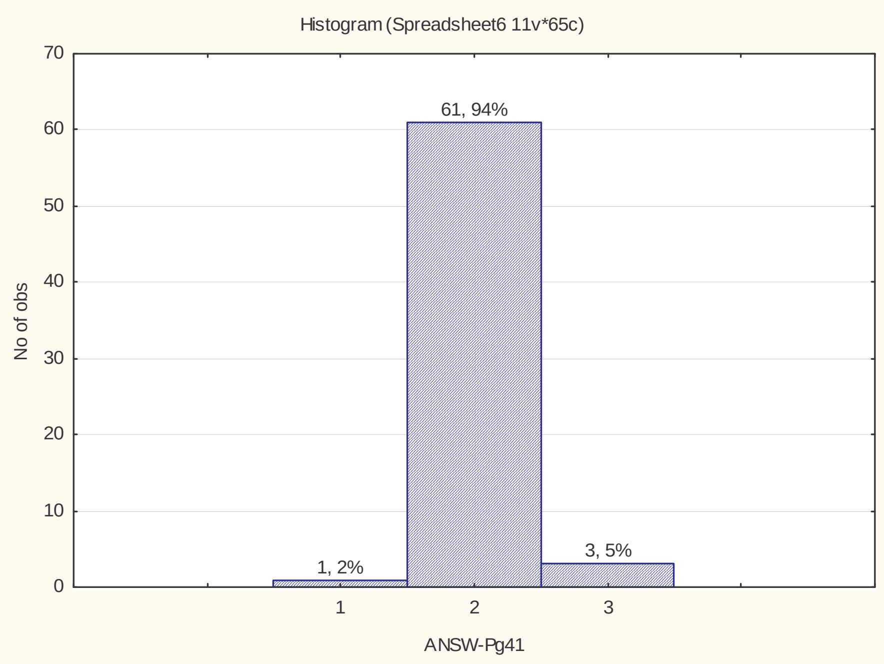


4.10 ANSW-Pg40

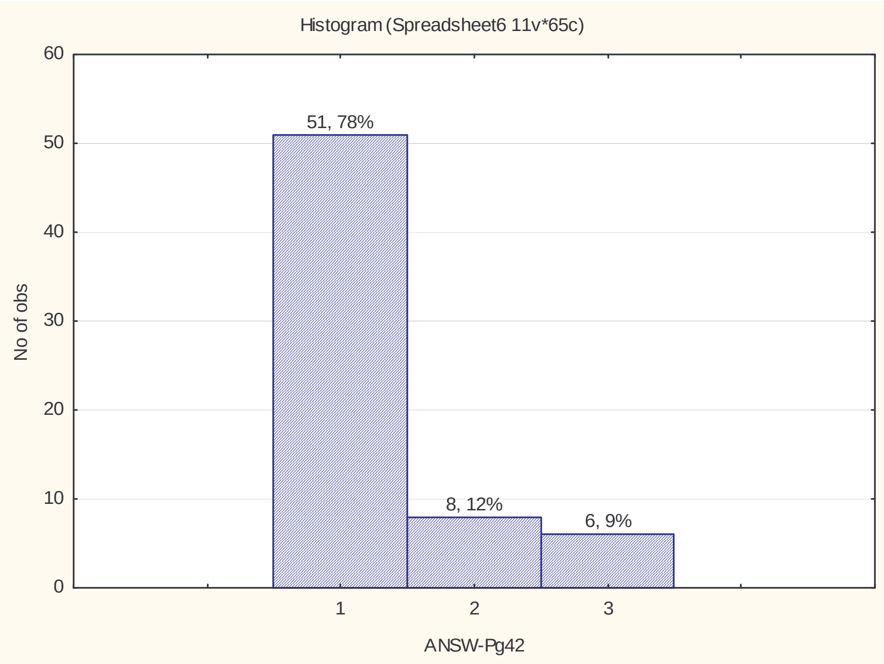


5 test1U

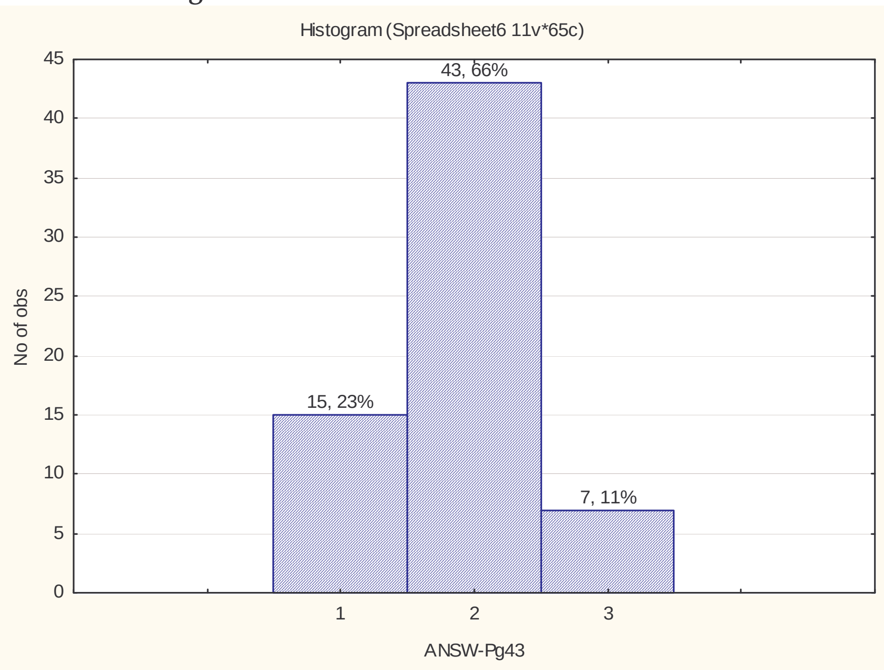
5.1 ANSW-Pg41



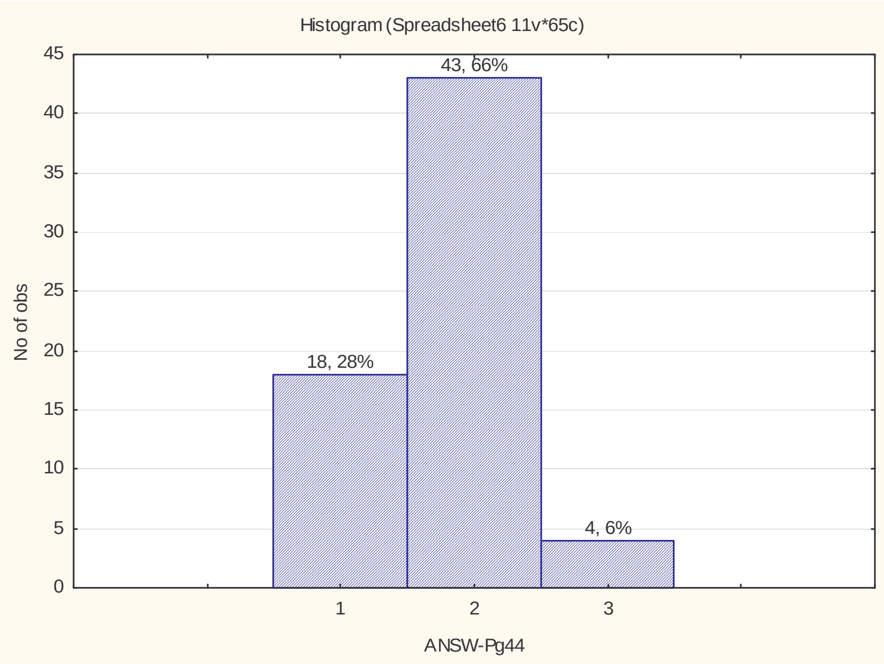
5.2 ANSW-Pg42



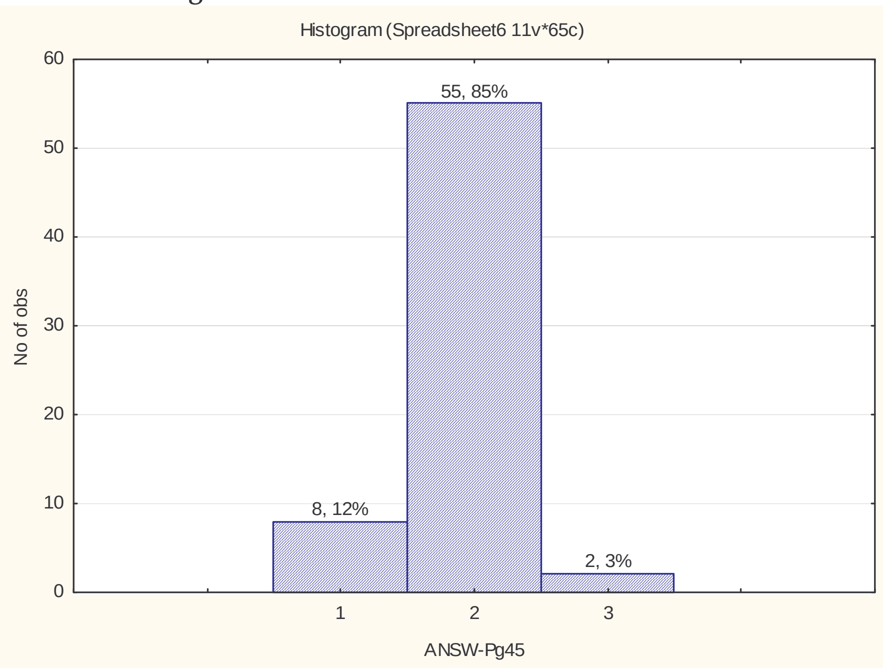
