T H E   P H O N E T I C S   O F   M A L T E S E :

Some Areas Relevant to the Deaf

Marie Azzopardi

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'If seven maids with seven mops
    Swept it for half a year,
Do you suppose', the Walrus said
    'That they could get it clear?'
'I doubt it', said the Carpenter,
    And shed a bitter tear.

Carroll,
'Through The Looking Glass'.

To
my father
who died last year

and

To
my mother

A B S T R A C T

This thesis deals with some aspects of Maltese Phonetics that are important as the groundwork of a general phonetic study as well as for the application to deaf pedagogy. The thesis is divided into five parts.

The first part is an introduction. It presents some background information on the language studies and the context in which the speakers of Maltese must be considered. It also introduces the basic framework for the study presented here, together with other introductory considerations regarding the informants used and the experimental situation involved. The second chapter in this first part deals with the relationship between the orthographical system of Maltese and phonetics in the light of possible biases of previous analyses towards more writing-speaking correspondences than actually exist.

The second part deals with the phonological system of Maltese. It presents a phonemic analysis of Maltese that is more phonetically-based than previous phonemic analysis. (Chapter 3.) It also presents a modification of the transcriptional conventions so far used for Maltese vowel phonemes, based on the phonetic analysis presented later in the thesis. Chapter 4 discusses the use of the syllable in linguistic descriptions of Maltese, establishes the syllable structure(s) of Maltese, and studies the distributional characteristics of the consonant phonemes.

The third part deals with vowels. It is divided into 4 chapters. There is an auditory and articulatory description of Maltese vowels in the first chapter, supported by spectrographic and electrokymographic evidence. The duration of vowels is also investigated (chapter 6). Chapter 7 includes an acoustic study using spectrography for instrumental evidence. Chapter 8 describes and discusses an experiment testing native speaker perception of the quality and duration of vowels in Maltese.

The fourth part is a study of consonants: the allophonic variants of the consonant phonemes are described in terms of their places of articulation, their manner of articulation and their voicing characteristics. This description is based upon electrokymographic investigations as well as impressionistic phonetic observation. A study of consonant duration concludes this part.

The fifth part is a study of the visible patterns of Maltese. This part is introduced by a review of other relevant studies made in different languages and of the terminology used in this respect in traditional phonetics. There are two main chapters: the first is a study of the visible patterns in prolonged articulation using still photography; the second is a study of visible patterns in connected speech using cinematography as the investigatory technique. These two studies are interrelated. Together, they constitute an investigation of the parameters relevant in a study intended as a basis for the application of lip-reading methodology.

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D E C L A R A T I O N

This thesis is my original work and of my own execution and authorship

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PART I : INTRODUCTION

CHAPTER 1.

Background to the Study.

1.1. Background to the language under investigation

Maltese is a Semitic language spoken by about 333,000 people in Malta and Gozo, as well as by about the same number of people in emigrant communities abroad. Aquilina calls it:

> "a separate language resulting from the interaction and fusion of North African Arabic, but with its own dialect features outside the North African group, and Siculo-Italian, covering two different cultural strata" (Aquilina 1959, p.73, Preface)

Maltese is not mutually intelligible with any Arabic or Italian dialect at a normal conversational level. Maltese has developed very distinctive traits of its own, especially in its development of a larger vowel system than Arabic, and a consonant system that fuses the Semitic and Romance origins (cf. Borg 1978).

There are various Maltese dialects spoken throughout the islands. These are identifiable geographically. They are marked by both systemic and realizational differences in the vowel system and by similar but more limited differences in the consonantal system. The main systemic differences in the consonant systems are the use of the /k/ and /ʔ/ phonemes in some dialects, and the use of only /k/ by other dialects, realised as [k] or as [q̠]. Other realizational differences involve more advanced front consonants or more retracted ones, and various realisations of the phonemes /h/ and /r/. The dialects also differ in their suprasegmental characteristics. These dialectal variations will not be dealt with since I am concerned here solely with Standard Maltese. All of the Maltese dialects are fully intelligible to the speakers of other dialects, however linguistically naive they may be.

Standard Maltese is used by most of the people living in the Valetta area (a very rough geographical area that includes most of the nearby urban areas). It is widely accepted as geographically-neutral and socially-unmarked.

1.2. The Influence of English on Maltese and on the Speakers of Maltese

1.2.1. Bilingualism in Malta

It would be fair to say that the Maltese are bilingual to varying degrees. Every Maltese school-leaver has at least a good enough knowledge of spoken Maltese-English to be able to cope with life on an island whose largest industry is tourism. A few years ago, a much more emphatic and general statement regarding bilingualism would have been appropriate. The tendency now is for the Maltese to use less English than they used to. There are no longer many permanent monolingual British residents on the island subsequent to state policies regarding the British forces who had been living there in influential numbers.

The importance of English as the second official language after Maltese (having replaced Italian in this role) cannot be emphasised enough from a sociolinguistic point of view. It is not so much the actual degree of direct influence on the lexis and syntax of Maltese as the common usage of English alongside with Maltese in a bilingual situation.

Maltese is used for most everyday affairs unless English is needed during occupational activities such as business arrangements and teaching. There is still a large number of people who use both languages interchangeably in normal social and occupational interaction. Both Maltese and English are used as official languages for public administration. Maltese is the language of the Church and the Law Courts; it is used as widely as English in newspapers and broadcasting though not as much in the wider sense for entertainment such as films and the theatre. Its use in the Arts is growing. Several local weekly magazines and journals are now being written in Maltese - a situation very different from that of only a few years ago. There is an increasing number of children's books in Maltese - usually adaptations or translations from books published in English, e.g. The Ladybird Books series, and there is certainly an increasing amount of poetry, drama, and short novels written in Maltese. There is, however, very little material available in Maltese in the way of dictionaries and reference or source books.

Maltese is used alongside with English in street names and the notices in local clubs and organisations. Road signs, however, are usually in English. Of course, a great deal now depends on what allowances the Maltese authorities are prepared to make to maintain a good tourist trade. Such traffic, unless deliberate measures are taken to produce contrary effects, will be favourable to retaining both English and Maltese as the officially acknowledged languages.

The situation could be termed diglossic. In all spoken matters, Maltese is dominant. But English has been maintained as the dominant written language, except for journalistic purposes and the arts where both languages are used. This state of affairs is quite predictable from the geographical situation of the island. The need for an internationally-used language is essential. Historical facts have been instrumental in the choice of that language.

English has also had some direct influence on Maltese in terms of word-importation. English lexical items have been adopted by Maltese, some without adaptation but most are assimilated, at least to some degree, to the Maltese phonological and morphological system. At times, a more-English version of a word exists alongside a more assimilated form. This is the case especially with words used for describing sporting events and technical auto-terms, for example. Thus, we get words like English 'goal' with two plural forms:- /gowlz/ (sometimes /gowls/ in accordance with the voicing rule[1]) and /gowlijiet/; both forms are used and accepted.

1.2.2. Language Policy in Education

English has for many years been the official medium of instruction in both primary and secondary education. In practice, however, Maltese was always used in state primary schools whereas Maltese was not even taught in private primary schools. Books for teaching subjects other than Maltese were only available in English.

The language policy has changed in recent years, so that in state schools, Maltese is becoming the first written language, whereas both Maltese and English are used throughout the primary classes in private schools. Some books on subjects taught in schools are now available in Maltese, but these are still restricted in number and variety. It can be said then, that Maltese has recently been used more widely to the exclusion of English both as a medium of education and as a taught language. The language situation is still in a state of transition. Educators are uncertain about the desirability or otherwise of a good command of either language at the expense of the other.

It was hoped that bilingual fluency would improve as a result of the acquisition of literacy in the first language. Literacy in English has, for many years, preceded or even replaced literacy in Maltese. Unfortunately, because of the sheer economics of the matter, the standard of literacy in Maltese could not be improved compatibly with the fast-changing educational policies during and after secondary school level. The dilemma of teaching secondary school children using English text books and resorting to verbal explanation in Maltese has rather unfavourable results.

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1. See sections 3.5 and 9.7.

1.2.3. The English Used in Malta

The English used in Malta is known as Maltese-English. It is identifiable by a number of characteristics in the same way as are other types of non-British English. The phonetics and phonology of Maltese-English probably mark it more prominently than does its grammar and vocabulary from any type of British English. To give just a few obvious examples, /t/ and /θ/ are not separate phonemes; nor are /d/ and /ð/; vowel weakening does not usually occur in unstressed syllables - at least not to the same extent as it does in English; and the pronunciation of specific words is influenced by the English spelling. The rhythm of Maltese-English is also very different from that of RP. Standard Maltese-English syntax does not differ as noticeably from that of Standard English; but the use of some lexical items is very specific to Maltese-English (for example 'scope' being used as meaning "aim" or "objective"). A description of Maltese-English is outside the scope of this thesis. It should be noted here that recent interest in the subject of Maltese-English was stimulated during the 1976 Conference on Bilingualism, primarily due to Dr. G. Broughton. It is a highly loaded subject, especially because there is still a great deal of controversy regarding the target standard of English used for education. The very existence of such a phenomenon as Maltese-English is itself still a question in the minds of many Maltese educators today.

1.3.1. The Informants

The near-non-availability of native speakers of Maltese in Edinburgh constituted a serious problem in the present study, when tape-recorded material was not adequate. The main bulk of the general description and auditory analysis, as well as of the data for the speech synthesis experiment described in chapter 8 was based on recordings of three adult male speakers and myself.

The informants are all adults with similar educational backgrounds, living in the same area. They learnt to read and write in English first. Their writing and reading in Maltese followed by quite a few years. They are exposed to a great deal more written English than Maltese. Although their use of spoken Maltese vastly overrides their use of spoken English, the reverse is easily the case where the written medium is involved. They would all unhesitatingly write to me in English at any level of formality and would probably choose to read the English version of any official notice or document since such a choice is still available.

Using such a small number of informants is, of course, a very limiting factor when it comes to drawing conclusions. However, I consider it quite valid to analyse data obtained from four informants whose speech is considered acceptable and non-deviant by other native speakers. It was important to use more informants for the perception test discussed in chapter 8, but that did not require the informants' presence in Edinburgh and could therefore be done away from the Phonetics Laboratory.

My informants were not all available at the same time.

1.3.2. The data

The data used for each section of the study is discussed in the sections concerned.

1.3.3. Problems related to the Experimental Situation

There are two main linguistic problems created by the experimental situation.

The first problem can be summarized by saying that the experimental speech act is always an unnatural situation. The second problem is related to the use of a script, and hence the written mode to obtain data of spoken Maltese. The influence of the written symbol where it does not reflect the processes of assimilation and neutralization cannot be ignored. This occurs sometimes with Maltese newsreaders on the media who consider it necessary to use unacceptable speech forms as a result of hypercorrection, e.g. producing voiced consonants in word-final position when these consonants are always voiceless, and where the voiced form would be unacceptable. The phenomenon of adherence to the written symbol is increased by the relatively much smaller exposure to Maltese in its written form.

One particular problem occurred when presenting one informant with semantically anomalous but syntactically and phonologically and lexically acceptable utterances. Because of the strangeness of the text and because of the lack of practice in reading aloud in Maltese, it was very difficult to obtain continuous stretches of the utterances in a natural, acceptable intonation. It was necessary to construct this particular text to include all of the possible cluster types (within the same syllable) as well as sequences (in contact across syllable boundaries) and consonant-plus-vowel type, within a text of a specific length for a cinematographic study. Since I had constructed the text myself and had familiarized myself with it in the course of refining it, I had totally overlooked the possibility of near-rejection by my subject. The knowledge that he was to read this at his fast colloquial speed under hot lights, in a cine-camera set-up, also added to his difficulty.

The non-linguistic, technical problems occurring in the course of my three years' work are too numerous and incredible to mention. The ultimate of MacDonald's Law was realized. If anything can possibly go wrong, however unlikely it may seem, then it will. And it did. Nevertheless, an adequate amount of data obtained using palatography, spectrography, electrokymography, visiography[1] and speech synthesis is discussed.

1.4. Framework and Limitations of this study

I know of no phonetic description of Standard Maltese. Phonetics is a necessary basis for any phonological and morphological study of any language. A study of Maltese phonetics for its own sake is a valid study. In the present study I am concerned primarily with the phonetics of Maltese, although some aspects of synchronic phonology of the language are dealt with because they provide a necessary framework for looking at sounds in context.

Some of the generalizations that have been made in the few pages on Phonetics in studies of Maltese phonology are quite accurate and useful, but a great deal has been assumed about the sounds of Maltese - usually on the basis of its Semitic origin. The primary aim of this study is to make explicit what has usually been implied or assumed about several areas of Maltese phonetics. I have approached Maltese as a language in its own right. What I say about Maltese phonetics need not apply to any other Semitic language at all; other similar or related languages may be better dealt with in entirely different ways.

The study of Maltese phonetics also has a number of practical applications. A teacher or speech therapist who needs more information about Maltese Phonetics has, so far, been expected to look towards the comparative studies of Maltese and Arabic and Italian. This is a highly undesirable state of affairs. A small number of highly-welcome, badly-needed Maltese speech therapists will be graduating this year. They have found themselves at a loss very often in their clinical practice. They are urgently in need of more basic phonetic information than this thesis can hope to cover.

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1. The study of visual patterns making use of a specific set-up devised for this purpose and described in part 5.

My own research with the deaf has reached a stage where a thorough investigation of the spoken language must be obtained before any more work can be done efficiently. Such areas as intelligibility of the speech of the deaf and other linguistically handicapped children and adults, remedial speech programmes (just to mention two of the many uses) cannot progress without further work in phonetics.

This study is meant to provide only the beginning of a solution to these problems. Several areas explored have not proved to be as useful as was initially thought. This in itself is still an important piece of information. If this thesis does nothing else, I hope it at least stimulates more thorough and extensive work in this area. It leaves many stones unturned: one of the main points I want to emphasise throughout this work. Not many answers have been achieved, but many questions have been asked. I consider that a modest but useful beginning.

CHAPTER 2

Maltese Orthography and Maltese Phonetics: Some Relevant Considerations

2. Orthography and Phonetics

This chapter deals with the relationship between the orthographical representation of Maltese and underlying phonetic facts, as well as the way the formulation of orthographical rules has affected previous analyses of the language. I want to point out the lack of correspondence between the spoken language and the writing system. However, my purpose is linguistic description and not spelling reform.

2.1. The Present Maltese orthographical system makes use of thirty symbols to represent the sounds of the language (cf. figure 2.1). Twenty-four symbols represent consonantal sounds. Six symbols represent vocalic sounds. Twenty-eight of the symbols are single units, two are digraphs: <għ> and <ie>. <ie> is not always considered as a composite orthographical symbol (cf. *Tagħrif* 1924, p.2).

The present orthographical system has been in use for about half a century. Its foundations were laid much earlier than 1924, when it was finally standardised by the "Għaqda tal-Kittieba Maltin" (The Association of Maltese Writers) - henceforth "Għaqda" /a:ʔda/ in their *Tagħrif Fuq Il-Kitba Maltija* (Notes on Maltese Writing) - henceforth *Tagħrif*. The reader is referred to Albert Borg's *Elementi per un' ortografia fonemica del Maltese* (Rome 1975) for a discussion of previous systems used, and a critical discussion of the present orthographical system.

The formulation of the rules by the "Ghaqda" (as well as by previous authors) had far-reaching effects on the outlook of subsequent writers on the phonetics and phonology of the language. These rules will be considered here in relation to these writers' statements or views on the Maltese sound system. Some of the phonetic issues discussed briefly here will be examined closely in the course of this work, and the reader will be referred to

Figure 2.1

Letters of the Maltese Alphabet and their phonetic correlates

A. CONSONANTS

Capital Symbol	Small Symbol	Phonetic Realization: Word-Initially	Word-Finally	/___+voice	/___-voice
B	b	b	p	b	p
Ċ	ċ	tʃ	tʃ	dʒ	tʃ
D	d	d	t	d	t
F	f	f	f	v	f
G	g	g	k	g	k
Ġ	ġ	dʒ	tʃ	dʒ	tʃ
GĦ	għ	∅ (1)	h	∅	∅
H	h	∅	h	∅	∅
Ħ	ħ	h	h	h (ɦ)	h
J	j	j	j	j	j
K	k	k	k	g	k
L	l	l	l	l	l
M	m	m (2)	m	m	m
N	n	n (2)	n	n	n
P	p	p	p	b	p
Q	q	ʔ	ʔ	ʔ	ʔ
R	r	{ɹ, ɾ}/{ɾ, r} (3)	{ɹ, ɾ}/{ɾ, r}	{ɹ, ɾ}/{ɾ, r}	{ɹ, ɾ}/{ɾ, r}
S	s	s	s	z	s
T	t	t	t	d	t
V	v	v	f	v	f
W	w	w	w	w	w
X	x	ʃ	ʃ	ʒ	ʃ
Z	z	z	s	z	s
Ż	ż	ts	ts	dz	ts

---

1. ∅ means that a symbol has a zero value phonetically. Thus, for example, ⟨għ⟩→∅ except word-finally.

2. m and n are realized differently in some consonant clusters. Thus, ⟨n⟩⟨m⟩→ ɱ /___f, v; ⟨n⟩→ ŋ /___g, k.

3. For speakers with ⟨r⟩→[ɹ], a [ɾ] is used for ⟨rr⟩; for speakers with ⟨r⟩→[ɾ] a [r] is used for ⟨rr⟩. [ɾ] and [r] can occur as free variants in some speakers. Some speakers have all three variants.

Figure 2.1 (continued)

B. VOWELS

(i) Monophthongs[1]

Capital Symbol	Small Symbols
A	a
E	e
I	i
O	o
U	u
IE	ie

(ii) Diphthongs

Capital Symbol	Small Symbol
AW[2]	aw
GĦU	għu
AJ[2]	aj
GĦI	għi
EW	ew
EJ	ej
IW	iw
OJ	oj
OW[3]	ow

1. Each of the first five symbols 'covers' two phonemes, one 'long' and one short, and their various realizations. The sixth symbol is always realized by a 'long' monophthong that contrasts phonemically with all of these ten vowel phonemes. (See chapter 5 for the various phonetic realizations of these vowel phonemes.)

2. AW / aw and GĦU / għu have the same phonetic realization; AJ / aj and GĦI / għi have the same phonetic realization.

3. For some speakers OW / ow and GĦU / għu have the same phonetic realization.

the appropriate section in this thesis. I want to emphasize now that phonetic facts have been ignored as a result of grammarians placing too much authority on the rules for standardised orthography.

Figure 2.1 shows the phonetic values of the consonantal symbols used in Maltese writing, together with a brief indication of the sound correlates of the vowel symbols.

2.2. Principles for Maltese Orthography

In the Foreword to the Tagħrif (cf. p.xi), the writers talk about the need for a standardized orthography that

> "corresponds to the grammar on which the Maltese language is built; an orthography that does not follow the ear, nor the orthography of other languages (Italian or English); but that, as an integral part of the grammar, uses the consonantal and vocalic symbols required by that same grammar." (Tagħrif, foreword, p.xii)

They comment on the inadequacy of an early dictionary because it

> "did not throw any light on the structure of the Maltese word nor on the original root-forms of the verbs since they were related to the morphology of Italian which has nothing in common with the structure of the Maltese Language."

The principles that form the basis for the standardization of the orthography can be considered as quite explicitly defined in the statements from the Foreword mentioned in the previous paragraph.

The first three rules in the Tagħrif, however, set up even further aims for a phonetic/phonemic orthography that are not always compatible with the primary ones:

Rule 1. Every consonant symbol in the alphabet must represent one sound.

Rule 2. Every sound must be represented by one consonant symbol, or shape.

Rule 3. Every consonant sound must always be represented by the same symbol.

But:

Rule 4. Every consonant that appears in the root-word - even if it changes its sound in the course of further word-formation, must always be represented by the same original symbol.

It is obvious from Rule 4 that morphological-etymological principles guide the choice of symbols.

However, it seems that various authors have been misled into thinking that no phonetic distinctions beyond those represented by the orthographic symbols are possible since the symbols are taken to represent all the significant distinctions in the Maltese sound-system. The belief is so strong as to lead to a fusion of the concept of a 'letter' or 'symbol' with that of a 'sound' such that these words are often used interchangeably. Thus, Rule 5 states:

> No syllable can be pronounced or written without the vowel which forms its nucleus.

This overlooks words like <mqar> and <ltiema> which are acceptable orthographical forms, even though the first part of each word is realized phonetically as [im] and [il] respectively. It seems that they are treated as monosyllables because there is only one orthographic vocalic symbol for the entire word.

2.3. The Written Medium Considered as Primary Mode

This concern over the written mode is discussed also in Borg 1975:

> "Una eccessiva preoccupazione per la lingua scritta ha portato a mettere in ombra la lingua parlata, cosicchè solo pochissimi si accorgono, per esempio, che nel maltese si trova una nuova forma verbale composta della caratteristica della quinta e della sesta forma insieme con quella della settima; o

che ci sono nuovi tipi di verbi deboli, fatto questi quasi completamente oscurato dall' inserzione dei segni grafici għ e ħ . Molti sarebbero stupiti di sapere che nel maltese si possono attualmente avere due vocali in posizione contigua all' interno di parola. D'altra parte chi scrive ha sentito lui stesso asserzione stravaganti come quella secondo la quale il maltese e completamente regolare e non vi si trova nessun' eccezíone." (Borg Albert, 1975, p.2)

(An excessive preoccupation with the written language has over-shadowed the spoken language so much that only a few writers notice, for example, that in Maltese there is a new verb form made up of the characteristics of the fifth and sixth form together with that of the seventh; or that there are new types of weak verbs, a fact almost completely overshadowed by the insertion of the graphemes għ and ħ . Many would be amazed to know that in Maltese it is possible to have two vowels in sequence word-medially. On the other hand, the present writer has himself heard extravagant claims that Maltese is completely regular and has no exceptions. My translation.)

The claim that the Maltese orthographical system (based primarily on morphological-etymological principles, as we have seen) is also phonemic has led to a great deal of reliance on the orthography to provide insight into the phonetics of the language by some authors, as well as to a reluctance to admit sound distinctions not reflected by the symbols. This attitude can be seen in statements like:

"Some Maltese grammarians also make a phonetically fictional distinction, otherwise unindicated by any particular symbol in the standard orthography ..." (Aquilina 1959, p.7)

It seems very much like a case of treating writing as the primary mode instead of speech. There is a reluctance to separate the written from the spoken mode, to make statements about spoken usage that do not correspond to orthographical representation, or to admit that some orthographical symbols are simply relics of original forms:

"The ... pharyngalized vowels are classified as special vowels to distinguish them from the unpharyngalized ones. Such differentiation is necessary to maintain the phonetic and historical individuality of the two sets; but it must be borne in mind that pharyngalisation is so weakened that although it is dialectally perceptible in some of our villages and towns, it is hardly perceptible in others." (Aquilina, 1959, p.18)

and

"Maltese, unlike Arabic, has only two spirant h's, a weaker one and a stronger one..."
"the spirant h in Maltese has weakened its sound to such a degree that it is hardly audible..." (Saydon, 1958, p.169, p.177)

This is an attitude that was adopted by dominant grammarians of Maltese. The sound system was reflected in the orthography to the extent that no further significant distinctions could be made than those expressed by the symbols chosen.