5.3 ANSW-Pg43



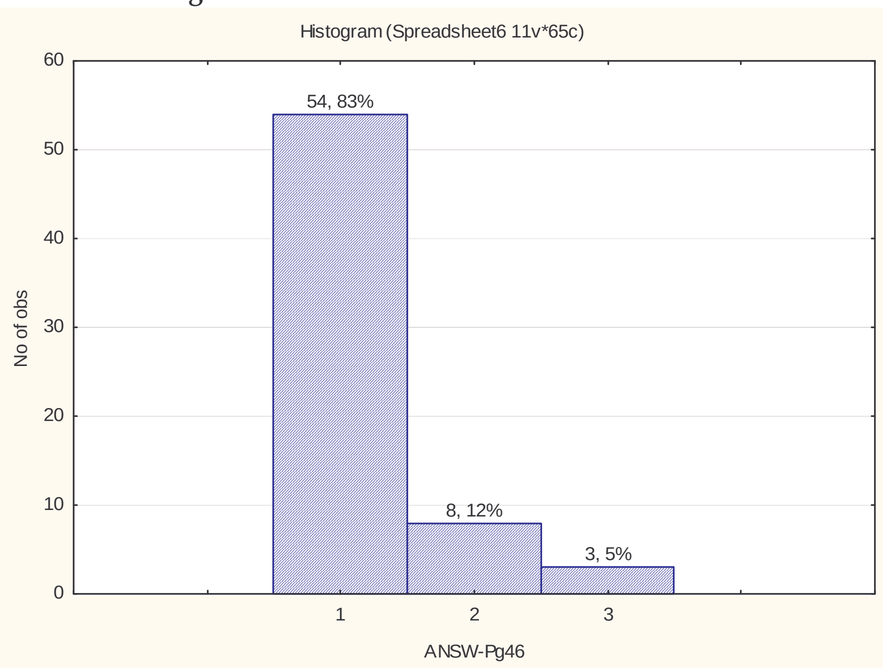
5.4 ANSW-Pg44



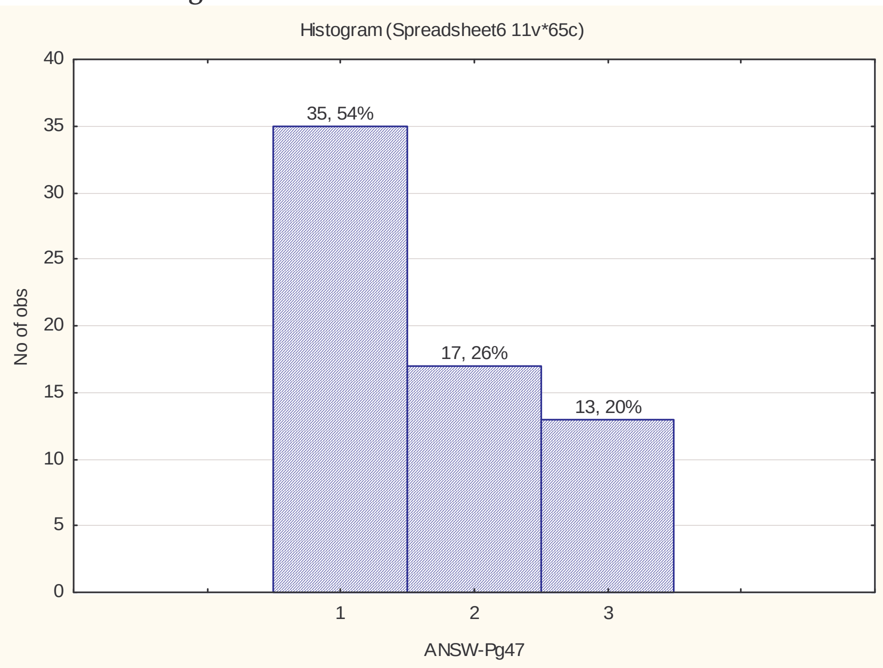
5.5 ANSW-Pg45



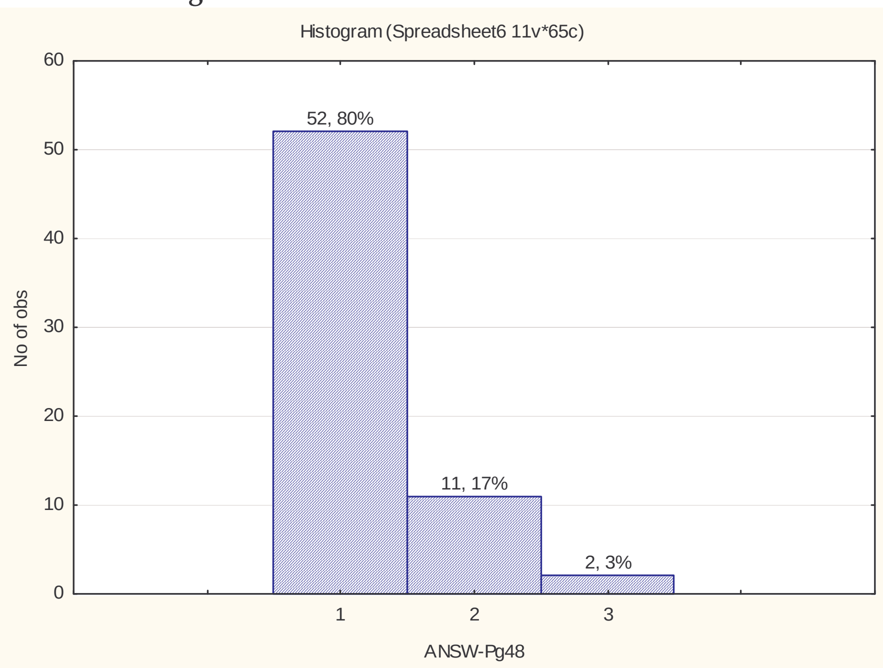
5.6 ANSW-Pg46



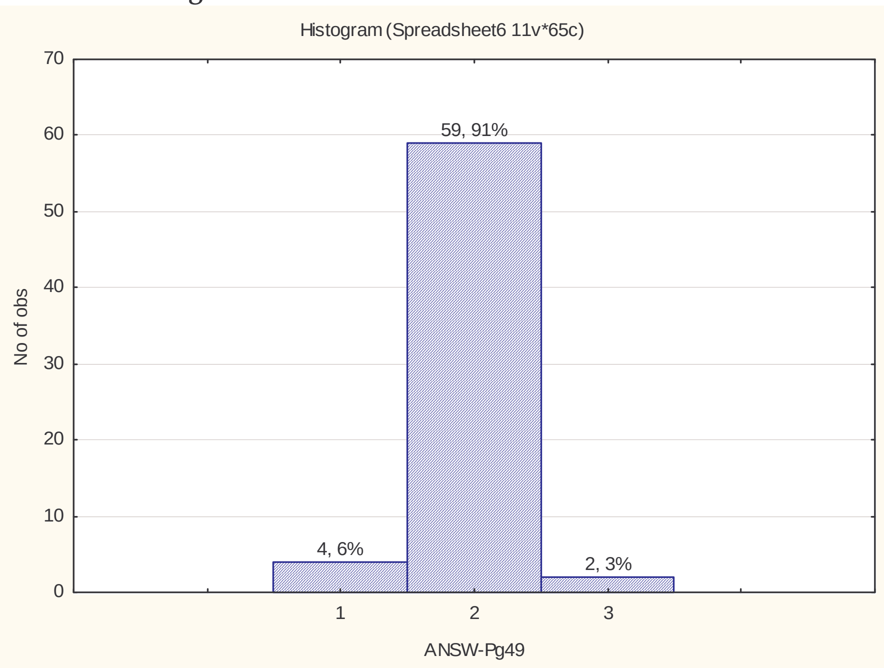
5.7 ANSW-Pg47



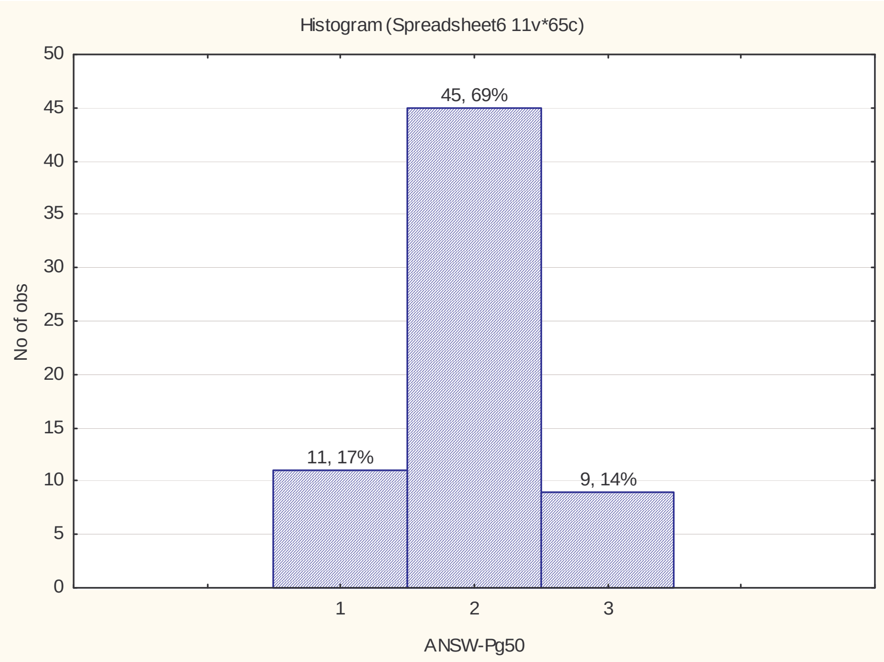
5.8 ANSW-Pg48



5.9 ANSW-Pg49

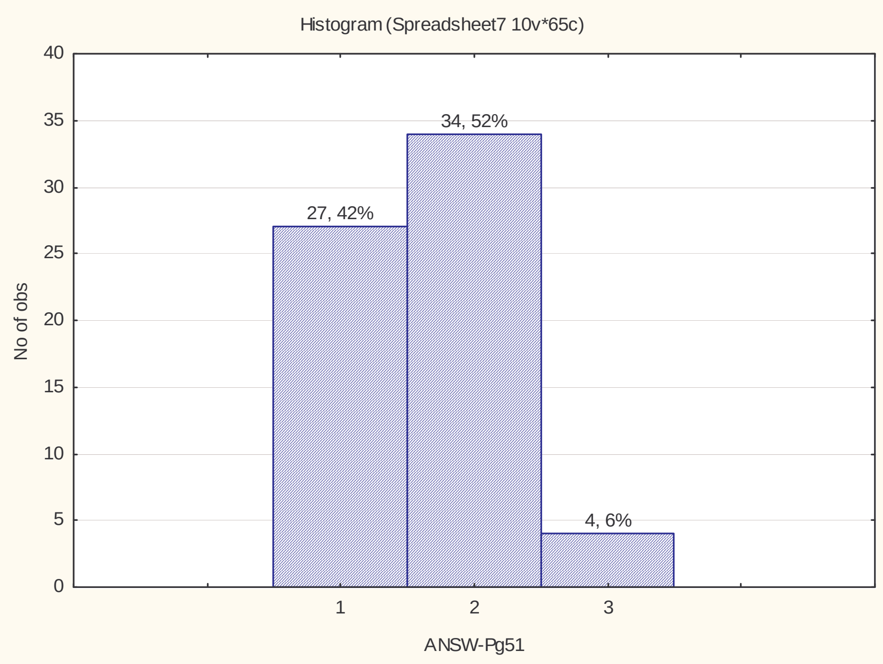


5.10 ANSW-Pg50

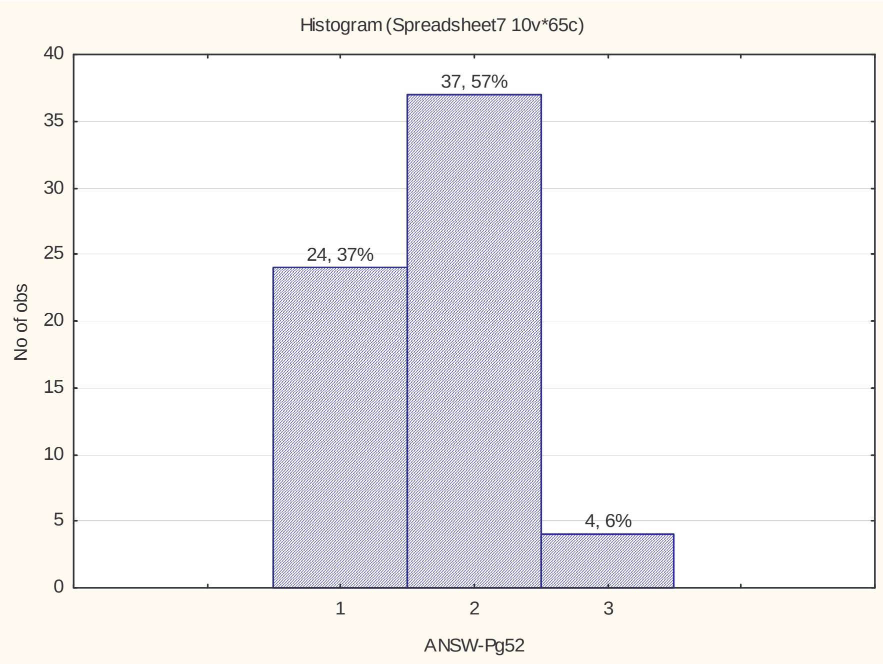


6 test2

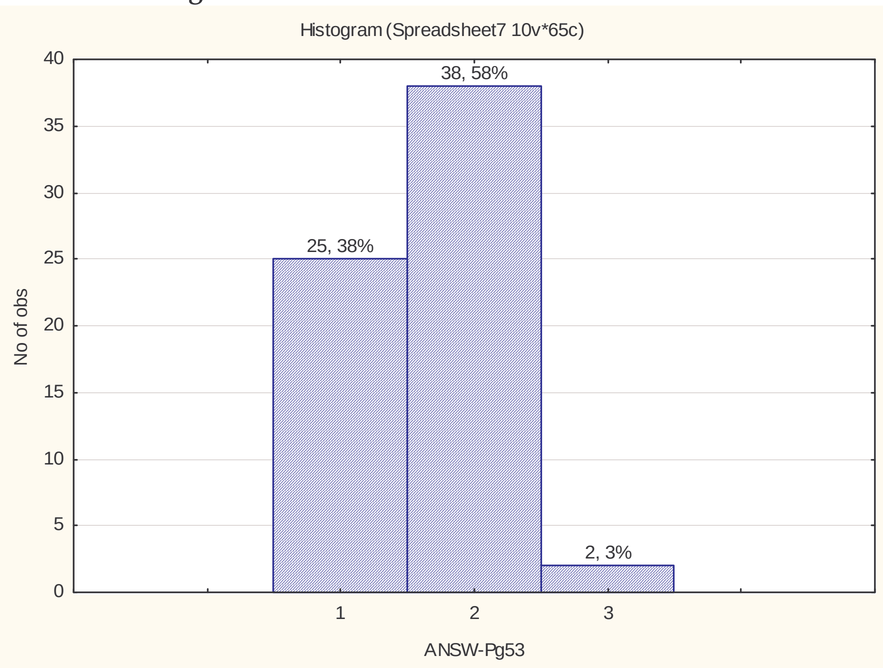