Thus we see that, although it is acknowledged in various places that <għ> and <h> in words like <lagħab> and <deher> 'are not pronounced', there is still constant insistence that they exist in some way, that they have some subtle phonetic value, even if 'almost inaudible' (Saydon, ibid) or 'hardly perceptible' (Aquilina, 1959). Thus the phonetically non-existent consonants represented by <għ> and <h> somehow constitute the consonantal boundary between two syllables as is required by Rule 7:

There must always be a consonant between the vowel of one syllable and the vowel of the following syllable.

The retention of an orthographical distinction is explained away as 'having an effect on the vowel, namely lengthening':

"Whereas the ordinary long vowels are always stressed, those pharyngalised ... are always long, even if they do not bear the main stress

> of the word in which they occur" (Aquilina, 1959, p.18).

It is not true to say that the historically-pharyngalized vowels are always long. They behave like 'ordinary' vowels, and their duration pattern depends on the same phonetic environmental factors (cf. discussion of vowel duration, 6.9).

Some of this confusion of phonetic statements based on the written forms is also obvious in the Tagħrif, where some rather ambiguous statements are made, such as the following definition and rule regarding diphthongs:

> "In Maltese and the Maltese word there is no such thing as a proper diphthong (that is, the sound of two vowels in one syllable) except in the splitting up of the long sound of 'a' into 'ie' as in ktieb, bieb ... two letters that together represent a single sound.
>
> The others are nothing else but a combination of vowels with one of the weak consonants, or a combination of a weak consonant with a vowel in a division of a word." (Tagħrif, 1924, Part 1, p.30)

and:

> "Rule 43:
> A diphthong occurs when the consonantal letters j or w are joined to a vowel, word-initially, medially or finally (In a syllable!)" (Tagħrif, Part 1, p.31)

Since, for the sake of graphemic consistency, etymological and morphological requirements take precedence over phonetic facts in standardizing the orthographical system (cf. Rule 4), then no phonetic claims can be made about the synchronic structure of words. The orthography is not required to reflect the dynamic processes of neutralization and assimilation occurring in the various styles of speech. Therefore, it does not follow that what is not represented in the orthography cannot exist in the spoken medium.

2.4. The Prescriptive Attitude of the Writers in the Tagħrif

It is worth noting at this point the prescriptive style in which some of the rules are written. Yet some so-called rules are much more like an attempt to encode the phonology of Maltese by way of its orthographical representation, and not merely a formulation of rules for the standardisation of Maltese orthography. This can be seen, for example, in the following, which are quite clearly phonological statements.

Rule 10. In monosyllabic words, a short stressed vowel must always be followed by a double consonant or by more than one consonant.

Rule 11. At a syllable boundary, a long vowel is followed by only one consonant.

Rule 15. Only one syllable can follow the stressed syllable in a word (i.e. only the final or penultimate syllable of a word is stressed).

Rule 27. When one or more letters are added to a word, the shape of the word changes: the stress, the vowel and the consonant position may change.

Rule 28. When a vowel, or a consonant followed by a vowel, is prefixed to a word, the lightly stressed or unstressed vowel is elided.

Rule 29. A vowel or a vowel followed by a consonant suffixed to a word causes the elision of the unstressed vowel in the second syllable.

2.5. Confusion Between Diachronic and Synchronic Statements

The bias towards the written mode at the expense of the spoken mode is paralleled in the adherence to etymological facts that, though highly interesting and significant, underestimate the separateness of Maltese as an independent language. The rules often confuse diachronic with synchronic facts. It sometimes appears that Maltese cannot be analysed and described in its own right. These biases have led authors to underrate the autonomy of the existing, synchronic sound system in particular and to ignore the phonetic characteristics of the sounds used, irrespective of their origin and historical development. It is assumed by the "Għaqda" (cf. p.9) - from the rules referred to throughout this section - that statements made about word origin must also apply to modern usage.

The attempt to split the language into the Semitic and Romance components for the purpose of comparative phonological and morphological analysis is justified by the fact that an explanation is thus provided for several variant forms that exist in the language. On the other hand, it is not in the least useful to extend this split into the synchronic phonetic and phonological analysis of the language. To do this would be to ignore the harmonious amalgamation of the two components in synchronic Standard Maltese. It could even imply that a native speaker's ability to use Maltese is partially dependent on his knowledge of Arabic.

2.6. <u>The Importance of the Consonantal Roots of Words</u> has been emphasized by various grammarians to the point where the role of the vowels is underestimated. The retention of the same consonants in the same order in all related word forms regardless of the lack of conservation of the distinctive voicing feature is upheld. This favours the immediate recognition of words as belonging to a particular set of related words and is a great advantage for the visual recognition of a great many words of Semitic origin. Because of the stability of the consonants in root-words and derivations, the role of the vowels has been almost ignored.

> "...i grammatici maltesi tendono a esagerare l'importanza delle consonanti rispetto alle vocali. Queste ultime, si dice, hanno un ruolo minore in quanto "segnalano alcune sfumature del significato centrale espresso dalle consonante radicali"." (Albert Borg, 1975, 3.4.4.)

(... Maltese grammarians tend to exaggerate the importance of consonants in relation to vowels. The vowels, they say, have only a minor role to play: they 'signal shades of the central meaning expressed by the root-consonants'. My translation.)

The vowels in Maltese play a much more important role than they do in any of the other North African dialects to which Maltese is related (cf. Alexander Borg, 1978). Vowel patterns can be related to both phonetic and semantic and morphological rules (e.g. verbal classes). They do not occur sporadically or unpredictably. They obey strict rules of harmony (cf. Saydon, 1958). Perhaps the tendency to attribute only inferior status to the vowels owes its origin to a number of factors including:

1. the more obvious importance of the consonants and retention of the same consonants in semantically-related word-forms, e.g.

<daħal>	-	<daħħal>	-	<daħla>	-	<dħul>
to enter		to admit		inlet		entrance

2. the fact that only six vocalic contrasts are represented explicitly in the orthography.

3. the historically lesser value of the vowels in the original Arabic dialect.

This is emphasized in the Tagħrif especially in the following:-

"In Maltese, the word is built on the consonants of the original forms: these consonants, usually three, sometimes four, are therefore called the roots of the word, and, by adding further consonantal letters or by changing the vowels, further word-forms - verbs, nouns and adjectives - can be formed." (p.33-34)

"We see therefore that (1) whilst in other languages the roots of words are a combination of consonant with vowel ... in Maltese, the consonants alone do this work; (2) therefore the consonants must always appear unchanged in any derivation of a word; (3) words that are written with the same three root-consonants are all related in meaning." (p.34)

Alexander Borg's (1978) A Historical and Comparative Phonology and Morphology of Maltese is an intensive comparative-phonological study with a greater emphasis on synchronic Maltese. His conclusion to a discussion of the Arabic component of the Maltese sound system merits an extensive quote at this stage:

> "One striking fact emerging from a comparison of the Arabic Maltese and Old Arabic consonant systems is the substantial reduction that has occurred in the consonant inventory characterizing the former. In contrast with the 24 consonant phonemes of the Old Arabic language, the Arabic component of Maltese displays a core of 17 fully fledged consonants (excluding / č, v and g/ which have a rather low functional yield). This reduction in the consonant inventory of Arabic Maltese is highly noteworthy in view of the opposite trend evinced in a great many contemporary dialects displaying an increase in the number of consonant roles chiefly through the spread of secondary emphasis."

> "Even more striking in Arabic Maltese is its large inventory of vocalic nuclei, amounting to no fewer than 18, (though if long segments are phonologically interpreted as combinations of unit phonemes, this number can be reduced to 5, including (/i, e, a, o, and uu[1]/). From the diachronic standpoint, the large vocalic inventory of Arabic Maltese is quite remarkable since it amounts to nothing less than a complete reversal of the situation prevailing in Old Maltese (or perhaps in the Arabic dialect(s) from which Maltese developed)."

> "Differences in vowel colour that were initially allophonic acquired functional status, and Maltese underwent ... (several) ... vowel splits ... The increase in vocalic functional roles characterizing modern Maltese was therefore a direct consequence of the general reduction in the number of consonantal distinctions suffered by the phonological system at large."

> "The most outstanding characteristic of the modern Maltese sound system is, then, the altogether innovative distributional balance reached in the overall assignment of structural roles to vowels and consonants" (My brackets) (Alexander Borg, 1978, p. 79ff., 80, 81)

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1. Borg uses uu as a symbol for the long monophthong in words such as <fur>.

Grammarians have ignored a synchronic description of Maltese as a consequence of the thoroughness with which they have retraced the historical development of the language.

2.7. <u>The Syllable</u> is a case in point where synchronic facts have been ignored in order to retain the original consonantal pattern regardless of the historical development of the Arabic component of Maltese words. The following rules illustrate the explicit ignoring of the phonetic and phonological features of the syllable in favour of the orthographical ones. They seem to express some orthographical harmony rules with no reference to phonetic reality.

Rule 6. Two vowels cannot follow each other in the same syllable, i.e. no syllable can have more than one vowel.

Rule 7. There must always be a consonant between the vowel of one syllable and the vowel of the following syllable.

Again, this is only an orthographic rule and the words 'consonant' and 'vowel' should be replaced by 'consonantal symbol' and 'vocalic symbol' since the following words can be pronounced acceptably in two ways, with or without an intervening consonant between the vowels:

<qiegħed> :	/ʔi - jet/	/ʔi - et/
<kruwa> :	/kru - wa/	/kru - a/

and since several words with a consonant-symbol separating two vocalic symbols are in fact mono-syllabic:

<lagħab>	<deher>	<taha>
/la:p/	/de:r/	/ta:/

Further rules involving syllable division are discussed in Chapter 4 . It need only be added at this point that the rules are formulated to refer to consonant and vowel symbols but assume a simultaneous reference to a definite phonetic entity corresponding to the symbols:

> Rule 17. In disyllabic words, if the first vowel is short, the syllable is divided after the consonant that follows that vowel, i.e. a short vowel is always followed by the consonant that follows it in the same syllable.

Yet most speakers would consider words like <dera> and <mexa> to have their syllable division as follows /de - ra/, /me - ʃa/.

PART II

SOME PHONOLOGICAL CONSIDERATIONS

Chapter 3

The Sound System of Maltese

3.1. Minimal Pair Lists of Maltese

It is convenient and economical to introduce the sound system of Maltese in terms of minimal contrasts. However, the distributional characteristics of Maltese sounds are such that only a relatively small number of true minimal pairs of words exist. Maltese words are usually differentiated redundantly. Both a vocalic and a consonantal difference in duration, for example, is usually utilized in a 'minimal' contrast (See Chapter 6 - Duration, and Section 8.10.4. - Minimal Pairs). In closed monosyllables, long vowels are always followed by single consonants whereas short vowels are always followed by geminate consonants or by consonant clusters.

The list of minimal pairs below may, therefore, give a distorted impression of the Maltese sound system as presented, since some of the contrasts are very limited and unproductive whereas others are of considerable importance in signalling consistent morphological and syntactic information.

The following, then, is a list of the minimally contrasting sounds in Maltese. No further distinctions are necessary in describing linguistically significant differences.

Figure 3.1 overleaf

ts	tʃ	dʒ	f	v	s	z	ʃ	h	w	j
tsop:a	tʃat:	dʒi:t	fat:	viᵊna	sop:a	zuʷra	ʃat:	hat:	wi:t	juʷri
pop:a	pat:	pi:t	pat:	piᵊna	pop:a	puʷra	pat:	pat:	pi:t	puʷri
·tsiᵊja	tʃint	dʒi:t	fiᵊna	viᵊna	seraʔ	zi:t	koʃ:a	hi:t	wi:sa	juʷri
biᵊja	bint	bi:t	biᵊna	biᵊna	beraʔ	bi:t	kob:a	bi:t	bi:sa	buʷri
tsok:	tʃiᵊna	dʒema	fe:ma	viᵊna	sema	zuʷɬ	ʃema	ha	ta:wa	jimʃi
tok:	tiᵊna	tema	te:ma	tiᵊna	tema	tuʷɬ	tema	ta	ta:ta	timʃi
a:ts:a	tʃa:ʔ	dʒema	fera	ve:ra	sema	zuʷra	ʃema	ha	wisa	ja:ra
a:d:a	da:ʔ	dema	dera	de:ra	dema	duʷra	dema	da	disa	da:ra
·tsop:	·tʃap:a	dʒon:a	fuʷɬ	va:s	suʷra	zuʷɬ	ʃorp	haɬ:u	wesa	jet:
kop:	kap:a	kon:a	kuʷɬ	ka:s	kuʷra	kuʷɬ	korp	kaɬ:u	kesa	ket:
mats	·tʃof:	dʒa:ɬa	fost	va:ra	sa:ɬa	zom:a	ʃof:a	has:	·wid:ep	ja:ra
mag:	gof:	ga:ɬa	gost	ga:ra	ga:ɬa	gom:a	gof:a	gas:	gid:ep	ga:ra
tsaɬtsa	tʃat:	dʒara	fat:	viɬ:a	sa:m	zara	ʃof:a	hat:	wi:sa	jaɬ:a
ʔaɬtsa	ʔat:	ʔara	ʔat:	ʔiɬ:a	ʔa:m	ʔara	ʔof:a	ʔat:	ʔi:sa	ʔaɬ:a
a:ts:a	tʃat:	dʒara	fiᵊna	viᵊna	seraʔ	zewtʃ	ʃuʷr	hat:	wes:a	jo:ɬa
a:ma	mat:	mara	miᵊna	miᵊna	meraʔ	mewtʃ	muʷr	mat:	mes:a	mo:ɬa
a:ts:a	tʃas:a	dʒiri:n	a:fa	va:s	·sa:r	·zebah	koʃ:a	hoɬ:	wi:sa	jimʃi
a:na	nas:a	niri:n	a:na	na:s	na:r	nebah	kon:a	noɬ:	ni:sa	nimʃi
a:tsa	tʃa:ʔ	dʒa:ba	a:fa	viᵊɬi	suʷra	zuʷra	koʃ:a	haʔ:a	waʔ:a	jista
a:ɬa	ɬa:ʔ	·ɬa:ba	a:ɬa	ɬiᵊɬi	ɬuʷra	ɬuʷra	koɬ:a	ɬaʔ:a	ɬaʔ:a	ɬista
a:tsa	tʃat:	dʒema	fat:	va:s	sema	zebah	ʃema	hat:	waʔ:a	ej:a
a:ra	rat:	rema	rat:	ra:s	rema	rebah	rema	rat:	raʔ:a	er:a
ts	ɬats	dʒi	a:fa	·viᵊti	a:ts:a	·ziᵊzi	·taʃ:a	hok:	·wiᵊwi	aj:a
	ɬatʃ	tsi	a:ts:a	tsiᵊti	a:s:a	tsiᵊtsi	tats:a	tsok:	tsiᵊtsi	ats:a
	tʃ	dʒa:ra	fat:	·va:ra	sa:ʔ	·za:r	ʃa:r	hat:	·was:a	ja:ra
		tʃa:ra	tʃat:	tʃa:ra	tʃa:ʔ	tʃa:r	tʃa:r	tʃat:	tʃas:a	tʃa:ra
		dʒ	dʒera	ve:ɬu	sema	zera	ʃema	hi:t	wera	jew
			fera	dʒe:ɬu	dʒema	dʒera	dʒema	dʒi:t	dʒera	dʒew
			f	·viᵊni	seraʔ	zuʷɬ	ʃuʷr	hat:	waʔ:a	ji:s
				fiᵊni	feraʔ	fuʷɬ	fuʷr	fat:	faʔ:a	fi:s
				v	·siᵊt	ziᵊt	·ʃiᵊni	hiᵊt	wiɬ:a	ja:ra
					viᵊt	viᵊt	viᵊni	viᵊt	viɬ:a	va:ra
					s	zuʷra	ʃema	hat:	waʔ:a	juʷm
						suʷra	sema	sat:	saʔ:a	suʷm
						z	ʃuʷr	hiᵊt	wera	zajr
							zuʷr	ziᵊt	zera	jajr
							ʃ	hok:	war:ap	ja:ra
								ʃok:	ʃar:ap	ʃa:ra
								h	wi:t	jaʔ:
									hi:t	haʔ:
									w	jeheɬ
										weheɬ

FIGURE 3.2 Minimal Pairs to Establish Vowel Phonemes in Maltese (Monophthongs).

iʲ	i:	i	e:	e	a:	a	o:	o	u	uʷ
	dʒi:t	a'dʒina	'be:la	'tela	da:n	'tala	'o:li	• so:r	sur	suʷr
	dʒiʲt	a'dʒiʲna	'biʲla	'tiʲla	diʲn	'tiʲla	'iʲli	siʲr	siʲr	siʲr
	i:	'niʃef	be:t	'tela	ba:t	'tala	mo:t	• bo:t	• kul:	kuʷl
		'ni:ʃef	bi:t	'ti:la	bi:t	'ti:la	mi:t	bɪ:t	ki:l	ki:l
		i	'fe:mta	mes:	'a:ra	mat:	• mo:t	'bol:a	'kel:u	'tuʷni
			'fimta	mis:	'ira	mit:	mit:	'bil:a	'kel:i	'tini
			e:	'dera	'ba:la	'dara	'to:ma	•'bol:a	u'ri:ni	duʷr
				'de:ra	'be:la	'de:ra	'te:ma	'be:la	e'ri:ni	de:r
				e	'ba:la	mat:	• mo:t	'posta	sur	suʷr
					'bela	met:	met:	'pesta	ser	ser
					a:	'dʒara	'o:li	'ol:i	sur	duʷr
						'dʒa:ra	'a:li	'a:l:i	sa:r	da:r
						a	• mo:t	mort	inkul:a:	'suʷfra
							mat:	mart	inkal:a:	'safra
							o:	'domna	sur	buʷt
								'do:mna	so:r	bo:t
								o	punt	• suʷr
									punt	sor
									u	suʷr
										sur

Words with a preceding • are derived from Albert Borg 1975.

FIGURE 3.3 Minimal Pairs to Establish Diphthong Phonemes in Maltese.

	aj	oj	ew	aw	ow	iw
ej	sajf	'dʒoj:a	dʒew	in'sawtu	'dʒow:a	'ɫiwja
	sejf	'dʒej:a	dʒej	in'sejtu	'dʒej:a	'lej:a
	aj	'boj:a	'ewda	ji'dawlu	'owma	-
		'baj:a	'ajda	ji'dajlu	'ajma	-
		oj	'sew:a	'dawli	'dʒow:a	-
			'soj:a	'dojli	'dʒoj:a	-
			ew	saw	ṭowm	-
				sew	ṭewm	-
				aw	owm	-
					awm	-
					ow	-

From these minimal pair lists the following vowel and consonant phonemes can be derived:

/i^j/, /i:/, /i/, /e/, /e:/, /a/, /a:/, /o/, /o:/, /u/, /u^w/

/iw/, /ew/, /aw/, /ow/, /ej/, /aj/, /oj/

/p/, /b/, /t/, /d/, /k/, /g/, /ʔ/, /m/, /n/, /l/, /r/, /ʦ/, /ʧ/, /ʤ/, /f/, /v/, /s/, /z/, /ʃ/, /h/, /w/, /j/.

I shall now deal with the problem areas that confront the phonologist dealing with Maltese. The first and most crucial problem is that of the criteria by which certain sounds are included and other sounds are excluded as members of a phoneme class. The second question concerns the affricates and why /ʧ/, /ʤ/ and /ʦ/ are considered as three single phonemes in Maltese whereas other stop plus fricative combinations are not. The last phonological problem dealt with is the decision made here to consider the elements that could be classed as diphthongs as sequences of vowel plus consonant. The distribution of the consonant and vowel phonemes is dealt with in chapter 4, section 4.7, and chapter 5.

3.2. Present and Previous Phonemic Analyses of Maltese

The minimal-pairs list shows a transcription of Maltese words as any native speaker of Standard Maltese would use if he or she were not aware of the conventional orthographical shape of the words. This means that my phonological system does not take account of any morphological, lexical or syntactic considerations. It therefore does not attempt to relate words to each other on the basis of their derivation from the same source, or because they have related meanings. For example, in my system the following would occur:

1.	<ktieb>	/kti:p/	book
2.	<kitba>	/kidba/	writing (n.)
3.	<niktbu>	/nigdbu/	we write
4.	<ktibta>	/ktipta/	I wrote it
5.	<niktibha>	/niktiba/	I write it
6.	<gideb>	/gidep/	lies
7.	<nigdbu>	/nigdbu/	we lie

and so on.

This transcription differs from the phonemic or archiphonemic transcriptions used in other studies essentially by not maintaining and reflecting morphophonemic alternations. The transcriptions of the words 1 to 7 above, in previous studies, would be as follows:

1.	/ktieB/	or	/ktieb/
2.	/kiTba/		/kitba/
3.	/niKTbu/		/niktbu/
4.	/ktiBta/		/ktibta/
5.	/niktiba/		/niktiba/
6.	/gideB/		/gideb/
7.	/nigdbu/[1]		/nigdbu/[2]

The difference in vowel representation reflects a difference in phonetic and phonological evaluation. The phonetic difference is dealt with at length in the analysis and description of vowels in chapter 5. Very briefly, I consider the vowel in <ktieb> to be a monophthong. I still retain a 3-way vowel contrast for the front close vowels - and as stated earlier, I do not differ from previous studies as to number of vowel contrasts. However, at this point I will deal only with phonemic identity and membership of vowels.

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1. As in Borg, 1978, and in Krier, 1975, and others.
2. As in Aquilina, 1959, and others.

The other variations in transcription relate to the consonants. In this chapter on the sound system of Maltese, I will be discussing consonant phonemes first.

3.3. Phonemic criteria

The basic question which has been given a different answer here is: Should sounds that alternate depending on the morphological structure of the word be considered as sharing membership in the same phoneme set? I have given a negative answer to this question for the purposes of my description of the Maltese sound system. I would now like to show why my answer is different and yet, at the same time why I consider the alternate phonemic approach adopted in other studies acceptable for the description of the Maltese sound system within their different frameworks.

The discussion centres round the definition of a phoneme and the qualifications that allow or disqualify a sound from membership of a phoneme set. It concerns, therefore, the relations between contrasting sounds of a language and the implications resulting from saying that two sounds are distinctive. It concerns the level of abstraction one adopts.

First of all, I would like to consider very briefly conventional phonemic criteria and to consider how the sounds shown so far to be distinctive in Maltese meet or do not meet these criteria. The three principles adhered to by all classical phonemicists are (1) that the various sounds used by a particular language can be grouped together in such a way that only one member of each group contrasts with one member of the other groups; the sounds of each group are said to be members of a phoneme, or the "allophones" of a phoneme; therefore (2) there are always fewer phonemes than there are varying sounds or allophones in a language and (3) the allophones of each phoneme are conditioned by the context so that they do not contrast amongst each other: their differences can be predicted from the context. The criteria by which sounds gain membership of one phoneme rather than another are various. One such criterion is phonetic similarity. The strict phonetic-phoneme approach allows no reference to morphology (or indeed, any non-phonetic criteria), apart from whether a different word results, in deciding phoneme membership. The word is taken as a unit in which the phoneme operates. Any sound that can be replaced by another and results in a significant linguistic change, i.e. a different word, must belong to a different phoneme from the other sound.

3.4. Levels of Abstraction

My analysis of Maltese sound patterns is based on a stricter phonetic approach than that used by other linguists in deciding which are the significantly contrasting sounds, or phonemes, of the language. The justification for my decision lies in the rather unusual purposes of this study: the applications to the Maltese deaf. By deciding to do this I am claiming that the native speaker's intuition-recognition about which sounds are recognisably different is more directly relevant to my purposes than are the linguist's awareness of morphological relations, i.e. his knowledge that different sounding words such as <ktieb>, <ktibt>, <kittieba> and so on, (/kti:p/, /ktipt/, /kit:i:ba/) are all related forms. This knowledge has been made use of by other investigators with different purposes.

I am working at a less abstract level of analysis. This concrete level accounts for the spelling of native speakers of Maltese with only a limited knowledge of Maltese orthography, whose spelling would coincide with the accepted orthography only when this reflects a more phonetic representation. For example, the shopping-list of a middle-aged educated housewife who is literate in English but only semi-literate in Maltese, might be as follows:

bajt for <bajd> [bajt], but bajda for <bajda> [bajda]
hops for <hobż> [hops], but hobza for <hobża> [hobza]

and so on. This means that to her no immediate relationship between <bajd> <bajda> and <hobż> <hobża> comes to mind.

My analysis does not present any problems of ambiguity because there are no two forms [kti:p] *[kti:b] or *[bti:hi] [pti:hi] that would have to be generalized to a more abstract-phonemic /kti:b/ and /bti:hi/. It is only the knowledge of the more abstract relations between different words that allows the linguist insight into the "root" or "base-form" as being /k - t - b/ or /b - t - h/.

The phonemes set up in the previous analyses mentioned, violate the maxim of biuniqueness since word-initial [k] in word 1 above, and [g] in word 3 above belong to the same phoneme /k/. On the other hand, [g] in words 6 and 7 belongs to the phoneme /g/ according to the same analysis. [t] in word 1 and [d] in word 2 belong to the phoneme /t/, whereas [d] in words 6 and 7 belong to the phoneme /d/, and so on.

Obviously, this decision to opt for a more abstract phoneme was made because the framework for the analysis is one of comparative phonology, where a more abstract unit needs to be postulated - a unit in a shape before it is assimilated in real speech forms. It is a convenient unit when dealing with more abstract relations such as the morphological, syntactic and semantic. This unit would have to be posited as a further stage in an analysis that is removed from the phonetic. My purpose here, however, is to show how the sounds in Maltese are patterned and to refer consistently to the phonetic level, drawing generalizations that are only minimally abstract, i.e. abstract enough to distinguish between phonetic differences that are linguistically different and those that are not. It is therefore desirable for me to stop at a more concrete or autonomous phoneme. The more abstract morphophonemic level could still apply to my analysis without having to go back again to start from the raw phonetic data. In other words, a morphophonemic analysis can still be made on the basis of the present analysis.

On the other hand, the more general linguistic approach to the phoneme concept allows the use of morphological and other non-phonetic criteria in deciding phoneme membership. This more abstract level of analysis of the phonetic data into systematic phonemes (cf. Crystal, 1980, p.348) is close to an archiphonemic approach. The neutralization of the voicing contrast is there explained in terms of archiphonemes operating in those places of non-contrast. This still leaves the more phonetic level of analysis to be referred to to explain the phonetic processes involved. For the present purposes, voicing and voicelessness are very important processes.

Both analyses allow a consistent transcription of the word since the voicing harmony that is at the root of all the differences reflected in the two distinct analyses is obligatory. There are no two possible phonetic forms of the transcribed words, i.e. sometimes voiced and sometimes voiceless. This would have created a problem that would have had to be solved by accepting a more abstract phoneme than the strictly phonetic one. On the other hand, for a discussion of morphology it is necessary to have access to this more abstract phoneme - and therefore to the analysis used in previous studies. But the more phonetic phoneme allows very direct access to the allophones of the language simply by reference to the context. The more abstract phoneme would need to refer to the morphemes of the language to rewrite the allophones involved.

Throughout this thesis, I am concerned primarily with the phonetics of Maltese speech forms. I will be referring mostly to forms such as [kti:p] and I am in no way concerned with the relations that this form may have to words such as [kidbet] , and so on, but with the fact that only [db] or [tp] occur in Maltese and never *[tb] or *[dp]. This must be kept in mind, especially in my analysis of the relations of elements within a syllable.

3.5. The Obstruents

The main problem, then, in dealing with distributional restrictions of consonant phoneme contrasts centres around voiced and voiceless obstruents and can be clearly stated as follows:

1. The contrast between voiced and voiceless obstruents which is linguistically significant does not operate in consonant clusters or consonant sequences within a word, although the contrast operates in other contexts. The obstruents in a cluster or sequence are either all voiced or all voiceless in harmony with the last obstruent in the group. The other consonants fall into two groups: (a) /l,m,n,r/ are not involved in this since they can occur with voiced and with voiceless consonants in a cluster or sequence; there are no consistent voiceless contrasts to /l,m,n,r,/ in any context. They do occur slightly devoiced in certain contexts, but there is never any significant contrast between the voiced and voiceless sounds (or, more commonly, not fully voiced) - the contrast is wholly conditioned by the context; (b) /w,j,ʔ and h/ are not themselves affected by other consonants in a cluster or sequence; only voiceless obstruents occur before /ʔ/

and /h/, but there is no other restriction. /h/ is often voiced when it precedes voiced obstruents.

2. There is no opposition between voiced and voiceless obstruents in word-final position. Only voiceless obstruents can occur word-finally unless the following word in the utterance has a voiced obstruent word-initially and the two words are not separated by a pause.

3.6. The Affricates

The next phonological problem concerns the affricates.

Phonetically, there seems little reason for considering /ʧ/, /ʤ/ and /ʦ/ as three simple unified segments, instead of sequences of two events since there are other stop plus fricative combinations in Maltese that seem to operate in the same way, for example:

p + s   k + s   p + ʃ   k + ʃ   b + z   g + z

The distinction is largely phonological. It is partly supported by the fact that the Maltese affricates [ʧ] [ʤ] [ʦ] are characterized differently from the other stop + fricative combinations in the following ways:

1. The sound [ʒ] does not have phonemic status in Maltese; it only occurs as the allophone of /ʃ/ when /ʃ/ precedes voiced obstruents. If [ʒ] were given phonemic status here, it would be unique in the Maltese phoneme system in terms of its distribution. (It would never occur in a minimal contrast with /ʃ/.) By analogy, and to avoid the unique CCCC cluster (see 2 below), [ʧ] and [ʤ] will be considered as single units.

2. The longest releasing consonant cluster permissible within one syllable in Maltese is CCC.

The affricates under discussion also operate as single consonants within a CCC cluster. If they are considered as consonant sequences, this would add CCCC as a possible releasing cluster simply to fit /tʃ/ and /dʒ/ into the generalization rule. CCCC clusters would uniquely consist of the affricates as part of the cluster.

3. The article ⟨il-⟩ which assimilates with dental, alveolar and post-alveolar consonants such as /d/ and /ʃ/ (called 'sunny' sounds) does not assimilate to /dʒ/. Thus:

⟨id-dubbien⟩	and	⟨ix-xemx⟩	but	⟨il-ġnien⟩
[id'dub:i:n]		[iʃ'ʃemʃ]		[il'dʒni:n]

The reason for this is probably partly historical (cf. Comrie, 1980).

4. The affricates can be geminated in the same way as any single consonant can, and in the same places in word structure. There is no gemination of consonants in Maltese within consonant clusters.

It seems then, that the three affricates above operate in the same way as any single consonant. (Gemination is discussed in chapter 4.)

3.7. The Monophthongs

The main problems concerning the vowel phoneme contrasts in Maltese can be outlined as follows:

The long and short vowel sounds (the monophthongs) are only in opposition in stressed syllables. The long vowels /i^j, i:, e:, a:, o:, u^w/ never occur in unstressed syllables and therefore there is no 'long' versus 'short' vowel contrast in unstressed syllables.

When they occur in stressed syllables, the vowel phonemes can contrast with one another minimally, although it is more common to have other features that add to the phonetic contrasts. Thus in monosyllables, short vowels are usually followed by geminate consonants or consonant clusters, long vowels are followed by short or single consonants. Short vowels do not occur in open monosyllables. The distribution of the vowel phonemes is not, however, restricted in non-final syllables of multisyllabic words.

The vowels do not alternate in the same way as do the consonants morphophonemically. Thus there is no difference between my analysis of vowel-phoneme contrasts and previous analyses. A more phonetic approach is adopted in both, since the vowel-phonemes are not seen as having the same type of morphophonemic/morphological significance as the consonants.

3.8. The Diphthongs

The decision to give the second element of the phonetic diphthong vocalic or consonantal status in different languages has often been arbitrary, depending mainly on the phonological distributional patterns rather than on phonetic facts. Although the consonant-vowel distinction is assumed to be fundamental, it is:

> "based not on a consistently articulatory criterion ... but rather on the function of a particular sound-type in relation to the syllable, vowels being syllabic central units, consonants being syllabic marginal units." (Catford, 1977, p.165)

Catford considers the distinction between such borderline cases as /w/ and /u/, /j/ and /i/ as clear-cut on a temporal basis. Hence, the distinction is made on an articulatory parameter, if time is accepted as such a parameter.

In Maltese, /j/ and /w/ preceding a vowel have always been considered consonantal, whereas /ew/, /aw/, /ow/, /ej/, /aj/, /oj/ and sometimes /iw/, along with /i:/ (<ie>), have been considered as diphthongs. It seems to me a preferable approach to the Maltese data to treat the phonetic diphthongs as a vowel plus consonantal /w/ or /j/.

I consider that a strong case can be made for moving the second element of the Maltese diphthongs from vocalic to consonantal status. One reason for doing this is simplification of the sound system, since all the Maltese diphthongs are of the Vowel + $\left\{ \begin{array}{c} /j/ \\ /w/ \end{array} \right\}$ structure.

/j/ and /w/ never function as syllabic nuclei. Their distribution is not limited to post-vocalic. Therefore, a consistent analysis would include the $\left\{ \begin{array}{c} /j/ \\ /w/ \end{array} \right\}$ + vowel sequences also as diphthongs. Considering post-vocalic /j/ and /w/ as consonantal would result in a reduction in the number of vowel phonemes.

A further argument for analyzing these sounds as consonants rather than vowels is that like all other consonants they can occur geminated. That is to say, they can occur as the closure phase of one syllable and can continue to the release stage of the following syllable.

Since I am working within the broader framework of deaf pedagogy, it seems highly desirable to opt for the simpler system.

Chapter 4

The Syllable and Consonant Distribution in Maltese

4.1. The Syllable

None of the major contributions to the theory of the syllable (Stetson 1951, Jesperson 1950, Ladefoged 1957, Rosetti 1959, Malmberg 1963, Jones 1964, Abercrombie 1967, Catford 1977) goes far towards an objective (possibly instrumental) identification of a syllable. It remains a fact that for most words, native speakers agree as to what constitutes one or more syllables, and what the syllable boundaries in words are. These differ from one language to another but the differences are, no doubt, relative to the syllable structure of each particular language. I will not be concerned here with the highly involved, though interesting, theoretical issues regarding syllables since such considerations will not be of importance in considering the effect that segments have on each other in Maltese.

However, I would like to discuss the way the syllable has been used - or not used - in linguistic analyses of Maltese. I shall first review what has been said or implied about the syllable by previous writers and then I will go on to describe the syllable structure in Maltese.

4.2. Rules Formulated by the "Għaqda" Regarding the Syllable

The "Għaqda" 's treatment of syllables and syllable division in orthography could be misleading because synchronic facts are ignored in order to retain the original consonantal shape and sequence in the word, reminiscent of the historical development of the Arabic component of Maltese words. As has already been pointed out (cf. Chapter 2), the criterion used by the "Għaqda" is valid for orthography but should not form the basis of a phonetic or phonological analysis. The following rules illustrate the explicit ignoring of the phonetic and phonological features of the syllable in favour of the orthographical one. They seem to formulate orthographical-harmony rules with no reference to phonetic reality. Since no distinction is made between the written and the spoken syllable, it could be assumed that the two are being treated as identical (again probably due to the actual formulation of the rules). The rules regarding the syllable are presented below (my translation), and discussed.

Some rules, such as rule 5, seem specifically meant to apply to both the written and the spoken language. However, even these appear a little short-sighted, as will be indicated. The statements that follow are meant to clarify the issues mentioned in the rules and to separate their application to orthography from their application to speech.

4.3. The Application of the "Għaqda" 's Rules to the Spoken Language

(a) Rule 5 states: No syllable or word division can be pronounced or written without the vowel which constitutes its nucleus.

However, some words are pronounced with more syllables than there are vowels in the written form:

<Msida>	<ltaqa'>	<mqar>	<rqaq>
/im-si^{j}-da/	/il-ta-qa/	/im-ʔar/	/ir-ʔa:ʔ/

(b) Rule 6:- No two vowels can follow each other in the same syllable; or, rather, every syllable can only have one vowel.

This is obviously applicable to the spoken syllable, since, by definition, a vowel constitutes the nucleus of a syllable; two vowels would therefore constitute two syllables.

(c) Rule 7:- There must always be a consonant between the vowel of one syllable and the vowel of the immediately following syllable.

Although no two vowels follow each other without an intervening consonant when the vowels belong to two separate succeeding syllables in the written word, nevertheless, some words - where <gh̄> or <h> is the intervening written consonant symbol - are pronounced with two uninterrupted vowels. There are, however, variant pronunciations of these words:

<qiegh̄ed>	<kruha>	
/ʔi - et/	/kru - a/	
/ʔi - jet/	/kru - wa/	(Rules 6, 7)

Also, several words with <gh̄> or <h> separating two vocalic symbols are, in fact, monosyllabic. Thus:

<lagh̄ab>	<deher>	<taha>
/la:p/	/de:r/	/ta:/

(d) Rule 8:- Double consonants are always preceded by a vowel even if the words are just derivations of words with double consonants, (even if the consonants are no longer long - personal comment).

Rule 9:- In monosyllabic words, the final vowel is always prolonged. (Only CV words are used in the examples.)

Rule 10:- In monosyllabic words, a short stressed syllable is always followed by a long (double) consonant or by more than one consonant.

These rules are applicable to the spoken form because (1) as is pointed out in section 4.7.2 geminated consonants cannot occur as a releasing consonant cluster; (2) word-final vowels are always longer than non-word-final vowels (see 6.5(ii)) and (3) vowels in monosyllables are redundantly contrasted in that we get VC: or V:C (see section 8.10.4 on minimal pairs).

(e) Rule 11:- A long vowel is followed by a single consonant at a syllable boundary.

This does not exclude the possibility of a long vowel being unarrested at a syllable boundary.

(f) Rule 16:- In disyllabic words: (1) The long or stressed vowel must be in the first syllable; (2) The long or stressed vowel is separated from the following consonant.

There is certainly a tendency to divide a word into syllables in such a way that, if only one consonant separates the vowels, then the division takes place before the consonant, giving a ...V-CV... structure. However, in the case of an intervocalic CC sequence, it is still possible for the C_1 to act as the arresting consonant of a long vowel, as, e.g.:

/e:l - bu/ <għelbu>
/a:n - ʔu/ <għanqu>

(g) Rule 17:- In disyllabic words, if there is a short vowel in the first division, the syllable is divided after the consonant that follows that vowel; rather, a short vowel attracts to itself the following consonant.

Several words are divided in such a way that the short vowel of the first syllable in a disyllabic word is arrested by the following consonant. However, I find this is not always the case. In fact, the tendency is to achieve a type of structural balance. Thus, we have:

<mixja> /miʃ-ja/
but: <dera> /de-ra/ and <mexa> /me-ʃa/

(h) In fact, this may be the reason why Rule 18 below holds up, rather than it being a simple matter of stress:

Rule 18:- In disyllabic words, with a stressed final syllable, the syllable is divided before the consonant that precedes the stressed vowel.

Rule 19:- Words of more than two syllables follow the same rules as disyllabic words as regards syllable division, i.e. depending on the vowel.

(i) Rule 20:- A long stressed vowel is always followed by only one consonant regardless of which syllable it is in;

Again, this is applicable to the spoken form and is related to the redundancy referred to under (d) above.

Rule 20:- (continued) Short stressed vowels can have two types of stress : a full stress, or a sweet/ light or half stress.

Rule 21:- Fully stressed vowels require two following consonants.

Rule 22:- A half-stressed vowel needs only one following consonant.

Rule 23:- An unstressed vowel also only takes one following consonant.

There seems no reason for distinguishing between stressed, half-stressed and unstressed vowels, since the differences referred to concern vowel length, not stress. To handle these phenomena, a distinction between syllable types such as made by Abercrombie, 1964, is probably more appropriate. The only distinction I wish to make, then, is between a stressed and an unstressed syllable: a syllable in Maltese is either stressed or unstressed. Even if it is possible to identify further degrees of stress, these differences can be accounted for by vowel duration. A long vowel is always fully stressed. A short vowel can be either stressed or unstressed.

4.4. Neglect of the Syllable as a Unit for Linguistic Description

No use has been made of the syllable as a unit for linguistic analysis by previous writers on Maltese except the "Għaqda".

Aquilina (1959, and elsewhere) does not use the syllable to identify vowel and consonant grouping. In fact, he uses orthography to determine the position of vowels as initial, final and interconsonantal without any reference whatsoever to the syllable. Thus, 'initial', 'medial' and 'final' indicate the position of the segments in word, i.e. word-initial, -medial and -final. In cases where the orthography does not show the epenthetic vowel, he dismisses it. Thus, ⟨mqar⟩ /im -ʔa:r/ is considered as having a consonant cluster with /m/ as the initial consonant of the cluster and of the syllable. This is rather a misleading state of affairs where consonant clusters are concerned because no distinction is made between open and closed syllables in the case of disyllabic or trisyllabic words. Thus, a word with the structure CV_1CV_2 is considered as having a V_1 followed by a consonant irrespective of whether the word is divided into:

$$\# CV - CV \# \qquad \text{or} \qquad \# CVC - V \#$$

The only specific reference made to the syllable is in reference to stress and to the fact that no two vowels can occur in the same syllable. This is a statement made on the basis of the diachronic fact that ⟨għ⟩ and ⟨h⟩ originate from segments realised as consonants in Arabic. Synchronically, in Maltese, they are graphemes reminiscent of the origin of certain Maltese words, such as ⟨qiegħed⟩, ⟨bluha⟩, etc. We do, in fact, get words of a CVVC, i.e. CV - VC structure, as has just been pointed out:

⟨qiegħed⟩	/ʔi - et/	with a free variant /ʔi-jet/
⟨bluha⟩	/blu -a/	with a free variant /blu-wa/

Borg (Alexander), in his article "Morphophonemics" (1975) also relates the clustering of consonants to word structure and not to syllable structure to which, in fact, he makes no reference. Thus he, too, considers initial, medial, and final clusters with no distinction between consonant sequences within a single syllable, i.e. 'clusters', and consonant sequences across different syllables within a word, i.e. 'sequences'. For example, /ndr/ is considered as a CCC cluster, and is given the same status as other clusters that can occur within the same syllable though /n/ cannot, in fact, occur as the initial consonant of a consonant cluster within a Maltese syllable.

One possible main reason for neglecting the syllable in Maltese may be that several important processes such as assimilation of voicing, place of articulation, and lip-rounding (or rather, lip movement) are not restrained by syllable division. However, it is important for any phonetic and phonological study of a language to work out the type of syllable structure and consider any possible relationship it may have with other phonological features especially segment duration, consonant clustering permissibility and, at a different but highly relevant level, rhythm.

Phonological studies of Maltese carried out so far disregard the syllable as a unit within which consonants and vowels function[1]. It is assumed implicitly that a syllable is constituted by each of the vowels in an orthographic word, plus the consonants around that vowel. What consonants go with which vowel is ignored. Consonant segments are spoken of simply as word initial, intervocalic or word-medial, and word-final. This seems to indicate that "open" and "closed" syllables are concepts related to the last syllable (if at all) of a word and not to any other syllable within a word.

Since I want to go on later, in section 4.7, to discuss the distribution of consonants in Maltese syllables and in Maltese words, I shall specify the syllables that operate in the language and the syllable structures permitted by the phonology of the language. The sequence of consonants at the boundary of a syllable will be referred to as syllable-releasing clusters and syllable-arresting clusters. These will therefore include only some of the "permissible" consonant sequences mentioned by Aquilina (1959) and Borg (Alexander), (1975). The sequences of consonants occurring at syllable boundaries with a division separating some of the consonants from the others in terms of the syllables they belong to, will be referred to as consonant sequences.

Therefore, consonant sequences occur as a group of consonants with no reference to the syllable to which they belong, whereas consonant clusters are defined by the syllable to which they belong. Segments belonging to different syllables that follow each other will be separated by a dash as in: CVC - CVC /mar-tek/. It will be assumed throughout that 'syllable' refers to the phonetic-phonological syllable and not to the orthographical syllable, if such a unit can be said to exist.

4.5. The Syllable in Maltese

The syllable in Maltese can have the following structure:

$$C_1C_2C_3VC_1C_2$$

or (C)(C)(C)V(C)(C)

The syllable nucleus in a Maltese syllable almost always consists of a vowel. The nasals /m/ and /n/, the lateral /l/ and the tap/trill (see chapter 9) /r/ function differently from other consonants at times: it is possible for them to be syllabic when they occur word initially. This may be a speaker-oriented feature. I have not been able to make any recordings of any Maltese speaker using syllabic /m, n, l, r/. I have caught myself and other native speakers doing so, especially when these segments occur word-initially in discourse-initial position too, i.e. the preceding state of the vocal tract and organs of speech is a non-speech, closed, "rest" mouth state. I hesitate to generalize from such observations, but it does seem to suggest the possibility of /m, n, r, l/ or even one or more of these, occurring optionally as syllabics.

4.6. Conclusion

It might be concluded at this point that it is not necessary to distinguish the syllable at all in terms of segment sequences since the syllable "ownership" is not responsible for what happens to them. However, there is one important way in which consonant sequences are related to the syllable. This is their distribution and grouping. The combinatorial restrictions that distinguish syllable-initial from syllable-final clusters and each of these from the combination of syllable-final clusters with syllable-initial clusters when they occur word-medially are discussed in the next section.

4.7. Consonant Distribution

4.7.1. Data

In this section I want to present a clear idea of the distribution of Maltese consonants in syllables.

Firstly, I will consider the distribution of single and geminated consonants. Geminated consonants can be treated as either long consonants or as consonant clusters. In Maltese, geminated consonants function like consonant clusters in that they can be arresting consonants of short vowels as are consonant clusters; whereas single consonants usually function as the arresting consonants of long vowels. However, they are like single consonants in that they cannot cluster with other consonants. I am considering them here with single consonants since I do not need to deal with the way they relate to other consonants.

All the claims I make about permissible clusters and sequences are illustrated. However, my views about syllable division are based mainly on my own introspection as a native speaker of Maltese and as a phonetician.