6.1 ANSW-Pg51



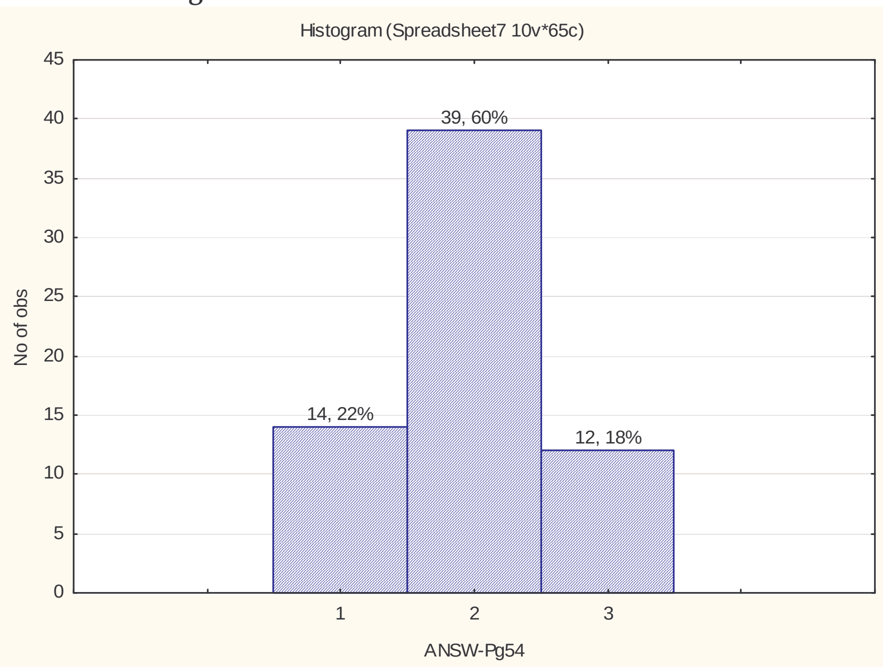
6.2 ANSW-Pg52



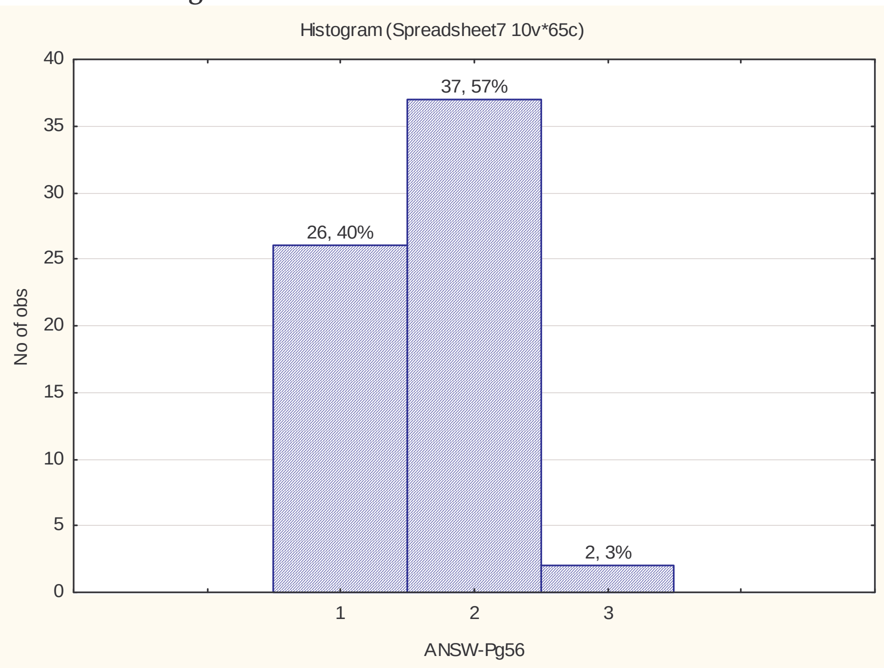
6.3 ANSW-Pg53



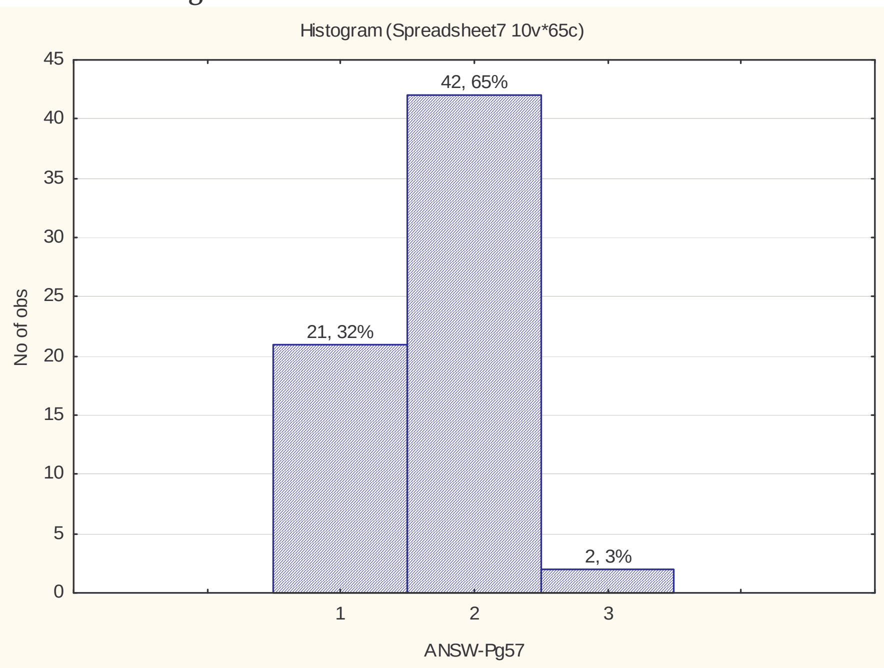
6.4 ANSW-Pg54



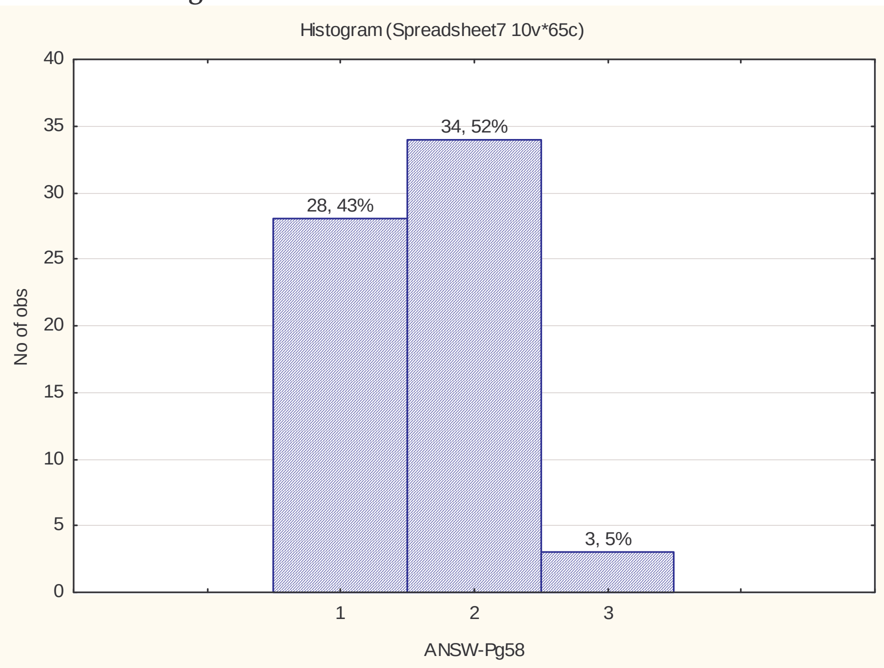
6.5 ANSW-Pg56