4.7.2. Distribution of Single and Geminated Consonants

Figure 4.1. shows the distribution of consonants as single and as geminated consonants. The phonological rules of Maltese will be further discussed in this chapter. All consonants can occur singly in word initial-syllable initial position (figure 4.1., column 1). All consonants can occur in word medial position. However, if they are strictly intervocalic they always occur as releasing consonants of the second syllable of the two syllables involved. Word-medial consonants can only occur syllable-finally

when they occur in a CC sequence, or CCC sequence. In this case, syllable division occurs to separate them into C - C and C - CC (possibly CC - C). This is illustrated in figure 4 .1, column 2. All voiceless and voiced consonants except voiced obstruents can occur in syllable final and word-final position. Voiced obstruents can only occur syllable finally when they occur in a C - C group, i.e. preceding a syllable that has a releasing voiced consonant, that is, they cannot occur word finally. Thus, column 3 could in fact have empty slots for all of the voiced obstruents if they were also to qualify as word-final consonants. Instead they are filled with bracketed items. Strictly speaking, they are syllable-final single consonants too.

No geminated consonant can occur word initially or syllable initially because (1) in Maltese, the geminated consonant in this position is always[1] pronounced with a very short vowel /i/, the epenthetic vowel; (2) geminated consonants in all positions except word finally have dual syllable membership even when the first part operates syllabically. Hence it is both syllable-final and syllable-initial and therefore does not really belong to any one position in toto, as a geminated consonant. However, since word-initially, geminated consonants preceded by /i/ are different functionally from geminated consonants in other positions, they are considered here as word-initial, syllable-initial geminated consonants and illustrated in column 6. But geminated consonants never occur word-initially. No geminated /ʔ/ /h/ /w/ /j/ occur in this position. (/ i___) This is an additional reason for considering this position of gemination.

1. Except for /m/ and /n/ if these are pronounced as syllabics.

All consonants occur geminated word-medially and word-finally. The exception /g/ is one due to a phonological gap rather than permissibility. The word-medial geminated consonant is another case of dual syllable membership. Thus word-medial geminates are never clusters. It is interesting to note that listeners to Maltese who have not heard Maltese spoken before often feel that word-final geminated stop consonants are in fact word-medial. Thus,

/hap:/ C V C : is heard as C V C : V

This is probably due to the length and audible release.

Syllable-initial consonants are also word-initial. Syllable-initial but word-medial consonants occur under "Word-medial single consonants", i.e. Word-medial single consonants are also syllable-initial. Syllable-final consonants are also word-final consonants in the case of the voiceless consonants and /m, n, l, r, w, j, ʔ/. No voiced obstruent consonant (apart from this group) can occur word-finally. However, these can occur word-medially, syllable-finally - usually in consonant groups not intervocalically.[1]

Word-medial geminated consonants are both syllable-final and syllable-initial because they function simultaneously, both as arresting and as releasing consonants in that these are the "geminates" in the strict sense of the term.

Although all the examples of voiceless consonants (and m, n, l, r, w, j) occur both syllable-finally and word-finally, the voiced obstruents do not and are therefore simultaneously both syllable-final and word-medial; they cannot otherwise occur syllable-finally.

1. /tʃ/, /dʒ/ and /ts/ usually occur geminated or in clusters.

Empty "slots" are the result of (a) phonologically possible but unrealized combinations, e.g. word-medial and syllable-final geminated /g/ seems perfectly acceptable but does not actually occur; (b) alternative phonological signalling, e.g. /t + qalleb/, /t + hallas/, /t + warrab/, /t + jassar/ instead of geminating the first consonant.

Figure 4.1.

Maltese words (in phonemic transcription) exemplifying the distribution of the consonant phonemes in various syllable and word structures.

Phoneme	Syllable Initial Single	Word Medial Single	Syllable Final Single	Word Medial Geminated	Syllable Final Geminated	Geminated /# i___
p	pa:-tri	ta-par-si	da:p	tʃap-pa	hap:	ip-po:-za
b	ba-har	se-bah	zib-dʒa	seb-bah	sab-bat	ib-bas-tard-jah
t	te-la	me-ta	ra:t	a:t-ta	hot:	it-tel-la
d	de-ra	a:-da	id-ra	a:d-da	sad-dat	id-dej-jaʔ
k	kel-lu	ri-kep	ra:k	sak-kar	hak:	ik-kal-ma
g	ga:-la	ri^{j}ga dog-ma	ig-gang-na:t	-	-	ig-gang-na:t
ʔ	ʔa:l	sa:-ʔa	sa:ʔ	raʔ-ʔa	daʔ:	-
s	saʔ-si	di-sa	ra:s	mas-sa	hos:	is-saʔ-si
z	zar-bu^{w}n	a:-zel	a:z-la	bez-za	raz-zan	iz-zar-rat
ʃ	ʃe:l	de:-ʃa	hda:ʃ	raʃ-ʃa	faʃ:	iʃ- ar-rap
f	fe-lah	ti-fel	ja:f	saf-fa	saf:	if-fit-ja
v	ve-lu	ba-va:r-ja	ta:v-la	ir-rev:-ja	tiv:-jadʒa	iv-ve-ri^j-fi-ka
ts	tsi^j-ja	ir-tsi:tet	bets-u^{w}n	a:ts:-tsa	mats:	its-tsap-pap
tʃ	tʃa:-ʔa	wer-tʃ:a	na:tʃ	sitʃ-tʃa	a:tʃ:	itʃ-tʃaf-las
dʒ	dʒe:lu	re-dʒa	sidʒ-ra	a:dʒ-dʒel	redʒ-dʒa	idʒ-dʒed-det
h	he-lu	da-hal	ra:h	bah-har	seh:	-
m	moh-hi	a:-ma	ra:m	sem-ma	om:	im-mi^{j}ra
n	na-hal	a:-ni	da:n	a:n-ni	hen:	in-ni
l	li:-ma	a:-la	ba:l	sel-lem	hal:	il-li^{j}ma
r	re-bah	ma-ra	ma:r	bar-ra	mor:	ir-ra:b-ja
w	we-ra	ta-wi:-la	raw	rew-wah	rew-wah	-
j	ja:-ra	a-ju^{w}la	haj	dej-jaʔ	raj-ja	-

4.7.3. Consonant Clusters and Consonant Sequences

Borg (1975) presents three tables with separate lists of what he calls initial, final and medial clusters. As we have already seen, he does not define "cluster" and it is therefore not clear what claims he makes regarding the status of some of his "clusters"[1]. Since he gives no examples, it is unclear whether he always refers to word position (hence "medial clusters"); or whether he sometimes refers to the syllable ("initial and final clusters") and sometimes to the word. Whatever the interpretation, Borg omits some possible combinations of consonants into genuine clusters. For this reason, I am presenting tables with possible clusters and I will then discuss the differences between my tables and Borg's tables. To ensure clarity, I will illustrate every possible consonant-combination that I claim has cluster-status. I will then go on to present word-medial consonant sequences, the members of which belong to two separate syllables and are therefore distinct from clusters in my analysis of consonant distribution.

I will now present the relevant figures illustrating all the possible clusters and sequences in Maltese. I will follow these by some discussion and an attempt to systematize the phonological rules that seem to be at work here.

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1. Whenever "cluster" is written in inverted commas, it indicates the use of the term in some other work, where the distinction between cluster and sequence as defined here is not clear or simply not made.

(i) Syllable-initial and Syllable-final CC Clusters

Figures 4.2 and 4.3 show as many of the syllable-initial and syllable-final CC clusters as I can find. There may be more. Each table is followed by one illustration of each cluster with a gloss in English. Figures 4.4 and 4.5 (and 4.6 later) are a comparison of my tables with those of Borg 1975. They show:

(1) syllable-final CC clusters not listed in Borg but seen in my table;

(2) syllable-initial CC clusters not listed in Borg but seen in my table;

(3) the four syllable-initial CC clusters listed in Borg but not in my tables. Of these, I cannot accept /mn/ and /ml/ as clusters in my definition, i.e. as belonging to one syllable. I could accept the other two but cannot find any example of them.

Figure 4.2.

Syllable-releasing CC clusters and Maltese words (in phonemic transcription) illustrating them.

C_1↓ C_2→	p	t	k	s	f	ʃ	tʃ	ts	b	d	g	v	z	dʒ	ʔ	h	m	n	l	r	w	j
p	–	pt	pk	ps	pf	pʃ	ptʃ	pts							pʔ	ph		pn	pl	pr	pw	pj
t	tp	–	tk		tf										tʔ	th	tm	tn	tl	tr	tw	tj
k	kp	kt	–	ks	kf	kʃ	ktʃ	kts								kh	km	kn	kl	kr	kw	kj
s	sp	st	sk	–	sf	sʃ									sʔ	sh	sm	sn	sl	sr	sw	sj
f	fp	ft	fk	fs	–	fʃ	ftʃ	fts							fʔ	fh	fm	fn	fl	fr	fw	fj
ʃ	ʃp	ʃt	ʃk	ʃs	ʃf	–	ʃtʃ	ʃts	ʃb	ʃd	ʃg	ʃv	ʃz	ʃdʒ	ʃʔ	ʃh	ʃm	ʃn	ʃl	ʃr	ʃw	ʃj
tʃ	tʃp		tʃk		tʃf		–									tʃh	tʃm	tʃn	tʃl	tʃr	tʃw	tʃj
ts			tsk		tsf			–											tsl			
b									–	bd	bg	bv	bz	bdʒ			bm	bn	bl	br	bw	bj
d									db	–	dg	dv					dm	dn	dl	dr	dw	dj
g								gts	gb	gd	–	gv	gz				gm	gn	gl	gr	gw	gj
v									vb	vd	vg	–	vz	vdʒ					vl	vr	vw	vj
z									zb	zd	zg	zv	–	zdʒ			zm	zn	zl	zr	zw	zj
dʒ									dʒb	dʒd	dʒg			–			dʒm	dʒn	dʒl	dʒr	dʒw	dʒj
ʔ	(ʔp)	ʔt		ʔs	ʔf	ʔʃ			ʔb	ʔd			ʔz		–	ʔh	ʔm	ʔn	ʔl	ʔr	ʔw	ʔj
h		ht	hk	hs	hf	hʃ			hb	hd			hz	hdʒ	hʔ	–	hm	hn	hl	hr	hw	hj
m																	–					
n																		–				
l																			–			
r																				–		
w																					–	
j																						–

Figure 4.2 (page 2)

Syllable Releasing CC Clusters

p + C

pt	ptantsa	pittance
pk	pkejt	I cried
ps	psi:pes	chicks
pf	pfa nal	with a lantern
pʃ	pʃi:ʃen	calves
ptʃ	ptʃi:tʃen	chicks
pts	ptsi:tsen	finger-bread
pʔ	pʔi^{j}ja	change
ph	pha:l	like
pn	pni:tsel	brushes
pl	pla:tʃidu	calm
pr	pri:tka	sermon
pw	pwi:ni	sorrows
pj	pja:ga	wound

t + C

tp	tpatti	to pay back
tk	tka:ken	heels (of shoes)
tf	tfejt	I switched
tʔ	tʔi^{j}l	heavy
th	thal:at	to mix
tm	tmi:m	end
tn	tnejn	two
tl	tlaj:a	hills
tr	tru^{w}ʃ	deaf
tw	twejt	I folded
tj	tju^{w}r	fowl

k + C

kp	kpi:pel	hats
kt	ktaj:en	chains
ks	ksu^{w}r	breakages
kf	kfi:f	hems
kʃ	kʃa:ʃen	drawers
ktʃ	ktʃi^{j}na	kitchen
kts	ktsa:tsen	pots
kh	kha:l	to become blue
km	kmi:m	sleeves
kn	kni^{j}sja	church
kl	kli:m	words
kr	kru^{w}a	ugliness
kw	kwi:t	quiet
kj	kjas:	noise

s + C

sp	spa:k	string
st	staha	he was shy
sk	ski:ken	knives
sf	sfar	he became yellow
sʔ	sʔa:ʔ	alleys
sh	sha:n	hot
sm	smajt	I heard
sn	sni:n	teeth
sl	sla:vatʃ	savages
sr	sraʔt	I stole
sw	swar	walls (outside buildings)
sj	sju^{w}f	summers

f + C

fp	fpost	in a place
ft	fti^{j}t	a little
fk	fki:ren	tortoises
fs	fsi:t	spoiling (children)
fʃ	fʃa:r	in a month
ftʃ	ftʃof:	in a bow
fts	ftsaltsa	in a sauce
fʔ	fʔa:r	poor
fh	fhalʔi	in my mouth
fm	fmej:u	in May
fn	fni:k	rabbits
fl	flimki:n	together
fr	fra:k	crumbs
fw	fwi:ha	perfume
fj	fjak:	hungry

ʃ + C

ʃp	ʃpak:a	it burst
ʃt	ʃtu^{w}t	beaches
ʃk	ʃko:ra	sack
ʃs	ʃsa:p	what did he find?
ʃf	ʃfar	brim (pl.)
ʃtʃ	ʃtʃajt	what a joke!
ʃts	ʃtsaltsa	what a sauce
ʃʔ	ʃʔet:	filth
	ʃʔa:l	what did he say?
ʃh	ʃha	what did he take?
ʃm	ʃmu^{w}n	Simon
ʃn	ʃni:at	rumours
ʃl	ʃli:f	fishing line
ʃr	ʃri:k	beams
ʃw	ʃwi:k	thorns
ʃj	ʃju:h	the old
ʃb	ʃbajt	I'm fed up
ʃd	ʃdi:ʔ	jaws
ʃg	ʃgerzu^{w}m	what a throat!
ʃv	ʃve:lu	what a veil!
ʃdʒ	ʃdʒara	what happened?
ʃz	ʃzara	what did he sow?

t + C

tʃp	tʃpa:r	mist
tʃk	tʃki:n	he grew smaller
tʃf	tʃfu^{w}f	bows
tʃh	tʃhat:	I denied
tʃm	tʃmajra	chill
tʃn	tʃni^{j}sa	coal dust
tʃl	tʃla:mi^{j}t	bricks
tʃr	tʃra:ret	rags
tʃw	tʃwi:vet	keys

ts + C

tsk	tsku^{w}k	branches
tsf	tsfun:arija	carrots
tsl	tsla:tsi	sauces

Figure 4.2 (page 3)

b + C

bd	bda:bat	goats
bg	bganga:la	with a double chin
bv	bvelu	with a veil
bz	bzar	pepper
bdʒ	bdʒirja	running
bm	bmára	with a woman
bn	bna:di	sides
bl	blantsuʷn	bud
br	bra:dʒo:la	beef olive
bw	bwi:t	pockets
bj	bjat:	he grew white

d + C

db	dbabar	blotches
dg	dgeddes	to curl up (for warmth)
dv	dvalja	tablecloth
dm	dmiʲja	bloodshed
dn	dnuʷp	sin
dl	dliʲk	ointment
dr	draw:a	habit
dw	dwa:na	customs house
dj	djuʷl	shadows

g + C

gb	gbiʲr	big
gd	gdiʲm	bites
gv	gverta	cover (blanket)
gz	gziʲra	island
*gdz	gdzuts	heaps
gn	gni:des	bulls
gl	gla:len	gallons
gr	griʲf	scratches
gw	gwardja:n	warden

v + C

vb	vbanju	in a bath
vd	vda:l	remains
vg	vgajt	I choked
	vgadʒ:a	in a cage
vz	vzibdʒa	in a bead
vdʒ	vdʒe:lu	in the icing

z + C

zb	zbuʷl	ears of corn
zd	zdi:t	it increased
zg	zgombru	obstruction
zv	zvelt	aware, aroused
zdʒ	zdʒi:t	glass
zm	zmandʒa:t	worn out
zn	zni:t	flint
zl	zli:d a	dimness
zr	zra:ben	shoes
zw	zwi:tʃ	marriage
zj	zja:ra	visit
zdʒ	zdʒi:tʃ	glass

dʒ + C

dʒb	dʒba:ra	poultice
dʒd	dʒdiʲt	new
dʒg	dʒgant	giant
dʒm	dʒmi:l	beauty
dʒn	dʒni:n	garden
dʒl	dʒli:t	quarrel
dʒr	dʒraj:a	happening
dʒw	dʒwi:na:h	wings
dʒj	dʒjufija	cowardice

ʔ + C

ʔt	ʔtaj:a	frights
ʔs	ʔsa:ri	plants
ʔf	ʔfi:f	baskets
ʔ	ʔʃuʷr	peelings
ʔb	ʔbilt	I agreed
ʔd	ʔdumija	oldness
ʔz	ʔzi:ʔes	pigs
ʔh	ʔha:p	prostitutes
ʔm	ʔmiʲs	shirt
ʔn	ʔni:pen	bells
ʔl	ʔlajt	I received
ʔr	ʔras	it grew sour
ʔw	ʔwi:l	idioms
ʔj	ʔja:t	bridle

h + C

hp	htija	blame
hk	hkimt	I reigned
hs	hsa:ra	damage
hf	hfi:f	light
hʃ	hʃuʷna	fatness
hb	hbejt	I hid
hd	hda:r	he became green
hz	hzi:na	bad
hdʒ	hdʒi:tʃ	glass
hʔ	hʔartu	I oppressed him
hm	hmejt	I baked
hn	hni:k	gums
hl	hla:s	payment
hr	hru:ʔ	fire
hw	hwi:net	shops
hj	hja:r	cucumbers

* An interesting example where the voicing of /g/ has influenced the following consonants - the only example I can find.

Figure 4.3.
Syllable-arresting CC clusters and Maltese words (in phonemic transcription) illustrating them.

C1↓ C2→	p	t	k	s	f	ʃ	tʃ	ts	b	d	g	v	z	dʒ	ʔ	h	m	n	l	r	w	j
p	–	pt				pʃ										ph						
t		–																				
k		kt	–			kʃ																
s		st	sk	–		sʃ									sʔ							
f		ft			–	fʃ																
ʃ		ʃt	ʃk			–																
tʃ		tʃt					–															
ts								–														
b									–													
d										–												
g											–											
v												–										
z													–									
dʒ														–								
ʔ		ʔt				ʔʃ									–							
h						hʃ									hʔ	–						
m	mp	mt				mʃ										mh	–					
n		nt	nk				ntʃ											–				
l	lp	lt	lk	lf		lʃ		lts							lʔ	lh	lm		–			
r	rp	rt	rk			rʃ									rʔ	rh	rm	rn		–		
w		wt	wk													wh	wm	wn	wl		–	
j	jp	jt	jk													jh		jn	jl	jr		–

Figure 4.3 (page 2)

Syllable Arresting CC Clusters

p + C

pt	la:pt	I played
ps	haps	prison
pʃ	masa:pʃ	he didn't find
ph	reph	victory

k + C

kt	dlikt	I buttered
ks	a:ks	famine
kʃ	marakʃ	he didn't see you

s + C

st	lest	ready
sk	tosk	poison
sʃ	mahasʃ	he didn't feel
s2	ris2	luck

f + C

ft	ʃaft	shaft
fs	nofs	half
fʃ	mana:fʃ	I don't know

+ C

ʃt	moʃt	brush
ʃk	laʃk	lax

tʃ + C

tʃt	hritʃt	I went out

2 + C

2t	la:2t	I licked
2s	inda2s	equal
2	mada:2ʃ	he didn't taste

h + C

hs	rohs	reduction
hʃ	mara:hʃ	he didn't see him
h2	dah2	laughter

m + C

mp	temp	weather
mt	domt	I lingered
mʃ	ʃemʃ	sun
mh	2amh	wheat

n + C

nt	tʃint	wall
nk	sink	sink
ns	tʃans	chance
nt	gant	hook

l + C

lp	?alp	heart
lt	salt	sudden
lk	palk	stage
ls	fals	false
lf	elf	thousand
lts	polts	pulse
l?	hal?	mouth
lh	melh	salt
lm	kalm	calm

r + C

rt	art	ground
rs	hars	looks
rʃ	mada:rʃ	he didn't turn
r2	er2	root
rn	?arn	horns
rl	karl	Karl

w + C

wt	mewt	death
wk	dawk	those
sh	hawh	peaches
wm	awm	swimming
wn	dawn	these
wl	dawl	light

j + C

jp	ajp	pity
jt	ajt	say
jk	idejk	your hand
jf	dejf	tender
jh	warajh	behind him
jr	tajr	she is jealous
jn	dejn	debt
jl	kejl	measurement

FIGURE 4.4 SYLLABLE RELEASING CC CLUSTERS (not incl. in Borg 1975)

C1↓ C2→	p	t	k	s	f	ʃ	tʃ	ts	b	d	g	v	z	dʒ	ʔ	h	m	n	l	r	w	j
p	–																	pn			pw	
t		–																				
k			–		kf		ktʃ	kts								kh						
s				–		sʃ[1]		⊗														
f	fp				–		ftʃ	fts														
ʃ					ʃf	–	ʃtʃ	ʃts				ʃv	ʃz	ʃdʒ								
tʃ			tʃk				–															tʃj
ts			tsk		(tsf)[3]			–											tsl			
b									–													
d										–												
g											–						gm		gl			gj
v												–	vz								vw	
z													–	⊗				zn				
dʒ										dʒd				–								dʒj
ʔ	ʔp[2]														–							(ʔj)
h																–						
m																	–	⊗	⊗			
n																		–				
l																			–			
r																				–		
w																					–	
j																						–

1. This is [ʃ:] usually, except in very careful speech.
2. This is often used instead of /pʔ/ in colloquial speech.
3. Only in /tsfun:arija/ which is usually pronounced [tsun:arija]

FIGURE 4.5 SYLLABLE ARRESTING CC CLUSTERS (not incl. in Borg 1975)

C_1 \ C_2	p	t	k	s	f	ʃ	tʃ	ts	b	d	g	v	z	dʒ	ʔ	h	m	n	l	r	w	j
p	–																					
t		–																				
k		kt	–																			
s				–		sʃ[1]																
f		ft			–																	
ʃ		ʃt				–																
tʃ		tʃt					–															
ts								–														
b									–													
d										–												
g											–											
v												–										
z													–									
dʒ														–								
ʔ		ʔt													–							
h																–						
m		mt															–					
n																		–				
l					lf														–			
r																				–		
w		wt	wk													wh	wm	wn	wl̥		–	
j	jp	jt	jk													jh		jn	jl	jr		–

1. See Footnote 1 under Figure 4.4

(ii) Word-Medial CC sequences

Figure 4..6 shows CC groups that occur word-medially in Maltese. Syllable division dismisses these groups from qualifying as CC clusters. From this, it is immediately clear that there are not as many combinatorial limitations on CC sequences as there are on syllable-initial or syllable-final clusters. Examples of each possibility follow the table. In addition, examples of word juncture CC groups are given to show that there are very few combinatorial restrictions of consonant sequences across syllable boundaries. It is possible that some of the gaps could be filled by words already in use in the language but which have not come to my attention.

Figure 4 .7 is a comparison of my table of word-medial groups with Borg's word-medial clusters.