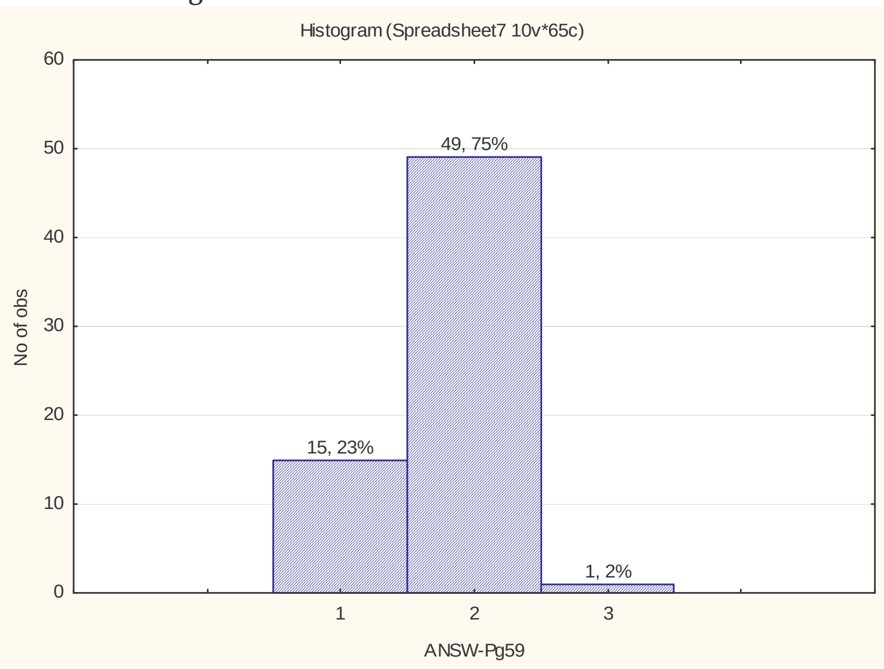
6.6 ANSW-Pg57



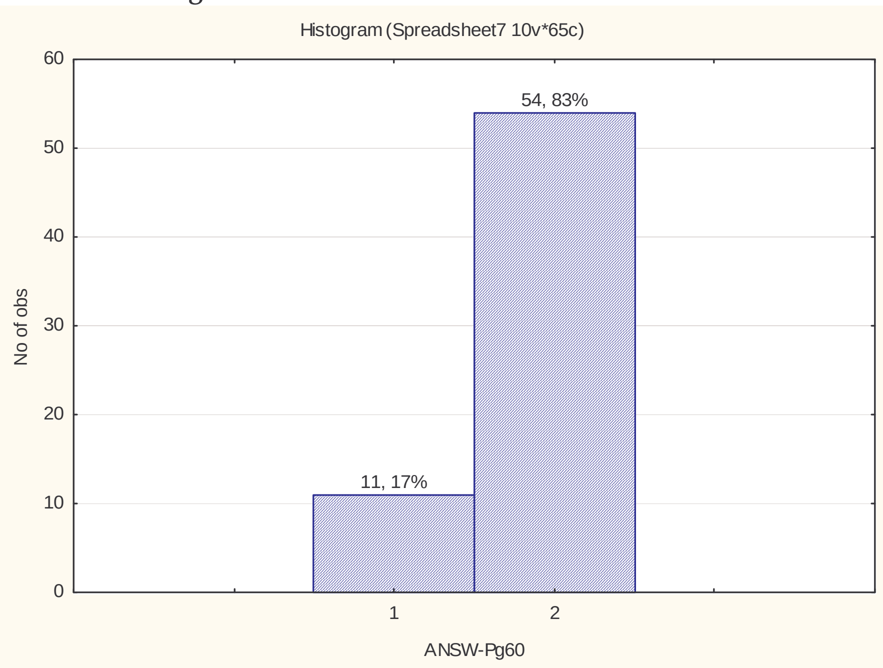
6.7 ANSW-Pg58



6.8 ANSW-Pg59

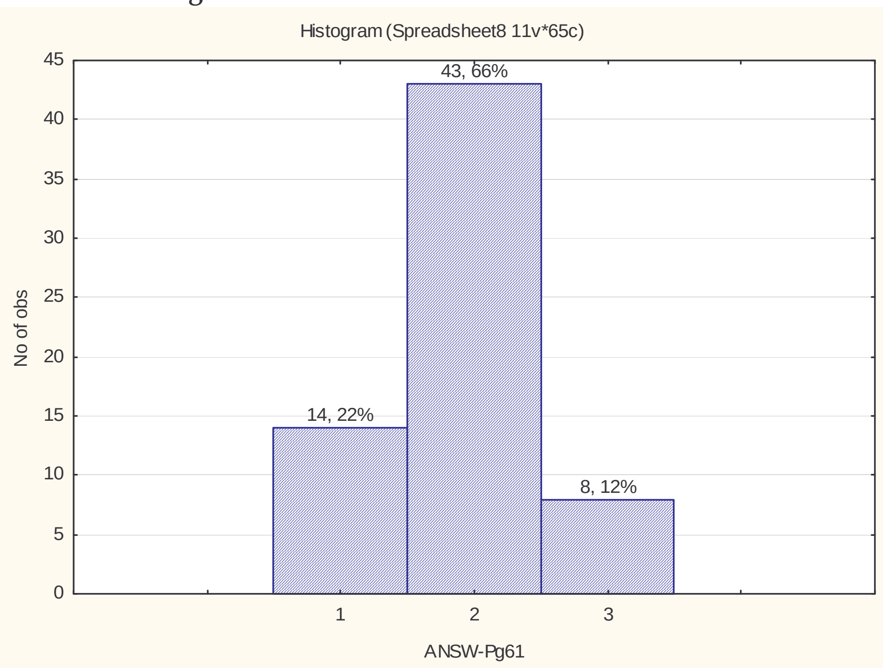


6.9 ANSW-Pg60

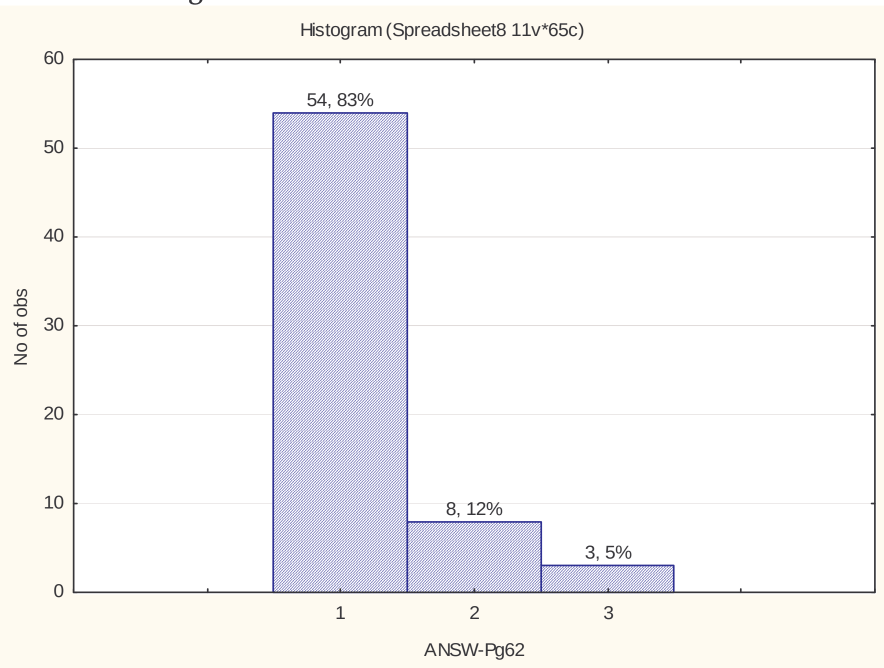


7 test3