FIGURE 4.6A

Word-medial CC sequences[1] and Maltese words (in phonemic transcription) illustrating them

C_1↓ C_2→	p	t	k	s	f	ʃ	tʃ	ts	b	d	g	v	z	dʒ	ʔ	h	m	n	l	r	w	j
p	–	pt	pk	ps		pʃ	ptʃ								pʔ	ph		pn	pl	pr		pj
t	tp	–	tk		tf										tʔ	th	tm	tn	tl	tr	tw	tj
k	kp	kt	–	ks	kf	kʃ	ktʃ									kh	km	kn	kl	kr	kw	kj
s	sp	st	sk	–	sf										sʔ	sh	sm	sn	sl	sr	sw	sj
f		ft	fk	fs	–	fʃ	ftʃ								fʔ	fh	fm	fn	fl	fr	fw	fj
ʃ	ʃp	ʃt	ʃk		ʃf	–									ʃʔ	ʃh	ʃm	ʃn	ʃl	ʃr	ʃw	ʃj
tʃ	tʃp	tʃt	tʃk	tʃs	tʃf		–									tʃh						
ts[2]								–									tsm	tsn				tsj
b									–	bd			bz	bdʒ				bn	bl	br		bj
d									db	–							dm	dn	dl	dr	dw	dj
g									gb	gd	–	gv	gz				gm	gn	gl	gr	gw	
v										vd	vg	–	vz	vdʒ			vm	vn	vl	vr		vj
z									zb	zd	zg	zv	–	zdʒ			zm	zn	zl	zr	zw	zj
dʒ									dʒb	dʒd			dʒz	–			dʒm	dʒn	dʒl	dʒr	dʒw	dʒj
ʔ	ʔp	ʔt		ʔs	ʔf	ʔʃ	ʔtʃ		ʔb	ʔd			ʔz		–	ʔh	ʔm	ʔn	ʔl	ʔr	ʔw	ʔj
h		ht	hk	hs	hf	hʃ			hb	hd			hz		hʔ	–	hm	hn	hl	hr	hw	hj
m	mp	mt	mk	ms	mf	mʃ	mtʃ	mts	mb	md	mg	mv	mz	mdʒ	mʔ	mh	–	mn	ml	mr	mw	mj
n	np	nt	nk	ns	nf	nʃ	ntʃ	nts	nb	nd	ng	nv	nz	ndʒ	nʔ	nh	nm	–	nl	nr	nw	nj
l	lp	lt	lk	ls	lf	lʃ		lts	lb	ld		lv	lz	ldʒ	lʔ	lh	lm	ln	–		lw	lj
r	rp	rt	rk	rs	rf	rʃ	rtʃ	rts	rb	rd	rg	rv	rz	rdʒ	rʔ	rh	rm	rn	rl	–	rw	rj
w		wt	wk	ws	wf	wʃ	wtʃ		wb	wd			wz	wdʒ	wʔ	wh	wm	wn	wl	wr	–	
j	jp	jt	jk	js	jf	jʃ	jtʃ		jb	jd			jz		jʔ	jh	jn	jn	jl	jr	jw	–

1. These are analysed as belonging to different syllables
2. This is very limited in its distribution, probably because of its recent introduction into the language.

Figure 4.6A (page 2)

Word-Medial CC Sequences

p + C

pt	sipta	I found it
pk	ʃipka	net
ps	i:psa	hard
pʃ	timpʃu	she teases him
pt	captʃiʲp	clapping
pʔ	tipʔa:	don't stay
ph	sepha	rising
pn	tapnuh	they tainted it
pl	tiplak:a	to plug
pr	tipri:tka	you preach
pj	tipja:na	you plan

t + C

tp	jitper:etʃ	he exposes
tk	titker:ah	you grimace
tf	titfiʲʃ	dont't switch off
tʔ	jitʔa:l	it grows heavy
th	jithol	he goes in rhythm
tm	ritmu	rhythm
tn	titnia	you fold it
tl	titlop	you pray
tr	lit:ra	the letter
tw	titwa:l	you grow tall
tj	titjiʲr	flying

k + C

kp	mikpi	(from 'mipki', missed)
kt	tiktep	you write
ks	tiksi	you cover
kf	tikfiʲn	burial
k	mikʃuf	uncovered
kt	tʃektʃek	to shake s.th.
kh	tikha:l	you grow blue
km	rakmu	embroidery
kn	rokna	corner
kl	takliʲf	compliments
kr	jokrop	he moans
kw	**matikwi**ʲʃ	it isn't very hot
kj	tikjiʲl	measurements

s + C

sp	jispa:ra	he shoots
st	jisten:a	he waits
sk	jisker	he gets drunk
sf	jisfa:r	he grows yellow (pale)
sʔ	tisʔi	you water
sh	tishet	you curse
sm	tisma	you listen
sn	tisniʲt	overbaking
sl	basla	onion
sr	tisraʔ	you steal
sw	jiswi:t	it grows black
sj	tisjiʲr	cooking

f + C

ft	jiftah	he opens
fk	tifkiʲr	remembrance
fs	jofsoʔ	to break an egg
fʃ	jifʃel	he confuses
ft	tʃiftʃi:ʔa	a tender blade of grass
fʔ	nifʔa:r	I become poor
fh	tifhiʲr	praise
fm	nifmu	we understand
fn	jifni	he wears out
fl	jiflet	he maims
fr	jofroʔ	to divide
fw	tifwi:h	perfume
fj	ifjen	finer

+ C

ʃp	jiʃpak:a	to burst
ʃt	jiʃtri	he buys
ʃk	liʃki:l	obstacle
ʃf	liʃfa:r	the edges
ʃʔ	a:ʃʔa	pleasure
ʃh	jiʃhet	he throws
ʃm	tiʃmiʲra	turn over (clothes)
ʃn	foʃna	fork
ʃl	tiʃliʲl	tacking
ʃr	tiʃraʔ	you choke
ʃw	tiʃwiʲʃ	don't toast
ʃj	jiʃji:h	he grows old

t + C

tʃp	patʃpiʲtʃ	chatting
tʃk	ʔatʃtu	to break
tʃk	jitʃki:n	he grows smaller
tʃs	itʃsma	bodies
tʃf	itʃfna	galleys
tʃh	nitʃhat	I deny

ts + C

tsm	ib:altsma:t	embalmed
tsn	tartsna	docks
tsj	antsja:n	elderly

b + C

bn	tibniʲʃ	don't build
bl	dublet:	skirt
br	tobrom	don't twist
bj	abjat	white
bd	ebda	none
bz	tibza:	don't be afraid
bd	zibdʒa	bead

d + C

dm	a:dma	bone
dn	ridna	we wanted
dl	tidlek	you grease
dr	tidra	you get used to
dw	tidwi	you dress a wound
dj	ʔadja	an errand
db	tidbi:l	it withers

Figure 4.6A (page 3)

g + C

gm	gemgmu	they grumbled
gn	ma:gna	machine
gl	ingli^{j}s	English
gr	ti^{j}gra	tiger
gw	rigwart	regarding
gb	tigber	you grow
gd	tigdem	you bite
gv	tigverna	you rule
gz	jugza	he accuses

v + C

vn	venvnu	they fling
vl	ta:vla	plank
vr	ba:vru	collar turnover
vj	tivjadʒ:a	you travel
vd	tavda:	don't trust
vg	jivga	he chokes
vz	avza:h	he warned him
vdʒ	a:vdʒu	he squashed him

z + C

zm	jizma:ga	he goes mad
zn	razna	discipline
zl	izloʔ	slide
zr	tizra	you sow
zw	gezwer	to wrap
zj	izjet	more
zb	jizbalja	he errs
zd	tizdi:t	it increases
zg	tizgar:a	you go out of time
zv	jizvojta	it empties
zd	nizdʒa	weaving

d + C

dʒm	tidʒma	you collect
dʒn	a:dʒnita	she kneaded it
dʒl	a:dʒlu	they hurried
dʒr	tidʒri	you run
dʒw	gedʒwid i^{j}ja	confusion
dʒj	midʒjup	respected
dʒb	tidʒbor	you collect
dʒd	tidʒdi^{j}m	leprous
dʒz	midʒzus	sheared

ʔ + C

ʔp	tiʔpa	from 'tipʔa', to stay
ʔt	taʔta:	don't cut
ʔs	saʔsi	ask
ʔf	aʔfel	lock
ʔʃ	taʔʃi^{j}r	peeling
ʔt	taʔʧi^{j}t	lopping
ʔh	taʔhi^{j}p	impudence
ʔm	aʔmi^{j}l	breeding (of lice)
ʔn	daʔna	beard
ʔl	taʔli	you fry
ʔr	taʔra:	don't read
ʔw	aʔwa	better
ʔj	taʔji^{j}s	measurement
ʔb	taʔbel	it matches
ʔd	taʔdi	you run an errand for s.o.
ʔz	moʔzi:s	dirt

h + C

ht	tahti	it's not your fault
hk	tahkem	you rule
hs	tahsil	don't wash
hf	jahfer	he forgives
hʃ	jihʃi:n	he grows fat
hʔ	jahʔar	he ill-treats
hm	jihma:r	he grows red
hn	johnoʔ	he chokes s.o.
hl	tohloʔ	you create
hr	jahrap	he escapes
hw	lahwa	the brothers (sisters)
hj	tahji^{j}r	
hb	tahbi	you hide s.th.
hd	tihda:r	you grow green
hz	ahzen	you store

m + C

mp	timpa:na	maccaroni pie
mt	imta:ten	sheep
mk	imki:n	nowhere
ms	hamsa	five
mf	ʔamfu^{w}t	hedgehog
mʃ	tomʃot	to comb
mt	imtʃarʧar	dripping
mt	imtsaptsap	lamed
mʔ	imʔa:r	if only!
mh	imha:r	limpets
mn	do:mna	medallion
nl	timla	you fill
mr	timrat	you become ill
mw	limwi:t	death
mj	kamju^{w}n	camion
mb	timbot:a	you push
md	mimdu^{w}t	lying down
mg	gemgem	to grumble
mv	imvenven	flung
mz	e:mzu	he winked at him
mdʒ	imdʒi:ba	behaviour

n + C

np	tinptu	she teases him
nt	tinten	you smell!
nk	tinket:	you take offense
ns	tinsa	you forget
nf	tonfoh	you blow
nʃ	tonʃor	you hang (clothes)
nʧ	tinʧensa	you incense
nʔ	tinʔafel	it can be locked
nh	jinhap	he is loved
nm	inmar:at	I make s.o. ill
nl	ki:nlu	it was (for him)
nr	inrab:i	I breed
nw	tinwi^{j}r	blossoming
nj	tinjo rah	he ignores him
nb	tinbot:a	you push
nd	jindahal	he interferes
ng	jingan:a	he cheats
nv	invel:	spirit level

Figure 4.6A (page 4)

nz	tinza	you undress
ndʒ	tindʒibet	you are attracted

l + C

lp	alpaka	type of goat
lt	tiltaʔa	you meet
lk	alka	alka
ls	helsi:n	freedom
lf	telfa	loss
lʃ	alʃejn	for nothing
lts	baltsami^{j}na	balsam
lʔ	tilʔa	welcome
lh	melha	salt (met.)
lm	jilmah	he notices s.o.
ln	kelna	we had
lw	jilwi	he twists
lj	taljo:la	pulley
lb	albumi^{j}na	albumen
ld	soldi	pennies (money)
lv	salvatʃ:	savage
lz	ilzaj:ar	a small sheet
ldʒ	aldʒebra	algebra

r + C

rp	orptu	tie him
rt	artab	soft
rk	jo:rku	they rub (wash)
rs	jersaʔ	he approaches
rf	jerfa	he lifts
rʃ	jirʃoʃta	he rises
rt	artʃipri:t	archpriest
rts	irtsi:tset	farms
rʔ	jorʔot	he sleeps
rh	jerhi	the colours run
rm	tarmi^{j}ʃ	don't throw away
rn	ʔarni^{j}ta	octupus
rl	arlotʃ	watch
rw	irwi:h	souls
rj	irju^{w}s	heads
rb	a:rbi	Arab
rd	tordom	get buried
rg	argument	argument
rv	serva	it was useful for ...
rz	jirzah	he feels cold
rdʒ	jerdʒa	he repeats

w + C

wt	awtu^{w}r	author
wk	tawkom	they gave you
ws	bewsa	kiss
wf	sewfu	they ruffled s.th.
wʃ	bawʃa:ta	picnic
wtʃ	awtʃi	Gozitan
wʔ	dewʔuh	they let him taste s.th.
wh	imrewha	fan
wm	tewmi^{j}n	twins
wn	tawni	they gave me
wl	tawluh	they lengthened it
wr	awra:ta	gilt head
wb	tewba	penance
wd	sewdu	they blackened s.th.
wz	dʒewza	nut
wdʒ	tawdʒu	you twist

j + C

jp	it:ajpja	he typed
jt	bejta	nest
jk	ajkla	eagle
js	dajsa	boat
jf	dajfi^{j}n	weak
jʃ	tajʃu	you live
jtʃ	lajtʃi	laity
jʔ	dejʔa	narrow
jh	ptejha	a little yard
jm	ajma	ouch! (hurt)
jn	tajnu	you help him
jl	bejli^{j}k	governorship
jr	tajru	they flew s.th.
jw	tajwa:n	Taiwan
jb	tajba	good
jd	tajdu	you say
jz	bejzu	corpulent

FIGURE 4.6B

CC sequences across words and the Maltese words (in phonemic transcription) illustrating them

pf	sa:pfa:na:l	he found a lantern
pw	sa:pwarda	he found a rose
pm	sa:pmara	he found a woman (wife)
kʔ	takʔampi:na	he gave you a bell
sʃ	has:ʃadiʲna	he felt a monkey
stʃ	has:tʃana	he felt a plane (tool)
fp	ja:fproverbju	he knows a proverb
ʃs	mara:hʃsa:bi:h	he didn't consider it beautiful
ʃtʃ	mara:ʃtʃa:r	he didn't see it clearly
tʃʔ	mara:tʃʔarniʲta	she didn't see an octupus
tʃm	mara:tʃmartel:	she didn't see a hammar
tʃn	mahatʃnasplą	I didn't take a fruit (like plum)
tʃl	makiltʃlumiʲa	I didn't eat a lemon
tʃr	makiltʃrum:i:na	I didn't eat a pomegranate
tʃw	marajtʃwahda	I didn't see one
tʃj	mari:tʃjahdem	he didn't want to work
ʔk	sa:ʔkarots:a	he drove a car
ʔts	da:ʔtsun:arija	he tasted a carrot
ʔg	da:ʔgami:ma	he tasted a turtle dove
ʔv	dahaʔvilment	he laughed vilely.
ʔdʒ	daʔdʒellewza	he tasted a walnut
hp	ta:hpa:lju	he gave him a fan
htʃ	ra:htʃuʷtʃ	he considered him an idiot
hts	ra:htsop:	he saw he was lame
hg	ta:hga:mi:ma	he gave him a turtle dove
hv	ra:hviʲli	he saw he was mean
hdʒ	ta:hdʒewza	he gave him a hazelnut
ltʃ	hal:tʃa:r	clear vinegar
lr	id:el:ri:saʔ	the shadow is approaching
lg	dʒol:gandot:	in the pot hole
wp	rawpastarda	they saw a cauliflower
wts	rawtsop:	they saw a lame man
wj	sawjasal	he can get to this point
wg	rawga:mi:ma	they saw a turtle dove
wv	rawvojt	they felt an emptiness
jts	rajtsop:	a lame shepherd
jg	majgerfiʃ:	he doesn't confuse
jv	majvarja:ʃ	it doesn't vary
jdʒ	majdʒiʲpʃ	he doesn't bring
tsp	matspitatsi	a pile of exercise-books
tst	gotstoʔop	many holes
tsk	matskarti	a stack of papers
tsf	matsfigol:i	a pile of easter cakes
tsʃ	matsʃwi:k	a heap of thorns
tstʃ	gotstʃwi:tʃ	several idiots
tsʔ	gotsʔta:tes	many cats
tsm	gotsma:gni	many machines
tsn	gotsnahal	many bees
tsl	gotslinef	many chandaliers
tsr	gotsramel	a lot of sand
tsw	gotswirdi:n	several cockroaches
tsj	gotsja:li	scalding (colloq.)

FIGURE 4.7.

Summary of the differences of consonant sequence and cluster classification between Borg 1975 and the present study.

C1↓ C2→	p	t	k	s	f	ʃ	tʃ	ts	b	d	g	v	z	dʒ	ʔ	h	m	n	l	r	w	j
p	–	pt		ps		x	x								pʔ	x		pn	pl	pr		pj
t	tp	–	tk		tf										tʔ	th	tm	tn	tl	tr	tw	tj
k	x	kt	–	ks	x	kʃ	x									kh	km	kn	kl	kr	kw	kj
s	sp	st	sk	–	sf										sʔ	sh	sm	sn	sl	sr	sw	sj
f		ft	x	fs	–	x	x								fʔ	x	x	fn	fl	fr		fj
ʃ	x	ʃt	ʃk		ʃf	–									ʃʔ	x	x	ʃn	ʃl	ʃr	ʃw	ʃj
tʃ	x	tʃt	x	x	tʃf	x	–									x			tʃl		tʃw	
ts								–									x	x				x
b									–	bd			x	bdʒ				bn	bl	br		bj
d									db	–							dm	dn	dl	dr	dw	dj
g									x	x	–	x	x	gdʒ			x	gn	x	x	x	
v										x	vg	–	vz	vdʒ				x	vl	x		x
z									x	zd	x	x	–	x			zm	zn	zl	zr	x	zj
dʒ									dʒb	x			x	–			x	dʒn	dʒl	dʒr	x	dʒj
ʔ	x	ʔt		ʔs	x	ʔʃ	x		ʔb	ʔd			x		–	x	ʔm	ʔn	ʔl	ʔr	ʔw	x
h		ht	x	hs	hf	hʃ			x	x			x		hʔ	–	hm	hn	hl	hr	hw	hj
m	mp	mt	mk	ms	mf	mʃ	x	x	mb	md	x	x	mz	mdʒ	mʔ	mh	–	mn	ml	mr	mw	mj
n	x	nt	nk	ns	x	nʃ		x	x	nd	ng	x	nz	ndʒ	nʔ	nh	x	–	nl	x	nw	nj
l	lp	lt	lk	ls	lf	lʃ		lts	lb	ld		x	x	x	lʔ	lh	lm	ln	–		lw	lj
r	rp	rt	rk	rs	rf	rʃ	rtʃ	x	rb	rd	rg	rv	rz	rdʒ	rʔ	rh	rm	rn	rl	–	rw	rj
w		x	x	x	x	x	x		x	x			x	x	x	x	x	x	x	x	–	
j	x	x	x	x	x	x	x		x	x			x		x	x	x	x	x	x	x	–

Summary of different classifications - Borg 1975 and the present study.
(1) Borg's Medial "clusters" (i.e. sequences) are written in, e.g. /pt/ , /ps/ , etc. (2) Borg's Syllable-Initial clusters are indicated by [/] ; Borg's syllable-Final clusters are indicated by [⁄] ; (3) [x] is considered as a word-medial sequence in my study. /t l/, /t w/ and /gd / are not included in my classification.

4.7.4. Classification of consonants according to their combinational restrictions

The clustering of consonants within a CC releasing or arresting structure is very flexible for almost all consonants. However, in talking about syllable structure, and, specifically, consonant clusters, it seems useful to use the following consonant classification or groupings because of their differing distributional restrictions:

1. The potential syllabics - /m/, /n/, /l/, /r/
2. The semi-vowels - /w/, /j/
3. The voiced obstruents:-
   (a) stops - /b/, /d/, /g/
   (b) the fricatives: /v/, /z/, /ʃ/ (the allophone [ʒ])
   (c) the affricate - /dʒ/
4. The voiceless obstruents:-
   (a) stops - /p/, /t/, /k/
   (b) fricatives - /s/, /f/, /ʃ/
   (c) affricates - /tʃ/, /ts/
5. The "isolates" - /ʔ/ and /h/.

The justification for this grouping should be clear from the clustering possibilities and restrictions presented in figures 4.1 to 4.3.

In accordance with the strict rule that determines the harmony of a consonant cluster in terms of voicing, consonants can cluster together only with members of their own group in the case of groups 3 and 4 (the obstruent classes). No inter-class clusters can occur. No group 3 and 4 consonant sequence (not just clusters) can occur unless separated by a pause.

Occasionally, some devoicing of /m/, /n/, /r/ and /l/ occurs (see section 9.3). These consonants are classified apart from the members of groups 3 and 4 because, although they sometimes participate in the voicing harmony rule, they are not restricted in the same way: they can cluster with members of both groups. Neither do they have the same flexibility in clustering as these sounds have. /ʔ/, for example, does not occur preceding /k/ or /j/ or /h/.

/m/, /n/, /l/, /r/ can occur as C_1 only in syllable-final CC clusters; in word-initial position they can function syllabically or are preceded by a very short epenthetic vowel /i/.

4.7.5. Word-Medial CC Sequences that do not occur

Some of the 'empty' word-medial CC sequences are similar in that the two phonemes are very close to each other in terms of place of articulation and in stricture.

1. Labial stops or approximants:- p + m   b + m   b + w   p + w   w + p

2. Alveolar fricatives:- ʃ + s   s + ʃ   (usually realized [ʃ:] in any position)

However, some consonants are simply not very productive:

/g/ Thus we have no:

l + g
j + g
b + g
w + g
ʔ + g
h + g {possibly for other reasons}
dʒ + g

/dʒ/

d + g {possibly for other reasons}
dʒ + v
l + dʒ
h + dʒ
j + dʒ
g + dʒ

/tʃ/

tʃ + s
tʃ + ?
tʃ + m
tʃ + n
tʃ + l
tʃ + r
tʃ + w
tʃ + j
h + tʃ
l + tʃ
s + tʃ

Other "odd ones out" are v + m, m + v, j + v - possibly /v/ cluster difficulties-and h + p.

It may be important to note that some groups do not work out both in their voiced and unvoiced "version" and as first or second element. Thus, there is no:

(1) f + p   v + b
    p + f   b + v

(2) kʔ   ʔg
    ʔk

(3) wp   bw
    pw

(4) vw
    wv

(5) ltʃ
    tʃl

(6) gdʒ
    dʒg

Yet many of these operate as word-initial clusters.

In general, therefore, it can be said that the groupings that are permissible as syllable-initial consonant clusters can function as well in word-medial consonant groupings ((a) below), whereas those that are not also syllable-initial clusters are unlikely or non-permissible as word-medial groupings ((b) below).

4.7.6. CCC Clusters and Sequences

(i) Borg's list of CCC "clusters"

The following is the list of CCC clusters as given by Borg (1975):

(a) Initial Clusters:

spt   spl   stʔ   stm   str   spr   stf   ʃtr   zbr

(b) Medial Clusters:

spl	str	skr	stl					
ʃtr	ʃmʃ							
rpr	rpt	rtr	rkr	rbl	rdn	rgr	rʔn	rwr
rʦj								
lbl	ldr	lsn	lmt					
ʔbl	mpj	tʃsm						
ndb	nth	ntr	nkw	nʔl	ndl	ndr	ngw	

(c) No final CCC clusters.

(ii) <u>CCC clusters beyond the initial clusters listed by Borg above</u>

Several other clusters beyond the initial clusters listed by Borg above actually occur in Maltese words. Fig.4.8 p.78 is an attempt to extend the above list to cover more possibilities. However, there are no medial CCC clusters according to my definition, since there is a tendency to split up all word-medial consonant sequences (even CC) to allow a closed syllable to precede a consonant released syllable, i.e. VC - CV seems a more preferable structure than VCC - V or V - CCV . This occurs even when related words consist of the same CC or CCC cluster.

E.g.: ʃtraj-na but miʃ-tri
ʔti^{j}l but maʔ-tu^{w}l.

CCC clusters only occur syllable-initially (and word-initially only) in Maltese. A formula that would reflect the structure of a conservative estimate of possible CCC clusters would be as follows - on condition that the obstruents harmonize with each other in voicing:

C_1	C_2	C_3
Fricative	Oral Stop or Labio dental fricative	Any consonant but usually a sonorant

However, CCC clusters are not very common in Maltese. The examples:-

(1a) /s/ + /p/ + /t/
/n/
/l/
/r/
/j/

(1b) /s/ + /t/ + /f/
/ʔ/
/m/
/r/

(1d) /s/ + /f/ + /l/
/r/

(1c) /s/ + /k/ + /f/
/r/
/w/
/j/

(2) /z/ + /b/ + /r/
/d/

(3) /ʃ/ + /p/ + /r/
/t/

These clusters are exemplified in the following examples:-

(1a) spta:r
spna:r
splengu^{w}n
sprej
spje:ga

(1b) stfajt
stʔar:i^{j}ja
stmajt
stramp

(1c) skfajna
skra:pan
skwer:a
skjaf:

(1d) sflask
sfrat:u

(2) zbriʃ:
zdraj:a:t

(3) ʃpru^{w}n
ʃtrajt

These examples do not include cases in which C_1 is a labial stop; nor does it account for all the fricatives as C_1 , the oral stops as C_2 or any consonant as C_3.

These are always the particles <bi> <xi> <fi> which are realised phonemically as follows when they assimilate with the consonant clusters that follow:

/b/ /p/ /ʃ/ (also [ʒ]) /f/ /v/.

This extends the CCC clusters in Maltese to:

C_1		C_2 C_3
Any Fricative or Labial Oral Stop	+	<u>Any</u> CC cluster allowed as a <u>releasing CC cluster</u> in Maltese, as shown in figure 4.2.

Since there is no exception to this rule, I will not illustrate these potential clusters. It is important to note, however, that because CCC clusters are not common in Maltese, most speakers will not use the assimilated forms of the particles when there is already a CC cluster. They usually opt for a 'fuller' form, using, for example /ʃipsi:pes/ instead of /ʃpsi:pes/, and so on.

I have already said that the structure of the Maltese syllable is (C)(C)(C) V (C)(C). Moreover, I have indicated that when a choice is provided, the speaker usually opts for the simpler structure (a) introducing the 'epenthetic' vowel /i/ when it is possible to separate the initial cluster into 2 syllables as in /ʃi/ + /fli:ʃken/ instead of /ʃfli:ʃken/; (b) dividing the cluster so that the consonants belong to different syllables when the arresting CC occurs word-medially (see section on Syllable Division, p. 79.

(iii). <u>CCC Sequences in word-medial position</u>

There are several possible combinations of consonants into a CCC structure in word-medial position. One quite common combination uses the same consonant in C_1 and

C_3 position with C_2 frequently being a stop, but not necessarily so. Thus we have:

iteptpu	ibaʔpʔu	
itektku	ibezbzu	
igelglu	igedʒwdʒu	
itemtmu	ihaʃwʃu	
izanznu	ipatʃptʃu	ipespsu
iparpru	isefsfu	ibezbzu
iwerwru	ipahphu	

Most consonants can occur as C_1 in a mixed sequence[1]. There are some distributional restrictions. Thus, there are no /ʃmʃ/ clusters, but /ʃimʃ/ as in /meʃimʃu/.

1. A mixed sequence is one where no two consonants are the same.

FIGURE 4.8

CCC sequences and the Maltese words (in phonemic transcription) illustrating them

C_1		C_2		C_3	
p	siptlu	p	naspla	p	iteptpu
t	nithlu	t	siptlu	t	jiʃhtu
k	niksru	k	niskru	k	lastku
s	naspla	s	niksru	s	ikewksu
f	tifʃlu^{w}ʃ	f	itʃfna	f	insefsfu
ʃ	miʃtri	ʃ	tifʃlu^{w}ʃ	ʃ	nimpʃu
tʃ	itʃfna	tʃ	tʃartʃru	tʃ	patʃptʃu
ts	......	ts	artsnel:a	ts	.....
h	nahdmu	h	jiʃhtu	h	jisthu
ʔ	jaʔblu	ʔ	inʔlajt	ʔ	nistʔar:u
l	nilmhu	l	......	l	naspla
m	nimpʃu	m	nilmhu	m	nahdmu
n	jindbu	n	......	n	artsnel:a
r	martri	r	......	r	mastrudaʃ:a
j	bajtra	j	......	j	nispje:ga
w[1]	ihaʃwʃu	w[1]	werwru	w	inkwi:t
b	nibdlu	b	jaʔblu	b	indbu
d	jidblu	d	nahdmu	d	jitʃhdu
g	nigdbu	g	nirgbu	g	.....
z	nizbra no:m	z	izanznu	z	ibezbzu
v	izavzvu	v	venvnu	v	izavzvu
d	gedʒwdʒu	d	bendʒlu	d	gedʒwdʒu

1. Phonetically [ihaʃʃ$_{W}$ʃu] , [werr$_{W}$ru] .

4.7.7. Syllable Division

Figure 4.6. shows CC sequences that occur word-medially in Maltese. We saw how syllable division dismisses these sequences from qualifying as clusters. Figure 4 .8. also shows how all word-medial CCC groups are broken up into a single consonant that arrests the previous syllable and a CC cluster that releases the following syllable. This is significant in terms of the tendency to divide syllables up into patterns, one pattern being more "congenial" or favoured than another.

Thus, we have, in the case of a single medial consonant:

(1) 0 - C

(2) C - 0

where pattern (1) is usually chosen in preference to pattern (2).

When there are two intervocalic consonants or a geminated consonant, we get syllable divisions in the following order of preference:

(1) C - C (always in the case where $C_1 - C_2$, i.e. geminated)

(2) 0 - CC

(3) CC - 0

With a three-consonant sequence occurring inter-vocalically, we get:

(1) C - CC

(2) CC - C

but never 0 - CCC or CCC - 0.

These preferences indicate an attempt to maintain the first of two syllables as open if it is not possible to balance out into a C - C structure. This seems to work out quite consistently with all of the examples of consonant sequences already given. Vowel length and stress are not, in any way, clues to syllable division.

Additional confirmation of this tendency is the fact that the sonorant group /m, n, l, r, j, w/ cannot occur as C_2 of a CCC sequence, thus following the same restriction as those in a CC word-initial cluster. In other words, CCC group is divided here into C - CC where C_2 becomes the first C of the syllable-initial CC cluster.

One syllable division problem occurs with the CCC clusters where $C_1 = C_3$ in the cases of C_2 being /m/ and /w/ allowed only in restricted CCC contexts. (See Figure 4.8.) It seems here that the medial consonant constitutes a separate syllable in some pronunciations. Usually, however, the least used option is used here, namely CC - C. Thus,

/ˈmerm-ru/ /ˈwerw-ru/

In the case of medial /w/, when a native speaker is asked to pronounce the word as two separate syllables, silence follows the /r/ sound, but the lips are protruded as for /w/ and a duration roughly equivalent to a short consonant elapses before the final /r/ is pronounced as [wer-w̥-ru] .

Thus, no CC cluster in medial-word position contravenes any CC syllable-initial rule when a C - CC division occurs. A CC - C division, in fact, is opted for when the last two consonants cannot occur as syllable-initial clusters but can occur as syllable-final clusters.

PART III

VOWELS

This part is divided into four chapters. Chapter 5 consists of a phonetic description of the Maltese vowels. It is divided into seven main sections. I discuss the references made to the phonetic quality of the vowels in previous analyses and to the transcription of the vowels. A discussion of the different approaches to the description of vowels appears in Appendix A. The vowel phonemes and their variants are presented first in auditory terms within the Cardinal Vowel System. This is followed by a verbal description of vowel production. A discussion of the terms laxness and tenseness is also included with reference to the Maltese vowels. Special reference to the more problematic phonemes /i^j/, /u^w/ and /iː/ as monophthongs concludes this chapter.

Chapter 6 is a study of the duration of the vowel phonemes of Maltese with special reference to certain contexts that were hypothesised as influencing vowel duration.

Chapter 7 is a brief acoustic study of the monophthongs.

Chapter 8 describes the use made of the acoustic data to synthesize sets of words to test the relative importance of formant structure and duration in native speaker's perception of vowels.

As already mentioned, Appendix A consists of a discussion of methods used to describe vowels in other general phonetic studies relevant to chapter 5. Appendix B is the data used in the study of duration in chapter 6. Appendix C presents the background to the speech synthesis experiment in chapter 8. Appendix D 1 describes the pilot experiment preceding that described in chapter 8. Appendix D 2 consists of the statistical results of the perception test and Appendix D 3 consists of the tabulated results of the perception test in terms of the subjects' responses.

Chapter 5

Vowels : General Phonetic Description

5.1. Introduction

Contrary to what has been said by previous writers, my studies of the phonetics of Maltese vowels indicate that phonetically, there is both a quantitative and a qualitative distinction amongst the eleven monophthongal phonemes in stressed syllables. Duration plays a very important role in the perception of stressed vowels by native speakers of Maltese, but there are also important qualitative differences which cannot be overlooked. The results of the perception test discussed in chapter 8 seem to confirm this view by indicating that (a) the formant structure of the close vowels /i^{j}/, /i:/, /i/, /u^{w}/, /u/, may be more important in recognising the vowels than is the vowel duration; (b) although vowel quality is significant for the recognition of the other vowels, duration plays a bigger part.

I will first discuss the views of previous writers. Next, to introduce the Maltese vowels phonetically, I use the Cardinal Vowel System (cf. Jones 1964) as a reference grid on which to place the vowels. This seems to be the only internationally understood system, at the present time, that is both practical and enables accurate descriptions of vowels in auditory terms. However, this system is only used to initiate the description that follows. The phonetic quality of the Maltese vowels is also described verbally.

Traditional and contemporary descriptions of Maltese phonetics are both sketchy and unsatisfactory. A great deal more attention has been given to the phonology and morphology of Maltese.

5.2. Review: Lack of distinction between diachronic and synchronic, and phonetic and phonological statements

There is an overlap between phonetic and phonological statements and between diachronic and synchronic statements throughout the available descriptions of the Maltese sound system. It is worthwhile examining some of the statements that have been made in the course of describing Maltese vowels.

1. "There are five vowels in Maltese, each of which can be long or short, according to its position in the word. A long vowel, like a lengthened consonant, approximately takes twice the length given to its single counterpart ... These five vowels in Maltese are a e i o u which can be either close or half-close, open or half-open, according to the amount of space left between the tongue and the roof of the mouth (the palate) ... Unstressed vowel e becomes ə when the primary stress of the word in which it occurs is moved forward to another syllable of another word following it. Exx. raadʒel (raġel 'a man'); but radʒəl mariit (raġel marid 'a sick man'); Unstressed vowel e becomes i in verbs when the accent falls on it. Exx. kitep (kiteb 'he wrote'); but kitibli (kitibli) not kitebli (kitebli 'he wrote to me') ... (Aquilina, 1965 p.25-26)

It is not clear whether Aquilina sees the vowel system as operating with five or ten vowel phonemes that occur both as monophthongs and in 'union' in the same syllable as diphthongs:

> "The union of two vowels pronounced in one syllable gives rise to the following diphthongal combination with w and j (y) pronounced more energetically than w and y in similar English diphthongal combination." (ibid. p.24)

2. References to vowel quality are often vague and ambiguous:

(a) "As to quantity, Maltese vowels may be long or short, and as to place of articulation they may be pharyngalised ... or unpharyngalised ... The ... pharyngalised vowels are classified as special vowels to distinguish them from the unpharyngalised ones. Such differentiation is necessary to maintain the phonetic and historical individuality of the two sets; but it must be borne in mind that pharyngalisation is so weakened that although it is dialectally perceptible in some of our villages and towns, it is hardly perceptible in others." (Aquilina 1959 (repr. 1973) p.18)

(b) "In Maltese there are five short vowels, five long vowels and six diphthongs. The five short vowel phonemes occurring in standard Maltese are /i/ /e/ /a/ /o/ /u/.

i high, slightly lowered, front, slightly retracted, unrounded vowel
e mid, slightly lowered, front, slightly retracted, unrounded vowel
a low, slightly raised, central unrounded vowel
o mid, slightly lowered, back, slightly fronted, rounded vowel
u high, slightly lowered, back, slightly fronted, rounded vowel

The five long vowels are ... /i:/ /e:/ /a:/ /o:/ /u:/. Long vowels in Maltese do not differ phonetically from short vowels in any regard other than length. Therefore, every individual phonetic description of the short vowels given above holds good also here, on condition that vowel length is included as an additional feature in every particular case. Since the difference between long and short vowels is so simple and so general, no particular description of the long vowels is attempted here." (Fenech 1978, p. 229-230)

(c) Elsewhere, the Maltese vowels are described with reference to English vowels - since the text is written for English learners of Maltese (cf. Aquilina 1965, p.24, quoted above under 1.), and to Italian, as in:

"The five Maltese vowels, long or short, a, a: e, e: i, i: o, o: u, u: with the phonological function of which we shall deal in extenso further on, as heard in Valletta and the neighbouring towns where most cultured Maltese live, are approximately like those of the standard, that is non-dialectal Italian, only comparatively more retracted as to the place of articulation." (Aquilina 1959, p.6)

(d) The first reference to a qualitative difference between the two sets of vowels appears in Krier, 1975:

"On formera deux classes, une brève et une longue qui a leur tour seront rangées selon le degré d'aperture et le timbre"

and,

"La quantité peut entrainer une modification de timbre pour e et o ..."

This is followed by Borg's (1978)[1] distinction with reference to the long front close vowel /i:/. Borg 1978, p. 56, includes ii «ie» (my /i:/) with the long monophthongs both in the Arabic and Romance component of Maltese.

I will not consider further works, since they deal mainly with comparative phonology (Semitic and Romance Maltese) or with a dialect very different from the one studied here, for example, that studied by Krier (1975)[2] and that of Marsaxlokk and St. Julians fishermen studied by Schabert (1976)[3].

5.3. The Phonemic Transcription of Maltese Vowels

All linguistic analyses of Maltese agree on the number of vowel contrasts in the language, but not on the identity of these contrasts. These differences will be discussed. I give my own evidence for the contrastive units (both vocalic and consonantal) in a chart of minimal pairs, figures 3.1 to 3.3.

What is, however, also at issue between previous phonological analyses and my own is how these phonemic contrasts should be transcribed - which symbols are preferable - and the phonetic description of these contrasts. I shall therefore start this description of the sound system of Maltese with a discussion of the transcriptional convention for vowels.

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1. Borg's work, in fact, came to my notice after my analysis of the eleven monophthongs was completed in June 1979. Borg also considers <ie> as representing phonemic monophthong /i:/.

2. Krier refers to her data as Standard Maltese, but her transcription of the recording bears close resemblance to a rural dialect different from Standard Maltese.

3. Marsaxlokk and St. Julians are both fishing areas, but St. Julians is a fast-growing tourist resort and large town whereas Marsaxlokk is a small village.

Since the vowel system has previously been treated as consisting of five monophthongs that can be short or long, or five pairs of monophthongs[1] that are qualitatively indistinguishable but quantitatively contrastive, they have usually been symbolized as: /i/, /i:/, /e/, /e:/, /a/, /a:/, /o/, /o:/, /u/, /u:/ (Aquilina, 1959 and others), thus using the diacritic /:/ for vowel length, whereas <ie>, the special 'diphthong'-symbol in the orthography is used in the same authors' phonological studies as (/ie/). Borg (1978), however, uses a double symbol for the long monophthongs, thus: /i/, /ii/, /e/, /ee/, /a/, /aa/, /o/, /oo/, /u/, /uu/ and /iy/ for what was previously symbolised as /i:/ by Aquilina 1959 and others, so that he uses /ii/ instead for the so-called diphthong /ie/. A clear illustration of the use of symbols can be seen in the following table. The table includes the symbols that I will be using in this work. The reasons for my choice of symbols are discussed below.

Word exemplifying vowel sound	Aquilina (1959) and others	Borg (1978)	This work
<żidt>	i	i	i
<żied>	ie	ii	i:
<żid>	i:	iy	i^j
<derra>	e	e	e
<dehra>	e:	ee	e:
<radd>	a	a	a
<ragħad>	a:	aa	a:
<bott>	o	o	o
<bogħod>	o:	oo	o:
<kull>	u	u	u
<kul>	u:	uu	u^w

The use of double symbols to refer to what is a phonetically single element, and what phonologically

1. The units described as diphthongs have always been symbolised as /iw/, /ew/, /aw/, /ow/, /ej/, /aj/, /oj/; they are not considered as diphthongs here but the transcription is not at issue here.

belongs to the same syllable has been avoided here. /:/ will be used to indicate longer duration and thus keep a long vowel distinct from the same vowel sound functioning in two distinct but successive syllables without an intervening consonant. The use of a double symbol seems to imply doubling of an element. The diacritic : denoting longer duration seems a satisfactory way of referring to vowels that differ in duration as long as this does not entirely rule out a qualitative difference. The use of the diacritic for longer duration is extended here to the so-called diphthong <ie> , which I shall treat as a monophthong (see section 5.7 below). On the other hand, I have excluded the most close vowels, in <żid> (the front close vowel), and in <kul> (the close back vowel) from the quantity-marked vowel pairs for reasons that will, I hope, be clear from the description of the vowels that follows. Briefly, it seems that native speakers discriminate between the members of the close vowel sets primarily on the basis of their quality (as reflected in their formant structure) and not on duration. (See chapter 8). The symbols for the glides /j/ and /w/ are superimposed on /i/ and /u/ to suggest the close quality of these two vowels, and to mark them as being distinguished from the other members of their sets differently from the way in which the other members of the other vowel sets are differentiated from each other, i.e. primarily by duration. This also avoids confusion with reference to the vowel in <żied> . The vowel symbols used here are visually distinctive[1], and are consistent with the phonetic description that follows, in section 5.4 below. They reinforce the departure of the present thesis in distinguishing between the close vowel sets and the other more open vowel sets for the just-mentioned reasons.

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1. I feel that they are more visually distinctive than ɪ and i.

One possible confusion may result from the fact that I am identifying a different segment by the use of /i:/, namely the vowel in ⟨żied⟩ since I consider this a monophthong. This is the vowel referred to as /ie/ in previous analyses. My /i:/ then, denotes what was previously referred to as a diphthong. However unfortunate this may seem, it is necessary for the sake of consistency to use /i:/ for the longer 'counterpart' of /i/, and /i^j/ for the vowel that is long but, more importantly, qualitatively distinct from both these vowels.

The diphthongs are symbolised in the same way as in previous works with /w/ or /j/ following a simple short vowel symbol:-

/iw/, /ej/, /ew/, /aj/, /aw/, /oj/, /ow/.

5.4.1. Auditory quality of the vowels

The most direct way of immediately presenting vowels is with reference to the Cardinal Vowels as described by Jones (1964). **Figure 5.1** shows the eleven Maltese vowels within the Cardinal Vowel chart, as plotted by myself and several other phoneticians trained within the CV[1] tradition.

1. CV is the abbreviation used here for Cardinal Vowel.

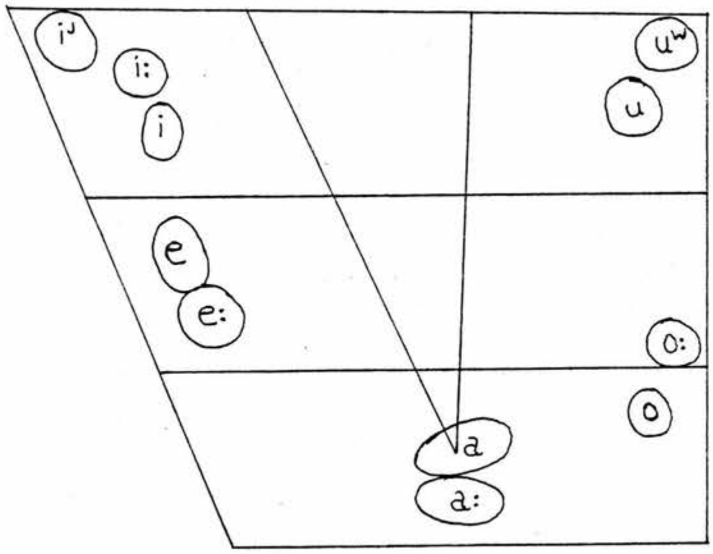

Figure 5.1. The relative auditory qualities of the Maltese vowels pronounced in the context /p-p/. Circles are used to indicate the area of variation involved between speakers.

The relative distance between the Cardinal Vowels and the Maltese vowels is as follows:

/iʲ/	slightly lowered and retracted from CV 1.
/i:/	between CV 1 and CV 2 in terms of openness but slightly retracted.
/i/	between CV 1 and CV 2 in terms of openness but slightly more retracted than the Maltese vowel /i:/.
/e:/	about one sixth of the way up from CV 3 (in CV 2 - 3 area) and a little retracted.
/e/	higher than /e:/ and also a little retracted from the CV.
/a:/	central, between CV 4 and CV 5, and slightly less open (therefore a little higher).
/a/	central, but varies from a more front to a more back vowel. Generally a little higher than /a:/.

/o/ near to CV 6 but slightly lowered and fronted.

/o:/ near to CV 6 but slightly raised and very slightly fronted.

/u/ near to CV 7, about one third up between CV 7 and CV 8, and slightly centralised.

/u^{w}/ very near to CV 8 in terms of closeness, but slightly centralised.

The decision as to where each vowel should be placed was made and revised several times after discussion with colleagues.

5.4.2. The Diphthongs

Figure 5.2 The relative auditory qualities of the Maltese diphthongs with reference to the CV system.

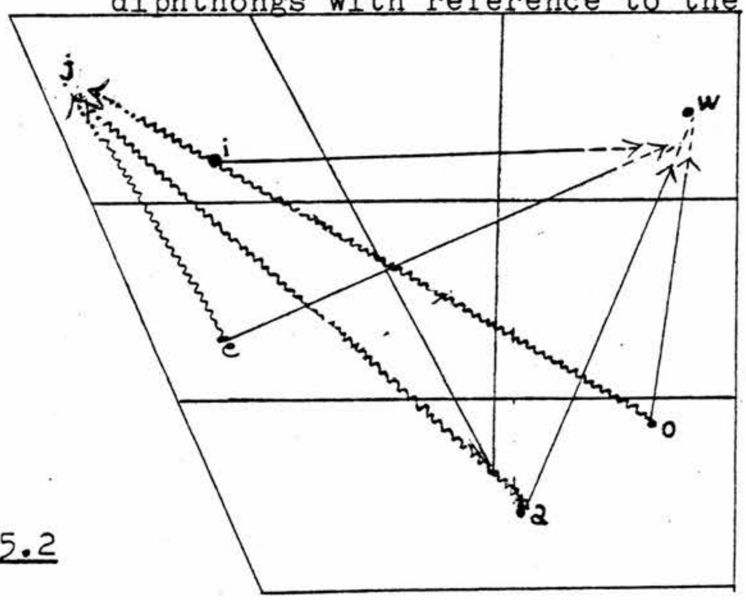

Figure 5.2

The auditory quality of the diphthongs starting from either of 4 places (i, e, a, o) and ending j or w. The arrows simply indicate the direction of movement. In fact, sometimes the quality at the end point of the diphthong is not as close as that indicated by [j] or [w] on the CV chart. The greatest degree of closeness is heard when the second element functions as the arresting part of a preceding syllable as well as the releasing part of the following syllable, e.g. hlew-wa. The most open quality characterizes the quality of the second element in all other positions, e.g. /raw-kom/, /tawh/. I am considering the diphthongs as combinations of vowels plus consonant.