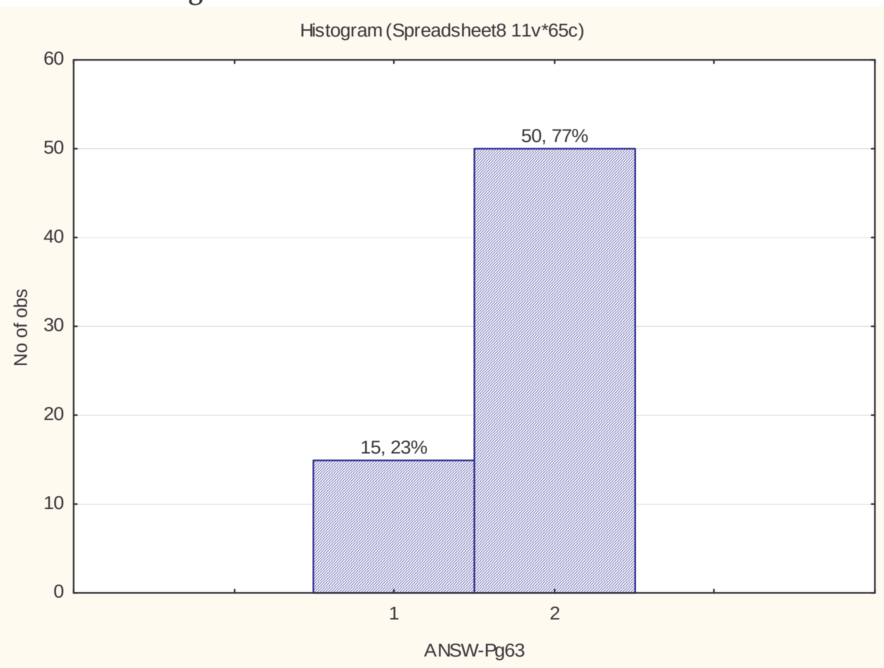
7.1 ANSW-Pg61



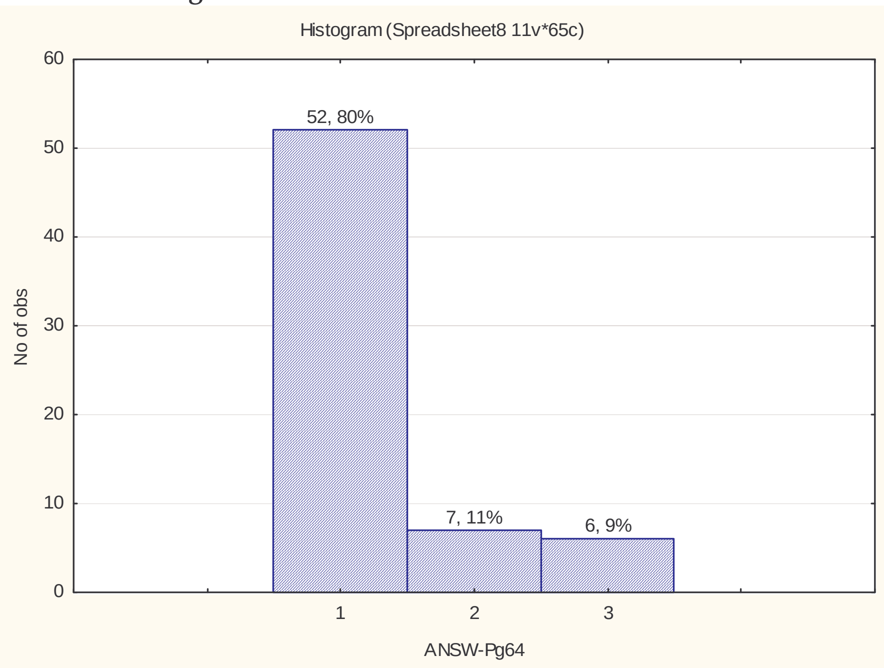
7.2 ANSW-Pg62



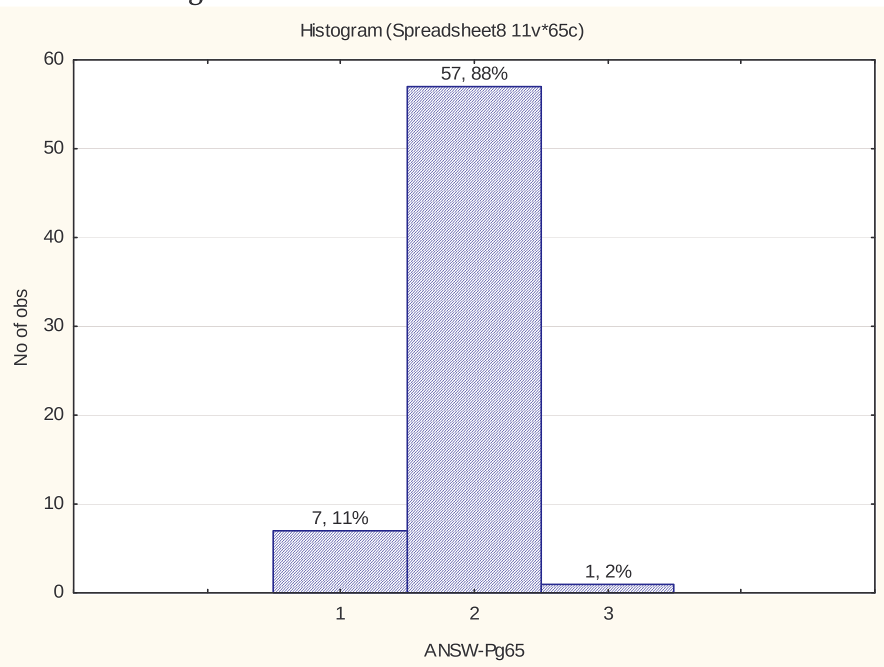
7.3 ANSW-Pg63



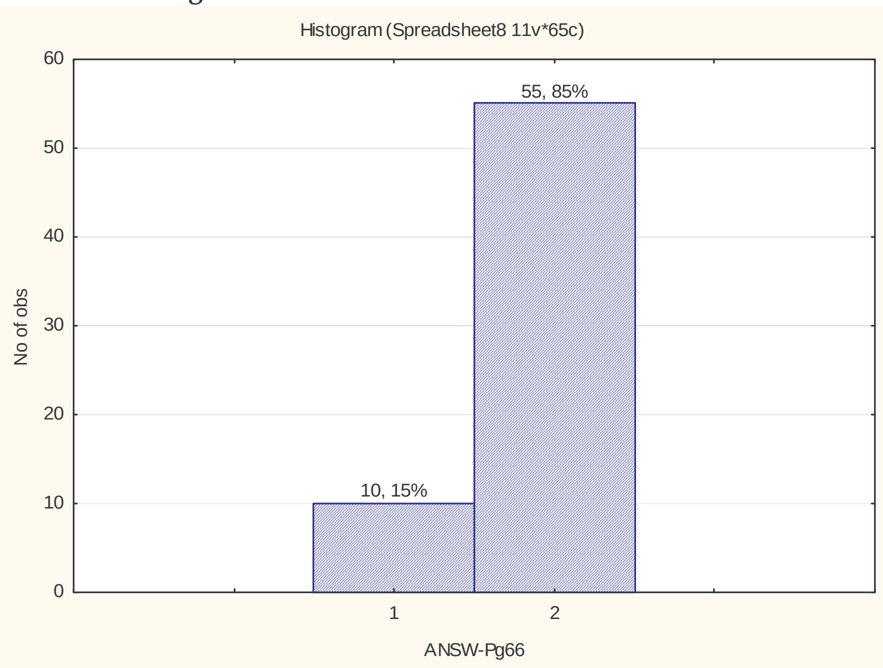
7.4 ANSW-Pg64



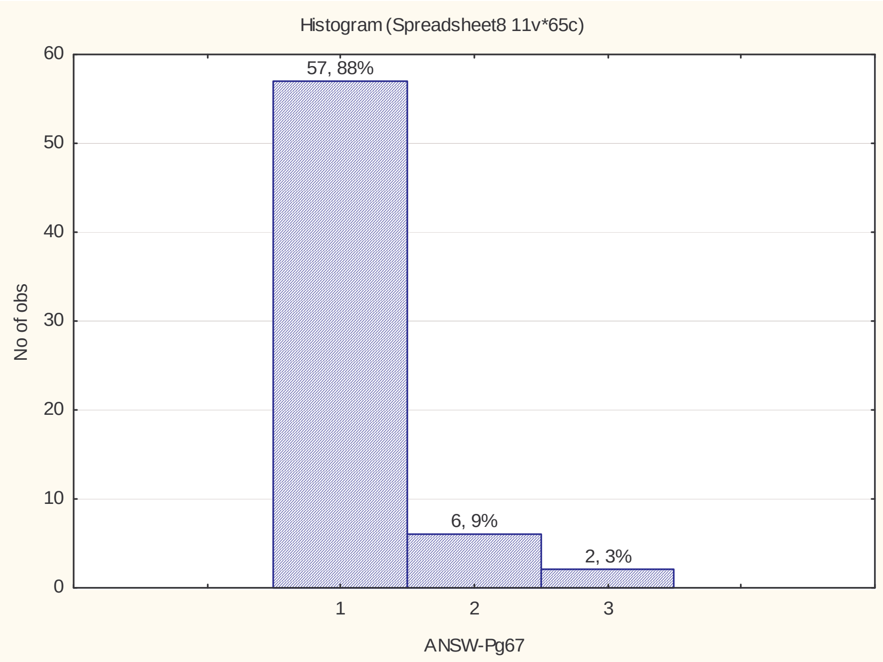
7.5 ANSW-Pg65



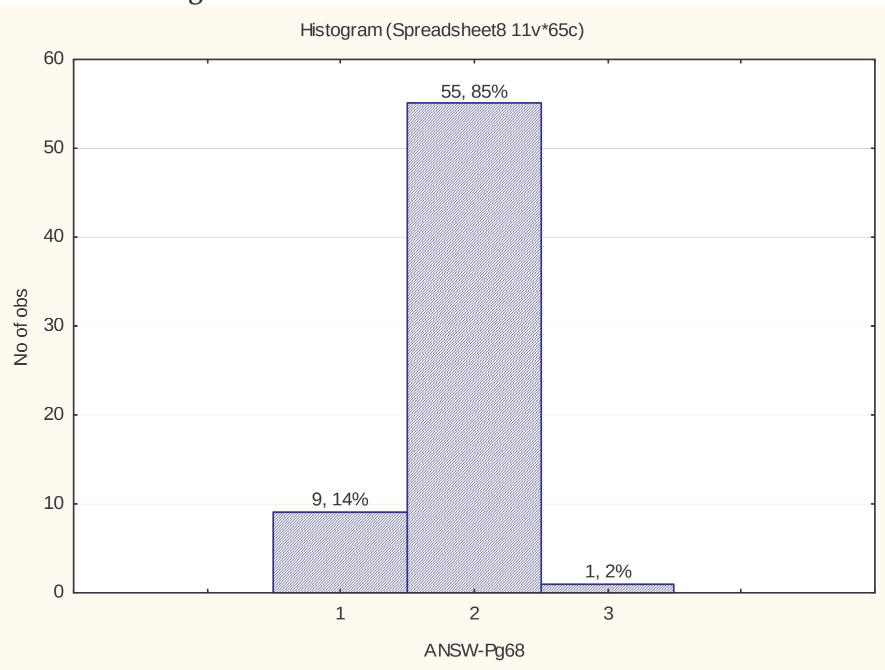
7.6 ANSW-Pg66



7.7 ANSW-Pg67



7.8 ANSW-Pg68



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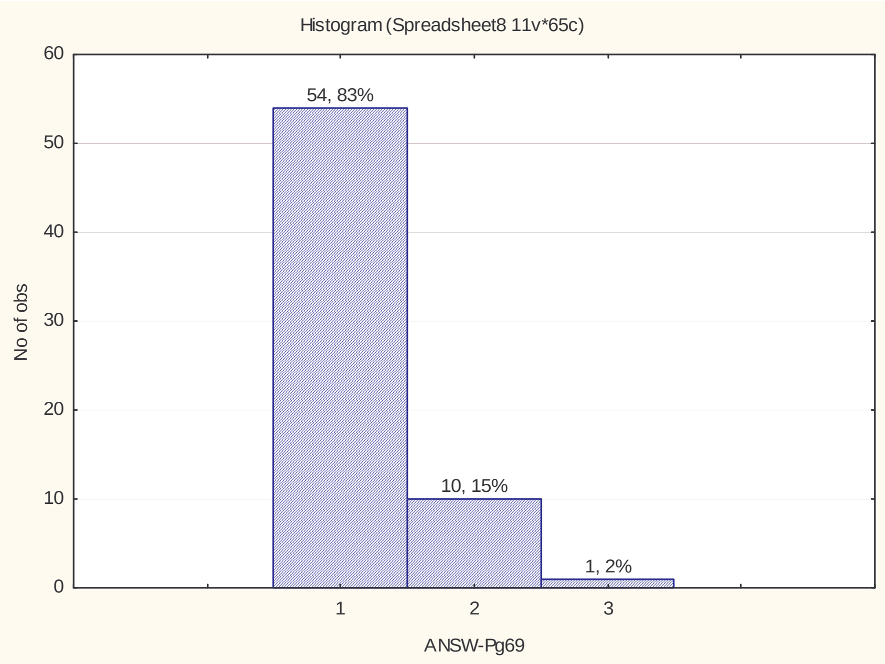
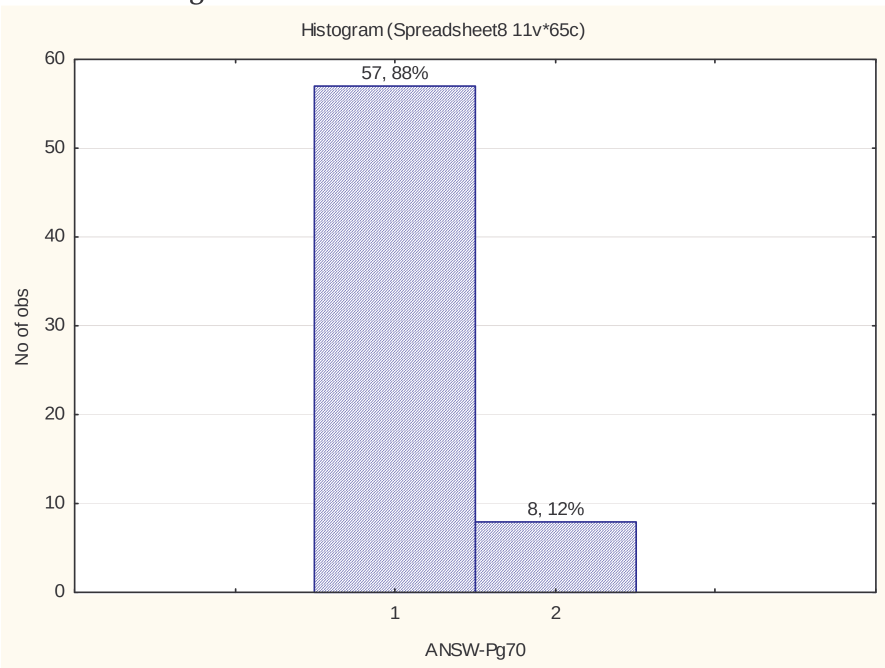