5.4.3. Variants and Distribution Patterns of the Monophthongs

/i^j/ : This vowel is sometimes very slightly diphthongized towards a less close [i] than CV [i] . Diphthongization can occur usually in open syllables. It is always stressed and long.

/i:/ : This vowel can be heard diphthongized towards a more central area by some speakers in specific contexts (possibly as a characteristic of some words), namely in syllables closed by alveolar (or denti-alveolar) stops. The tendency towards diphthongization may be more widespread with some speakers than with others. However, since a monophthongal quality is the usual rendering of this vowel, I will be considering it as such. More definite diphthongization is characteristic of dialectal pronunciation. The vowel is long and always stressed.

/i/ : This vowel varies in quality depending on its duration. It is a very short vowel except in word-final open syllable position and occurs in both stressed and unstressed positions. It is more open and more back when it occurs in open syllables or in syllables closed by a glottal stop or a glottal (or pharyngeal) fricative. (This context will be referred to as 'glottal consonant' below.) However, these depend especially on the clarity and speed of utterance (i.e. ranging from citation form to fast dialogue).

The phonetic quality - in terms of Cardinal Vowel values- of the most common realizations of the Maltese syllabic monophthongal vowel phonemes /i^j/ , /i:/ and /i/ can be summarized as follows:

Phoneme	Auditory Quality	Phonetic Notation	Syllable	Example
/i^{j}/	Similar to CV [i]	[i]	CVC OVO	/zi^{j}t/ /i^{j}t/
	Lowered and slightly retracted from CV [i]	[i̞]	CVO OVO	/aˈd͡ʒi^{j}na/ /ˈi^{j}li/
/i:/	Lowered and retracted from CV [i]	[ï̞]	CV{h, ʔ}	/fi:h/
	Retracted, between CV [i] and [e]	[ï] or [ï̠]	CVC OVO CVO	/zi:t/ /ˈi:bes/ /ˈni:ʃef/
	Retracted, between CV [i] and [e] but glides slightly	[ï̞ ə̞]	Free variant when word is prolonged in hesitation	
/i/	Retracted and raised from CV [e]	[ë̝]	CVO CVC:	/ˈniʃef/ /aˈd͡ʒina/ /hit:/
	Retracted from CV [e]	[ë]	CV{h, ʔ}	/jihˈda:r/ /jiʔˈdi:m/

/e/ : The openness of this vowel depends in part on syllable structure. It is more open in open syllables and syllables arrested by glottal consonants. The degree of openness, however, varies quite freely even in the same speaker's speech. This vowel occurs stressed and unstressed and is short.

/e:/ : This vowel has few distinct variants. It only occurs in stressed syllables. It is slightly more close in a CVC syllable than in any VC or CV context. It is always long.

The phonetic quality - in terms of Cardinal Vowel values - of the most common realizations of the Maltese syllabic monophthongal vowel phonemes /e/ and /e:/ can be summarized as follows:

Phoneme	Auditory Quality	Phonetic Notation	Syllable	Example
/e/	Retracted and lowered from CV [e]	[ë̞]	CVCC CVC:	/tʃens/ /mes:/
	Retracted and more lowered (than [ë̞]) from CV [e]	[ë̞̞]	CVO	/ˈdera/
	Retracted and slightly raised from CV [ɛ]	[ɛ̝̈]	CVO	/te/
/e:/	Retracted from CV [ɛ]	[ɛ̈]	OVC CVC CVO	/e:ʃ/ /fe:m/ /ˈfe:ma/

/a/ : The quality of this vowel varies considerably between speakers. However, its relative quality and especially its relative 'distance' from the realizations of /a:/ are remarkably constant for the same speaker. In some speakers it is more retracted than in others. The vowel is usually more advanced in closed syllables unless the arresting consonant is glottal. It is usually short except in word-final open syllables. It can be stressed or unstressed.

/a:/ : The quality of this vowel also shows inter-speaker variation. It is also realized as more advanced in closed syllables unless the arresting consonant is glottal. This is a long vowel and is always stressed.

The phonetic quality - in terms of Cardinal Vowel values - of the most common realizations of the Maltese syllabic monophthongal vowel phonemes /a/ and /a:/ can be summarized as follows:

Phoneme	Auditory Quality	Phonetic Notation	Syllable	Example
/a/	Raised to a quality between CV [ɑ] and [ɔ] and centralized	[ɑ̞̈] or [ə̠]	All contexts	
/a:/	Central, above fully open CV [ɑ]	[ɑ̝̈˖] or [ə̞˖]	All contexts	

/o/ : This vowel is more constant in quality than the other short vowels. (Hence, the smaller circle on the CV chart.) However, it is slightly more open in an open syllable or a syllable arrested by a glottal consonant, and more advanced in a syllable closed by a front (labial to alveolar) consonant. It is a short vowel and can be stressed or unstressed.

/o:/ : This vowel shows similar stability to /o/. (Hence smaller CV circle.) It is sometimes more close in syllables closed by front consonants or closed syllables followed by another syllable in the same word. This usually long vowel is always stressed.

The phonetic quality - in terms of Cardinal vowel values - of the most common realizations of the Maltese syllabic monophthongal vowel phonemes /o/ and /o:/ can be summarized as follows:

Phoneme	Auditory Quality	Phonetic Notation	Syllable	Example
/o/	Lowered and advanced from CV [ɔ]	[ɔ̈˕]	All contexts	
/o:/	Raised and advanced from CV [ɔ]	[ɔ̈˔]	All contexts	

/u/ : This vowel has many variants. These are not determined by specific contexts. /u/ is more advanced in syllables arrested by front consonants or in an OVO[1] syllable. It is always a short vowel except in word-final open syllable position, and is usually only unstressed except in monosyllables (or baby-talk, like 'tuttu' (horse), etc.)

$/u^w/$: This vowel is very close and retracted, but occurs more advanced in syllables closed by front consonants. It is always stressed and long. In syllables closed by the glottal consonants /ʔ/ and /h/, it occurs as more open than any of the $/u^w/$ allophones and more retracted than any of the /u/ allophones. When the syllable is arrested by a pharyngeal/glottal fricative it sometimes has a very short glide to a closer position. However, this is characteristic of only some speakers of Standard Maltese, and is also possibly a characteristic

1. Vowel not released or arrested by a consonant.

of specific CV/h/ words. /u^w/ can occasionally be heard as slightly diphthongized to a position nearer CV [u] when it occurs in other non-glottal contexts.

The phonetic quality - in terms of Cardinal Vowel values- of the most common realizations of the Maltese syllabic monophthongal vowel phonemes /u/ and /u^w/ can be summarized as follows:

Phoneme	Auditory Quality	Phonetic Notation	Syllable	Example
/u/	Advanced, between CV [u] and [o] but closer to [u]	[ö̝]	All contexts	
	Advanced, between CV [u] and [o] but closer to [o]	[ö]	All contexts	
/u^w/	Slightly lowered and advanced from CV [u]	[u]	All contexts except V{/h/, /ʔ/}	
	Lowered and advanced from CV [u]	[ü̞]	{C, CV}{/h/, /ʔ/}	/iˈfu^{w}h/ /fu^{w}ʔ/

5.5. Articulatory Description

The basis for the verbal articulatory description that follows is my own speech, supplemented by observation and experimental evidence of that of at least one other native speaker of Standard Maltese. Lip position is dealt with in detail in Part V.

/i^j/ : The jaw is in its most closed position in terms of the production of Maltese vowels. The teeth overlap to a great extent, such that the front lower teeth are hidden behind the upper teeth. The tongue sides at the back are supported quite firmly by the u upper and back molar-insides. It is the sides and front of the tongue that lie highest in relation to the palate - at a point just opposite the pre-palatal zone. The tongue tip is suspended tensely well behind the upper teeth. The lips are spread and only parted to the degree that leaves only the middle (horizontal) section of the upper and lower teeth visible.

/i:/ : The jaw is slightly less closed than for /iʲ/. The tongue-molar contact is not as firm but still occurs. There is less tension forwards-and-upwards and the tongue body is slightly further away from the palate, especially at the sides. The highest point at which the tongue is raised is also a little more retracted than for /iʲ/. The tongue tip is suspended less tensely than for /iʲ/. The lips are also more open vertically and less spread than for /iʲ/, but the difference is not always noticeable as it is one of less lip tension too (introspective evidence).

/i/ : This vowel is produced in much the same way as /i:/. However, as its lax counterpart, it is produced with even less tension of the tongue throughout. The front of the tongue is raised towards a more retracted part of the palate than for /i:/. The jaw is slightly more open than for /i:/ so that the tongue makes very light contact - if any - with the molars. The lips have the same degree of openness and spread as for /i:/. This vowel is always realized as extremely short.

/e:/ : The jaw is half-closed so that the upper teeth appear over the rims of the front lower teeth, although they do not usually overlap. The tongue is quite high up in approximation to the palate. The top sides of the rim are supported under the bottom and insides of the back upper molars, whereas the bottom of the tongue makes light contact with the top part of the lower front molars. The tongue is bunched up and back to some extent so that the most raised part lies close to the palatal zone and the tongue tip is suspended away from the 'floor' and front teeth. The lips are separated in relation to jaw opening and are slightly spread in a downward direction. The spreading movement is not extensive but still noticeable.

/e/ : This vowel is very similar to its tense counterpart /e:/. It is slightly closer. Less firm contact than for /e:/ can be felt between the tongue sides and the upper molars.

/a:/ : This is the most open Maltese vowel. As for the front vowels, the tongue is not in contact with the lower incisors, or with the "floor"[1] of the mouth, but is somewhat retracted and away from the floor. The tongue is not in contact with any area of the upper teeth or palate. The lips are open, that is, well separated but not protruded. Their degree of separation is dependent on the open jaw position. The upper and lower front teeth are usually visible.

/a/ : This vowel can best be described as the shorter and lax counterpart of the vowel /a:/, requiring less muscular effort. (The tense-lax distinction will be discussed in detail below for all the vowels.) This difference - apart from its realization in temporal terms, as a short vowel - lies mainly in the fact that the tongue is not tense. This difference cannot be neatly separated from the temporal one, since in practice, tense vowels are usually also of longer duration than lax vowels.

/o:/ : The back of the tongue is bunched upwards opposite the post-palatal zone. The tongue tip is curled down and under, well behind the lower front teeth. The tongue does not make any contact with the lower molars or teeth because it is in a suspended position away from the floor of the mouth. The lips are open slightly in relation to jaw opening but they are also rounded and protruded to a degree such that the lip-"creases", due to horizontal constriction (see 11.8.2 and 12.15), are definitely noticeable. The lips are active articulators: there is a definite lower lip movement upwards and outwards as opposed to a simple opening as is the case for /a:/ and /a/.

/o/ : This vowel is opener than /o:/ although the difference is slight. There is less back-and-up tension of the tongue. The lip-position is noticeably different from that for /o:/ - the lips are more open and less protruded. There seems to be less tension of the cheeks needed to maintain protrusion.

/u^W/ : The jaw is almost closed for this vowel. There is no upper to lower molar contact, but the front teeth could overlap. The tongue is very close to the velar region of the palate. The top sides of the rims of the tongue are in light contact with the inner side rims of the upper back molars. There is a tense backwards and upwards movement of the tongue so that the tongue tip is well away from the front teeth and the tongue is well away from the floor of the mouth. There is some contact of the upper sides of the front of the tongue with the lower front molars in the area front of the highest part of the tongue. The lips are active articulators: they are rounded and protruded tensely leaving only a very small slit-opening (see Figure 12.23, Vgm. 14 to 16).

/u/ : This vowel is very different in quality from /u^W/. It is more open; the tongue sides make hardly any contact with the molars because the tongue is much less tensed upwards. The lips could be less protruded so that it may be possible to see a little of the upper teeth through the slightly wider opening. This is caused to some extent by upper-lip raising. The lower lip takes a less active role than for $/u^w/$ in terms of tenseness.

5.6. Laxness and tenseness in vowels

A traditional classification of the Maltese vowels by means of the conventional three dimensions already discussed is quite adequate for a clear phonetic differentiation between the vowels. However, I feel that such a description does not account for the differences between the members of each monophthongal set - traditionally distinguished as long and short counterparts. I feel that a fourth parameter is also needed to make up for the limitations of the traditional vowel quadrilateral that is most extensively used (cf. Ladefoged 1959, and Catford 1977, and Appendix A.)

The qualitative distinction in Maltese between /i/ and /i:/ (and $/i^j/$) /e/ and /e:/, /a/ and /a:/, /o/ and /o:/, /u/ and $/u^w/$ is closely related to the durational difference but not limited to it. (This is not the only difference, though, for $/i^j/$, $/u^w/$ and /u/.) This is a distinction that Sweet (1890) tried to make between narraw and wide, that Jakobson, Fant and Halle (1951) made between tense and lax. The long-felt need suggests that some important factors involved in vowel production must be accounted for in some way. Since the narrow - wide, tense - lax distinction has not been well substantiated by experimental data, it seems necessary to reassess it at this point.

Sweet (1906) used the narrow - wide dimension to refer to the shape of the tongue used to modify vowel production:

> "The distinction depends mainly on the SHAPE of the tongue. In forming narrow vowels there is a feeling of tenseness in that part of the tongue where the sound is formed, the surface of the tongue being made more convex than in its natural 'wide' shape, in which it is relaxed and flattened. This convexity of the

tongue naturally narrows the passage - whence the name. The narrowing is the result not of raising the whole body of the tongue (with the help of the jaws), but of 'bunching up' lengthways that part of it with which the sound is formed." (Sweet, 1906, p. 19-20)

"Tense phonemes display a longer sound interval and a larger energy" (Jakobson, Fant, Halle 1951)

Daniel Jones (1964) considered the distinction between tense and lax vowels as:

"a lowering and advancement of the tongue and a wider opening of the lips"

in the case of the back close vowels (Jones 1964, p. 40).

The tense-lax distinction is a feature in the Distinctive Feature theory expounded by Jakobson, Fant and Halle in 1951:

"In sum the production of lax as opposed to tense phonemes involves a lower (vs. higher) air pressure in the cavity behind the only or main source (i.e. below the vocal cords for the vowels, and behind the point of articulation for the consonants). Furthermore, tense phonemes are produced with more deviation from the neutral, central position than the corresponding lax phonemes: the tense consonants show primarily a longer time interval spent in a position away from neutral, while the tense vowels not only persevere in such a position optimal for the effectuation of a steady, unfolded, unreduced sound but also display a greater deformation in the vocal tract."

The distinction is stated in more concrete, near-acoustic terms by Lehiste and Peterson (1961) as:

"it appears that the characteristic difference between the long and short monophthongs may be described as a difference in the articulatory rate of change associated with the movement from target position to the following consonant ... "lax" vowels, then, are those vowels whose production involves a short target position and a slow relaxation of the hold; for "tense" vowels the target position is maintained for a longer time, and the (articulatory) movement

> away from the target position is relatively rapid. The relationships of the three stages to the total duration remain approximately constant, regardless of the fluctuation in duration produced by the following consonant ... The tense-lax opposition becomes particularly significant when the difference in intrinsic duration is neutralized."
> (Lehiste and Peterson, 1961, p. 274-275)

Ladefoged, 1971, considers tension as:

> "the degree to which the root of the tongue is pulled forward so that the tongue is bunched up lengthways."

> "Tension or tenseness is a modification of vowel articulation but can be an inherent quality of some vowels. It is usually associated with the muscular tension of the tongue as it is domed towards the palate - as opposed to its more relaxed flattened posture."

In conclusion, it seems to me that the longer set of vowels are more tense than the shorter vowels in that more muscular tension is involved in their articulation. However, like others, I cannot find any instrumental evidence to substantiate this distinction.

5.7. The monophthongal quality of /i:/ - orthographic <ie>

One of the main departures of this study from previous works[1] is the status of the first vocalic element in words such as <bied> /bi:t/, <miet> /mi:t/, <dieħes> /di:hes/, and the last vowel in <sikwiet> /sikwi:t/. I want to argue that the phonetic characteristics of this vowel are such that it should be classified as a monophthong rather than a diphthong. It is only the orthographic system (see chapter 2 for more detail) that distinguishes between the initial and final quality of this vowel (that is <ie>) which is historically derived from the long Arabic vowel /a:/.

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1. Alexander Borg's (1978) work being the one exception.

The sound that is symbolised orthographically as a digraph <ie> is, in fact, as stable as any of the other monophthongs. It has a more sustained quality - longer steady state than these monophthongs - because it is usually of quite long duration. There is no more diphthongization for this vowel than for any of the other monophthongs (cf. Sgm. 1, 2. Figure 7.3, 7.4 and 7.5.)

A study of dialects that differ from Standard Maltese, especially as regards the vowel system, will show great variations in the quality of this as well as other vowels. I do not propose to discuss such variations here. In my speech, and in the speech of all of my subjects, as well as of several other native speakers of this particular dialect, the vowel /i:/ (<ie>) is a monophthong. I have included a description of its production along with the other monophthongs.

5.8. The monophthongs /i^j/ and /u^w/

These two vowels cannot be classified as diphthongs because they do not sound like movements from one vowel quality to another.

The vowels /i^j/ and /u^w/ are the most close vowels in the Maltese vowel system. Their close quality varies to some extent with the context - as does the quality of all the vowels. For some speakers they are prone to diphthongization. The degree of diphthongization varies with different speakers.

The symbols /i^j/ and /u^w/ are also intended to reflect the important qualitative differences of the vowels over and above the durational differences from those of the shorter corresponding vowels. Hence the post-superposition of the glide symbols to distinguish them both from the other monophthongs and from the diphthongs. Spectrograms of the vowels /i^j/ and /u^w/ are reproduced below in figure 7.4.

Chapter 6

Vowel Duration

6.1. Purpose of Study of Vowel Duration

I made a study of the duration of the vowels of Maltese in different contexts as measured from electrokymographic tracings of single words and phrases as well as complete utterances[1] spoken by two main informants.

Some points raised by the description of vowel quality provided specific questions:

A. What is the average duration of a 'long' vowel and what is the average duration of a 'short' vowel?

B. Does stress affect vowel duration?

C. Does the number of syllables in a word affect vowel duration?

D. How does the duration of /i:/ ⟨ie⟩ compare with that of the long vowels? Do /i^{j}/ and /u^{w}/ differ in duration from the other long vowels?

E. In those structures in which phonemic contrast is possible, what are the durational differences between "long" and "short" vowels?

F. What interplay exists between: VC V:C VC: VCC ?

G. Do any of the claimed phonetic universals regarding duration apply to Maltese?

6.2. Factors Accounted for in the Data

The data I selected was intended to provide adequate samples of vowels under different phonetic conditions which seemed to have some influence on vowel duration or

1. Sample electrokymographic data is presented in Appendix G - specifically, G1.

which have been considered relevant in other languages. These influential factors are:-

1. Stress: stressed syllables and unstressed syllables (section 6.4).

2. Place in phonological hierarchy: monosyllabic word, multisyllabic word (section 6.5.).

3. Position in the word: word-initial (a syllable without a releasing consonant), word-final (in open syllable), or bounded - by a consonant or consonant-group (section 6.5.).

4. Consonant duration: whether followed by a single or geminate (or simply long) consonant or consonant cluster (section 6.6.).

5. Vowel type (section 6.7.).

6. Nasalisation (section 6.8.).

7. Historically Pharyngalised Vowel (section 6.9.).

8. Voicing and place of articulation of preceding and following consonants (section 6.10.).

Some of the data consisted of both contextualised words and of citation forms. Contextualisation was intended to elicit a more natural utterance from the informants. However, this often led to a hesitation-pause immediately preceding the word being investigated, that is, mid-way through the utterance. For this reason, it was decided to abandon this idea when very long lists of words were being spoken.

Speech tempo is obviously a very important consideration in any study of duration, since the very object of the study is the time taken to produce speech. As much as possible of the data was included in one session to avoid too many inconsistencies as a result of the speech rate of utterances changing drastically across sessions. Some of the data was repeated at every session to allow some comparison to be made. Variation in speech tempo is, unfortunately, inevitable, even within the same session. The examples that appear in each table were taken from a single session.

6.3. Results

The analysed data is presented in tables with preceding explanatory discussions.

Figure 6.1A. Average absolute duration for the 11 monophthongs in (a) Monosyllabic words and (b) Multisyllabic words: i. Stressed syllables; ii. unstressed syllables.

When Maltese monophthongal vowels are considered in a sample of words differentiated only by stress and syllable number (and undifferentiated as to place in syllable and syllable type), it can be seen that they are related in the following ways in terms of average duration:

Long vowels in monosyllables	230 msec.
Stressed long vowels in multisyllables	204 msec.
Stressed short vowels in monosyllables	155 msec.
Stressed short vowels in multisyllables	107 msec.
Unstressed short vowels in multisyllables	119 msec.

The short vowel in multisyllables, then, is about half as long as the long vowel in stressed syllables of multisyllabic words, and about two-thirds the duration of the long vowel in monosyllabic words. The ratios of these durations are:

/V/	:	/V:/		
2	:	3	-	in monosyllabic words
1	:	2	-	in multisyllabic words (stressed syllables)

And,

/'V/	:	/V/
9	:	10

Figure 6.1A

Average duration in msec. for the Maltese monophthongs as measured from electrokymographic tracings of two informants.

	In Monosyllabic Words - Stressed		In Multisyllabic Words Stressed		In Multisyllabic Words Unstressed	
i	123 ms	(13)	97	(151)	90	(216)
e	163 ms	(15)	121	(160)	127	(120)
a	171 ms	(59)	123	(75)	143	(147)
o	151 ms	(196)	116	(102)	116	(65)
u	160 ms	(5)	91	(12)	119	(121)
Short Vowels :	155 ms	(228)	107	(500)	119	(669)

i^j	216	(36)	157	(123)
i:	230	(59)	206	(121)
e:	253	(29)	230	(41)
a:	227	(32)	212	(107)
o:	231	(31)	222	(63)
u^w	220	(32)	199	(115)
Long Vowels	230	(210)	204	(570)

FIGURE 6.1.B.

Absolute Average Duration for the monophthongs (in milliseconds) presented separately for two informants.

	Monosyllabic Words		Multisyllabic Words: Stressed Syllables		Multisyllabic Words: Unstressed Syllables	
INFORMANT	A	B	A	B	A	B
i	133ms(7)	172ms(6)	97ms(78)	97ms(73)	97ms(79)	83ms(137)
e	180ms(6)	145ms(9)	117ms(58)	124ms(102)	122ms(56)	132ms(64)
a	163ms(17)	178ms(42)	114ms(38)	131ms(37)	127ms(91)	159ms(56)
o	142ms(24)	172ms(172)	117ms(46)	114ms(56)	116ms(31)	116ms(34)
u	143ms(2)	177ms(3)	91ms(5)	90ms(7)	132ms(58)	106ms(63)
Short Vowels	152ms(56)	157ms(232)	107ms(225)	107ms(275)	119ms(315)	119ms(354)
iʲ	216ms(19)	216ms(17)	153ms(50)	166ms(73)		
I:	252ms(15)	208ms(44)	208ms(45)	204ms(76)		
e:	253ms(9)	253ms(20)	230ms(15)	229ms(26)		
a:	223ms(16)	230ms(16)	216ms(47)	208ms(60)		
o:	227ms(11)	235ms(20)	219ms(36)	224ms(27)		
uʷ	209ms(9)	231ms(23)	204ms(50)	194ms(65)		
Long Vowels	230ms(79)	229ms(140)	205ms(243)	203ms(327)		

These ratios are interesting because of the previously postulated 1 : 2 ratio of short and long Maltese vowels (Aquilina 1959, p.25-26). These factors - stress and syllable number - are discussed below along with other factors affecting vowel duration.