7.10 ANSW-Pg70



Appendix M: Transcription Alphabets: IPA, ASG & OLG

The International Phonetic Alphabet (IPA)

THE INTERNATIONAL PHONETIC ALPHABET (revised to 1993, corrected 1996)

CONSONANTS (PULMONIC)

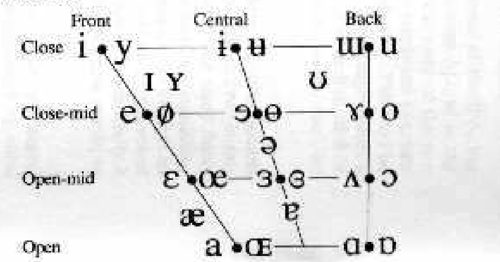
	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap				ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

CONSONANTS (NON-PULMONIC)

Clicks		Voiced implosives		Ejectives	
ʘ	Bilabial	ɓ	Bilabial	ʼ	Examples:
ǀ	Dental	ɗ	Dental/alveolar	pʼ	Bilabial
ǃ	(Post)alveolar	ʄ	Palatal	tʼ	Dental/alveolar
ǂ	Palatoalveolar	ɠ	Velar	kʼ	Velar
ǁ	Alveolar lateral	ʛ	Uvular	sʼ	Alveolar fricative

VOWELS



Where symbols appear in pairs, the one to the right represents a rounded vowel.

OTHER SYMBOLS

ʍ Voiceless labial-velar fricative
w Voiced labial-velar approximant
ɥ Voiced labial-palatal approximant
ʜ Voiceless epiglottal fricative
ʢ Voiced epiglottal fricative
ʡ Epiglottal plosive
ɕ ʑ Alveolo-palatal fricatives
ɺ Alveolar lateral flap
ɧ Simultaneous ʃ and x

Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary. k͡p t͡s

DIACRITICS Diacritics may be placed above a symbol with a descender, e.g. ŋ̊

Voiceless	n̥ d̥	Breathy voiced	b̤ a̤	Dental	t̪ d̪
Voiced	s̬ t̬	Creaky voiced	b̰ a̰	Apical	t̺ d̺
Aspirated	tʰ dʰ	Linguolabial	t̼ d̼	Laminal	t̻ d̻
More rounded	ɔ̹	Labialized	tʷ dʷ	Nasalized	ẽ
Less rounded	ɔ̜	Palatalized	tʲ dʲ	Nasal release	dⁿ
Advanced	u̟	Velarized	tˠ dˠ	Lateral release	dˡ
Retracted	e̠	Pharyngealized	tˤ dˤ	No audible release	d̚
Centralized	ë	Velarized or pharyngealized	ɫ		
Mid-centralized	e̽	Raised	e̝ (ɹ̝ = voiced alveolar fricative)		
Syllabic	n̩	Lowered	e̞ (β̞ = voiced bilabial approximant)		
Non-syllabic	e̯	Advanced Tongue Root	e̘		
Rhoticity	ɚ a˞	Retracted Tongue Root	e̙		

SUPRASEGMENTALS

ˈ Primary stress
ˌ Secondary stress
ˌfoʊnəˈtɪʃən
ː Long eː
ˑ Half-long eˑ
˘ Extra-short ĕ
| Minor (foot) group
‖ Major (intonation) group
. Syllable break ɹi.ækt
‿ Linking (absence of a break)

TONES AND WORD ACCENTS

LEVEL		CONTOUR	
e̋ or ˥	Extra high	ě or ˩˥	Rising
é ˦	High	ê ˥˩	Falling
ē ˧	Mid	e᷄ ˦˥	High rising
è ˨	Low	e᷅ ˩˨	Low rising
ȅ ˩	Extra low	e᷈ ˧˦˧	Rising-falling
↓	Downstep	↗	Global rise
↑	Upstep	↘	Global fall

Alphabet Scientifique des Langues Gabonaises (ASG)/ *Scientfic Alphabet for Gabonese languages*, 1990

Vowels		Consonants				Tones	
Small	*Capital*	*S*	*C*	*S*	*C*	*Signs & Denominations*	
a	A	b	B	n	N	ȍ	infra-low
ə	Ǝ	c	C	ŋ	ŋ	v̀	low
e		d	D	p	P	v̄,	medium
ɛ		ð	Đ	r	R	v́	high
i	E	f	F	ɍ	Ʀ	v̂	falling
ɔ	ɛ	g	G	s	S	v̌	rising
o	I	ɣ	ɣ	ʃ	ʃ	v̋	very high
u	ɔ	h	H	t	T	v̇	high lowered
ṳ	O	ʒ	ʒ	v	V	v̋̂	very high falling
	U	j	J	β	β		
	Ṳ	k	K	w	W		
		ʔ	ʔ	w̤	W̤		
		l	L	x	X		
		m	M	y	Y		
				z	Z		

Diacritics	
Signs et Use	
v̰	tilde for nasal vowels
v̮	very short vowels
v̤	palatalization
ꝟ	centralization

Digraphs		
ny	mb	ts
ty	nd	dz
dy	ŋg	aa
kw	kp	oo
tw	gb	ee

Orthographe des Langues Gabonaises (ASG)/ *Orthography for Gabonese languages*, 1999

Vowels		Tones		Consonants		
Signs / realizations		*Signs / denominations*		*Monographs*		*Digraphs*
a		´	high	b	m	gh
e		`	low	c [tʃ]	n	[ɣ]
e̲	[ɛ]	¯	medium	d	n̲[ŋ]	jh
ə		ˆ	falling	d̲[ð]	p	[ʒ]
i		ˇ	rising	f	r	sh
o				g	s	[ʃ]
o̲	[ɔ]			h	t	vh
u				j	v	[β]
u̲	[y]			k	w	ny
				l	y[j]	[ɲ]
					z	

Appendix N: **Candidate's Biography**

Hugues Steve NDINGA-KOUMBA-BINZA is a researcher at the Stellenbosch University Centre for Language and Speech Technology (SU-CLaST). He is the author of 5 papers published, and of another currently in press in peer-reviewed accredited journals. He also has 5 contributions in various books, two have been published and the others are currently in press. He is also the author of a number of creative writings and poetry (http://13751719.blogmilitant.com). He has presented academic papers at both national and international levels (South Africa, Gabon, Lesotho, Botswana, Netherlands and France) and read his poems at various local festivals.

He holds a *Baccalauréat Série B* (Economic and Social Sciences) from Nelson Mandela Application High School of Libreville, Gabon (1996). He obtained the *Diplôme Universitaire d'Etudes Littéraires* (DUEL) in 1998, the *Licence ès Lettres* in 1999, and in 2000 the *Maîtrise ès Lettres* in Language Sciences (specializing in African linguistics) at Omar Bongo University in Libreville, Gabon.

After learning English for a year at Stellenbosch (2001-2002), he served as group leader for international students at the International Office of Stellenbosch University (2001-2003), research assistant to the Director of SU-CLaST (2004-2005), lecturer at the Department of Modern Foreign Languages (French Section, 2004-2005), Chairperson of the Gabonese Research & Scientific Discussion Group (GRSDG, 2003-2005), Chairperson of the Association of Gabonese Student at the University of Stellenbosch (2005-2006) and IT Manager of the Stellenbosch University Poetry Society (SUPS, 2007-2008).

He currently serves as Chairperson of the High Council of the GRSDG as well as:

- Member of the Evaluation Committee of the Quebec Student Journal in Linguistics;
- Member of the African Language Association of Southern Africa (ALASA);
- Member of the African Association for Lexicography (AFRILEX),
- Founding member of the GRSDG, and
- Founding member of the SUPS.

Hugues Steve Ndinga-Koumba-Binza is registered as African intellectual and academic with the Association of African Universities (AAU).