6.4. Vowel duration and stress

It seems that vowels in unstressed syllables are not always of shorter duration than their stressed counterparts (see figure 6.1A); they are certainly not weakened to the same extent as unstressed vowels are in English for the cause of isochrony. Of course, if we exclude the examples of unstressed word-final vowels, there is a significant difference (i.e. beyond the just noticeable difference[1]) for the non-word-final unstressed vowels /i/, /a/, and /u/. However, from the data available for the vowels /e/ and /o/, which rarely occur in word-final place, no such difference exists in duration between the stressed and the unstressed instances.

When stress shift is also accompanied by an addition of morphemes within the same word, the duration of the vowel changes significantly. A few examples illustrating this appear in figure 6.2. The main evidence for the lack of relationship between stress and vowel duration can be seen in figure 6.1A.

6.5. Vowel Duration and Place in Word Structure

(i) Number of Syllables. It seems, therefore, that the number of syllables does influence the duration of the long vowels, and has an even greater influence on the duration of the short vowels. All the vowels are realised as longer in monosyllabic words than in multisyllabic words by an overall average of 25 msec. for long vowels and 50 msec. for short stressed vowels and 38 msec. for

1. The just-noticeable difference (J.N.D.) is considered to be about 40 msec. by Lehiste (1970) in segments of between 40 and 200 msec. duration.

FIGURE 6.2.

Vowel duration in stressed and unstressed words. Those under (b) are related to those under (a), but have undergone stress-shift.

	(a) STRESSED		(b) UNSTRESSED	
/i/	/ˈtitwi/	75 ms	/titˈwiːʃ/	60 ms
/e/	/imˈteːt:/	135ms	/timˈted:uʷʃ/	80ms
/o/	/ˈsod:u/	115ms	/is:ˈod:uʷʃ/	100ms 70ms
/a/	/inˈstad:u/	120ms	/manstˈad:uʷʃ/	90ms

FIGURE 6.3.

Average duration of the unstressed vowels presented according to position in a word. (The number of words appears in brackets in each case.)

Unstressed Vowels						
	ABSOLUTE AVERAGE		WORD - FINAL		NON WORD - FINAL	
INFORMANT	A	B	A	B	A	B
/i/	97ms (79)	83 (137)	141ms (28)	145ms (33)	70ms (51)	66ms (104)
/a/	127ms (91)	159 (56)	143ms (49)	179ms (40)	99ms (42)	108ms (16)
/u/	132ms (58)	106 (63)	167ms (35)	150ms (26)	82ms (23)	75ms (37)
/e/	122ms (56)	132 (64)				
/o/	116ms (31)	116 (34)				
Average for 5 vowels.	119ms (315)	119ms (354)	150ms (112)	158ms (99)	84ms (116)	83ms (157)

FIGURE 6.4.

Average duration of vowels followed by single and by geminated consonants in balanced word-pairs. (e.g. /siket/ - /sik:et/).

	SINGLE CONSONANT		GEMINATED CONSONANT	
	A	B	A	B
/i/	96ms (18)	53ms (16)	71ms (18)	50ms (16)
/e/	136ms (12)	86ms (12)	110ms (12)	90ms (12)
/a/	149ms (12)	101ms (8)	116ms (12)	91ms (8)

short unstressed vowels. The longer duration exists both in terms of total averages and in the case of each individual vowel without exception. The averages in Figures 6.1A,1B also indicate that stress does not seem to have the predicted[1] effect on the duration of vowels since all of the vowels are as long or even longer in unstressed syllables than they are in stressed syllables. This may seem a rather strange phenomenon but several other factors are obviously at play here. Firstly, stressed syllables are usually penultimate syllables, and never in open, word-final syllables; unstressed syllables are usually final syllables or pre-penultimate. This means that there are more instances of unstressed vowels in open syllables in word-final position than unstressed vowels in closed word-final syllables.

(ii) Vowel Position (unstressed vowels)[2]: Figure 6.3 shows that the vowels /i/ /a/ and /u/ are of much longer duration when they occur in word-final position. The difference between the durational values of these vowels in non-word-final position and in word-final position is more than the just noticeable difference[3]. When the word-final examples are omitted from the total average vowel duration, the absolute average for all of the three vowels changes dramatically such that the ratio of word-final to non-word-final vowels comes close to a 2 : 1 relation.

6.6. Vowel Duration and Consonant Duration

Figure 6.4 above, shows two interesting factors at work:

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1. Predicted in terms of stress-timing (see 13.15.1) - rhythm.
2. No word-final unstressed vowels /e/ and /a/ because there are only a limited number of words with this structure.
3. See Footnote 1, p. 110.

1. The longer arresting consonant (or the geminate consonant) following the vowel influences the average vowel duration of speaker A much more than that of speaker B.

2. The absolute average for these particular examples differs from the absolute average for the undifferentiated unstressed vowels.

We have already noted that syllable type is an additional factor that influences vowel duration: the vowel in an open syllable is usually longer than that in a closed syllable. Since Maltese seems to favour open syllables, a single, word-medial consonant usually acts as the releasing consonant of the next syllable and not as the arresting consonant of the previous one. It is not possible to consider monosyllabic words with differing consonant duration since, in a monosyllable, a short vowel is usually followed by a long consonant whereas a long vowel is followed by a short consonant, e.g. /hi^{j}t/, /hi:t/, but /hit:/.

It could be concluded from fig.6.4 that for speaker A, vowel duration decreases when the vowel is followed by a geminate consonant but that there is very little difference between the duration of the vowel followed by a single short consonant and the duration of the vowel followed by a geminate consonant, for speaker B.

6.7. Vowel duration and vowel height

It has been concluded by some investigators that the duration of open vowels is usually greater than that of more close vowels.

> "The actual duration of vowel-sounds in speech is related to their degree of openness. Everything else being equal, the more open a vowel is, the longer it is. This is easily explained by the fact that the change of articulatory position from that of a consonant to that of an open vowel

> and back again involves a longer movement and hence requires more time than the movement to and from a less open vowel" (Catford, p. 196-7)

If this factor - vowel height - were an overriding factor, or one that was significant enough to show up in an adequately large sample, then, the Maltese vowels could be set up according to the following hierarchical scale from longest to shortest:

V	=	a	o	e	i	u	
V:	=	a:	o:	e:	i:	i^j	u^w

The results in fig.6.1 do not indicate a clear relation between vowel duration and vowel height. However, if the data in fig.6.3 is considered, a clearer correspondence can be seen. It seems then, that if one had to exclude the vowels on which more overriding factors than vowel height are at work, vowel-openness can be considered as an influential factor where vowel duration is concerned. This conclusion can only be reached with reservation since only the most open and the most close vowels are being considered here. Vowel height is therefore, not as important as factors such as word-position, in determining vowel duration. The relationship of the vowels to each other along the parameter of vowel duration from longest to shortest can be seen in figure 6.5. This shows that vowel duration is not predictable from vowel height.

6.8. Vowel Duration in the context of nasalization

Figure 6.6 shows data that differentiates vowels in the context of nasal consonants from vowels in a context that is oral. The reason for isolating this factor is that initially, it was observed that some vowels that were followed by nasal consonants were of far longer duration that other vowels in an oral environment.

The effect of a preceding and following nasal

	INORMANT A	INFORMANT B
Short Vowels in Monosyllables	$e > a > \substack{u \\ o} > i$	$\substack{a \\ u} > o > e > i$
Short Vowels in Stressed syllables	$\substack{e \\ o} > a > i > u$	$a > e > o > u > i$
Short Vowels in Unstressed syllables	$u > a > e > o > i$	$a > e > o > u > i$
Long Vowels in Stressed syllables	$e: > o: > a: > i: > u^w > i^j$	$e: > o: > \substack{a: \\ u^w} > i^j > i$
Long Vowels in Monosyllables	$\substack{e: \\ i:} > o: > a: > i^j > u^w$	$e: > o: > a: > i: > u^w > i^j$

FIGURE 6.5.

Rank-ordering of long and short Maltese monophthongs by duration for two speakers in stressed and unstressed syllables and monosyllables.

<u>FIGURE 6.6.</u> Average duration of vowels in different contexts: (a) preceding and following oral consonants (b) a preceding nasal consonant (c) a following nasal consonant in (i) monosyllables (ii) stressed and unstressed syllables in multisyllabic words.

		MONOSYLLABLES			MULTISYLLABIC STRESSED			MULTISYLLABIC UNSTRESSED		
Vowel	Inf	/ORAL	/N—	L—N	ORAL	LN—	L—N	ORAL	LN—	L—N
/iʲ/	A	210ms (14)	225ms (1)	253ms (2)	153ms (31)	172ms (3)	150ms (16)			
	B	216ms (16)	270ms (1)	190ms (2)	166ms (51)	129ms (4)	174ms (18)			
/ɪ:/	A	257ms (11)	225ms (2)	253ms (2)	197ms (28)	197ms (3)	235ms (14)			
	B	212ms (36)	190ms (3)	190ms (5)	206ms (63)	145ms (1)	200ms (12)			
/i/	A	125ms (4)	130ms (1)	150ms (2)	102ms (78)	70ms (11)	103ms (8)	93ms (58)	125ms (15)	69ms (6)
	B	123ms (2)	160ms (1)	107ms (3)	105ms (56)	80ms (15)	66ms (7)	85ms (106)	91ms (14)	61ms (17)
/e:/	A	264ms (2)	-	250ms (7)	223ms (11)	-	250ms (4)			
	B	266ms (13)	220ms (1)	230ms (6)	231ms (22)	-	220ms (4)			
/e/	A	160ms (1)	160ms (1)	190ms (4)	116ms (34)	93ms (5)	126ms (19)	122ms (38)	111ms (7)	130ms (11)
	B	155ms (3)	140ms (2)	140ms (4)	123ms (65)	109ms (17)	139ms (20)	138ms (50)	125ms (7)	97ms (7)
/a:/	A	218ms (9)	-	229ms (7)	214ms (30)	174ms (4)	234ms (13)			
	B	229ms (15)	-	240ms (1)	210ms (43)	204ms (4)	204ms (13)			
/a/	A	164ms (14)	140ms (1)	165ms (2)	118ms (31)	-	103ms (7)	124ms (60)	140ms (25)	103ms (6)
	B	177ms (38)	180ms (2)	198ms (2)	131ms (30)	-	133ms (7)	168ms (43)	129ms (11)	130ms (2)
/o:/	A	251ms (7)	163ms (2)	208ms (2)	215ms (22)	237ms (3)	222ms (11)			
	B	239ms (17)	190ms (1)	225ms (2)	223ms (19)	200ms (1)	230ms (7)			
/o/	A	136ms (19)	140ms (1)	175ms (4)	117ms (35)	100ms (3)	125ms (8)	106ms (21)	-	136ms (10)
	B	172ms (28)	170ms (2)	173ms (6)	117ms (45)	97ms (6)	110ms (5)	110ms (26)	-	137ms (5)
/uʷ/	A	216ms (7)	183ms (2)	-	201ms (28)	175ms (3)	213ms (19)			
	B	235ms (20)	207ms (3)	-	190ms (44)	243ms (3)	196ms (18)			
/u/	A	121ms (1)	-	165ms (1)	93ms (4)	85ms (1)	-	139ms (51)	90ms (3)	71ms (4)
	B	216ms (2)	-	100ms (1)	87ms (5)	98ms (2)	-	109ms (57)	82ms (3)	70ms (3)

consonant seems rather inconsistent in the data examined. On the whole, short vowels in monosyllabic words are of longer duration when preceded or followed by nasal consonants, whereas the duration of vowels in stressed and unstressed syllables of multisyllabic words is determined by factors other than a nasal consonant in the environment.

6.9. Historical Pharyngalisation and vowel duration

Although the Maltese long vowels are unpharyngalized, it has been stated that the vowels that were once pharyngalized (i.e. have pharyngalised vowels as their Arabic origins) still retain their long duration in any position, and that they are, in fact, of longer duration than the 'ordinary' long vowels (cf. Aquilina 1959, p. 7).

Figure 6.7 shows the average durational values of 'originally' pharyngalised vowels and 'ordinary' long vowels in similar phonetic contexts. The average duration-values for both groups is very similar. If this is a representative sample, then it is not possible to distinguish between these two groups of vowels on the basis of length. It has been suggested already that there is in fact no distinction between these two sets of vowels on any level; they have been treated as synchronically identical vowels with diverse origins, in this thesis.

6.10. Voicing and Place of Articulation

Some phonetic conditions that seem to influence the duration of vowels in other languages have not been found to be relevant here. Two such conditions are the voicing of following consonants and the place of articulation. (See figures 6.8 and 6.9.)

In general, it appears that:

FIGURE 6.7. Average duration of 'ordinary' long vowels and 'originally pharyngalised' vowels in fairly balanced word sets for Informant B only. (Numbers in brackets indicate number of words compared.)

		VOWELS ORIGINALLY PHARYNGALISED		ORDINARY VOWELS	
Monosyllabic	/e:/	200 ms	(9)	–	
	/a:/	204 ms	(5)	224	(10)
	/o:/	204 ms	(7)	205	(2)
Multisyllabic - Stressed	/e:/	191 ms	(7)	198	(7)
	/a:/	172 ms	(15)	176	(15)
	/o:/	172 ms	(8)	165	(1)
	TOTAL AVERAGE	191 ms		194 ms	

FIGURE 6.8. Average duration in msec. of /i^j/ and /i:/ (1) preceded (2) followed by (a) labial (b) an alveolar (c) a velar consonant

Preceding Consonant is:	Labial		Alveolar		Velar	
INFORMANT:	A	B	A	B	A	B
/i^j/	177ms (24)	171ms (17)	178ms (16)	157ms (10)	171ms (25)	180 ms (5)
/i:/	215ms (20)	225ms (13)	218ms (19)	222ms (9)	198ms (11)	230ms (2)
/i^j/, /i:/	196 ms	198ms	198ms	190ms	185ms	205ms
Informants A and B:	197ms		194 ms		195 ms	
Following Consonant is:	Labial		Alveolar		Velar	
INFORMANTS:	A	B	A	B	A	B
/i^j/	171ms (12)	171ms (7)	168ms (21)	187ms (30)	186ms (23)	158ms (11)
/i:/	205ms (12)	224ms (4)	215ms (27)	213 ms (17)	201 ms (15)	216ms (4)
/i^j/, /i:/	185ms	198ms	192ms	200 ms	194 ms	187ms
Informants A and B	193ms		196ms		191ms	

FIGURE 6.9. Average duration in milliseconds of $/i^j/$ and /i:/ (a) preceded and (b) followed by (1) a voiced consonant and (2) a voiceless consonant.

	Vowels with a preceding VOICED CONSONANT		Vowels with a preceding VOICELESS CONSONANT	
INFORMANT:	A	B	A	B
$/i^j/$				
In monosyllables	238 ms (4)	211 ms (6)	205 ms (13)	217 ms (10)
In multisyllabic wd.	174 ms (16)	165 ms (14)	175 ms (36)	160 ms (23)
/i:/				
In monosyllables	211 ms (10)	244 ms (5)	194 ms (13)	256 ms (10)
In multisyllabic wd	210 ms (11)	205 ms (16)	201 ms (33)	213 ms (27)
$/i^j/$, /i:/				
In monosyllables	225 ms	228 ms	200 ms	237 ms
In multisyllabic wd	192 ms	185 ms	188 ms	187 ms
	209 ms	207 ms	194 ms	212 ms

(B)

	Vowels with a following VOICED CONSONANT		Vowels with a following VOICELESS CONSONANT	
INFORMANT:	A	B	A	B
Multisyllabic words.				
$/i^j/$	160 ms (38)	154 ms (23)	164 ms (31)	164 ms (21)
/i:/	204 ms (44)	221 ms (21)	204 ms (44)	202 ms (23)
$/i^j/$, /i:/	182 ms	188 ms	184 ms	183 ms

> "In a number of languages ... vowels are longer when followed by voiced consonants than when followed by voiceless consonants" (Catford 1977).

and

> "there is some indication that the duration of vowels is determined in part by the articulatory location of surrounding, particularly following, consonants. Fischer-Jørgensen (1964) concludes, ... that the conditioning factor is the length of movement required to pass from the vowel position to the consonant position: ... all vowels in her study (of Danish vowels) are shorter before [b] than before [d] or [g]". (Catford 1977)

Interspeaker and intraspeaker variation cannot be underestimated. The samples used, however, seem to be adequate to avoid the many exceptions from dominating the results and to illustrate the influence of determining factors quite clearly.

6.11. Conclusion

The data analysed in this study indicates that in Maltese:-

1. Vowel duration is related to the number of syllables in a word. Vowels are longest in monosyllables.

2. Vowels in unstressed syllables are as long and sometimes longer than vowels in stressed syllables.

3. Vowels in word-final position (in an open syllable) are longer than vowels occurring elsewhere in the word.

4. A vowel preceding a geminate consonant is shorter than a vowel preceding a single consonant only for some speakers (one out of two here).

5. Vowel duration is not related to tongue height, i.e. to the openness or closeness of the vowel.

6. There is no difference between the duration of the long vowels that are known to derive from pharyngalised vowels and those known to be "ordinary" long vowels.

7. Nasal context does not influence vowel duration.

This study does not claim to make any sweeping generalizations. The main purpose was to get a general idea of what kind of absolute average duration there is across vowel sets and what type of phonetic conditioning exists in Maltese. In comparative studies of the speech of hearing and deaf speakers, total utterance duration - and syllable duration - have been found to be highly related to judgements of normal speech rhythm, itself highly related to speech intelligibility (Hood, 1966).

Chapter 7

An Acoustic Study of the Monophthongs

7.1. Acoustic Description of the Maltese Vowels

There is ample justification for an acoustic study of Maltese speech within the framework of the present work. An acoustic description of Maltese utterances would be very helpful to audiologists in their assessment of hearing for speech, as well as to teachers of the deaf in grading material for speech and materials in auditory training.

7.2. The Spectrograph - Its use in phonetic analysis

The spectrograph can provide the phonetician with the relevant data for such an acoustic analysis. Spectrography is the most precise method available at the moment for analysing speech sounds into their frequency components.

Several descriptions of the way the Spectrograph/ Sonagraph operates are available (for instance, Potter, Kopp and Green 1947, Fry 1979, Ladegoged 1962). It is sufficient for these purposes to say that the Sonagraph 707A, used for the work reported here, operates by means of filters that analyse the frequencies of an incoming sound-sample across a time dimension. The analysis is recorded graphically by means of a stylus on a special sheet that revolves on a drum at a constant speed, enabling the stylus to plot the energy present in the recording (the energy being converted electrically) at particular frequency and time-points in shades of grey - with darker shades corresponding to increasing intensity or greater energy. The narrowband spectrogram is made with a filter width of 45 frequencies whereas the wideband spectrogram is made with a filter width of 300 frequencies. Hence there is a greater indefiniteness in wideband than in narrowband spectrograms. The smears (time indefiniteness) are approximately 1 Hz. and 7 Hz. respectively.

7.3. Disadvantages

Unfortunately, however, the spectrographic data is very far from being homogeneous. It is difficult to discuss not only the speech of different speakers in exact acoustic terms, but also the different utterances of the same speaker since these are not identical. The frequency of the glottal tone[1] varies in relation to the size and shape of the oral cavity. It is shaped by the mobile articulators of the oral cavity. Physiological differences between speakers cause major changes in the glottal tone.

> "At the moment no one can use spectrographic data or other records of the acoustic characteristics of a vowel to give as exact a specification of its phonetic quality as can be given by a well-trained phonetician. We can often (but not always) use spectrograms to assess the relative phonetic quality of two vowels spoken by the same speaker. But we can seldom make any precise statements about the relative phonetic quality of two vowels spoken by different speakers." (Ladefoged 1967, p. 74)

No utterance is ever repeated in an absolutely identical way by a speaker, although the utterance may be auditorily perceived as identical by listeners. Therefore, the acoustic analysis of each utterance will be different.

The fundamental frequency does not affect the formant pattern but has a characterizing effect on the exact frequency location of the formants:

> "... the fundamental tone can be eliminated from the vowel harmonic complex without disturbing the vowel recognition significantly." (Lehiste and Peterson 1959)

The spectrograph - even when fitted with a special filter for female voices - does not deal very

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1. Joos 1948, p. 20, and in further sections.

adequately with high pitched voices. Since not all informants possess a low pitched voice, several more difficulties have to be dealt with in resolving formant centre frequencies over and above the difficulties predictable from the vowel type.

The study of a particular vowel phoneme also implies consideration of varied contextual data, namely the study of the various phonetic realizations of that phoneme in various phonetic contexts. However, no phoneme is a:

> "totally independent stable unit from beginning to end. It is an event with a source and a target, and the target itself having another target ahead. In other words a sound exists in a specific environment which influences it and is influenced by it. The "pure" sound, if we can call it that, is of very short duration. The onglide and offglide could be much longer than the pure sound. Usually, in fact, the whole sequence of a speech event is a continuous movement so that there is no such thing as a pure sound. This is the case especially with vowels." (Pulgram 1959)

7.4. Spectrography - Procedure

Analysis of the spectrographic data is also problematic. This is not to say that the spectrogram of an utterance is not adequate, but Ladefoged discusses the extent to which vowel formant tracking is interpretation based on experience rather than on scientific rules:

> "... unless one knows, at a particular moment, which 'type of formant' one is dealing with, it is impossible to know how to handle the acoustic data. Indeed, on the basis of the experience of analysing all the acoustic data discussed in this work, it would seem that without knowing the sound which is being investigated, and without some previous knowledge of approximately where the formants of such a sound might be expected to be, it is impossible to make valid measurements of the formant frequencies. The knowledge of approximately where the formants might be expected to be is partly the result of

the experience of examining many similar sounds and is partly derived from experience in synthesizing sounds. Thus we know that in figure 36 the formants are in the places indicated partly because these places are the ones which are in the usual ranges for the formants of e , and partly because if we tried to synthesize a sound as similar as possible to this one, it would have to have something like these formant frequencies.

"In summary, therefore, the procedure for determining formant frequencies used in the current research consists of (1) listening to the sound and estimating from experience of analysing and synthesizing similar sounds the possible parts of the spectrum in which the formants might be located and (2) examining spectrographic analyses and finding the centre frequencies of the regions within those parts that have a relatively high intensity. The essential weakness of this procedure is its circularity - the necessity of having to prejudge the answer before examining the acoustic data. However, the procedure adopted is, in the present state of our knowledge, the only possible way of overlooking the difficulties in locating formant frequencies which have been noted above; no other procedure has been formulated which is equally useful in the analysis of spectrographic data." (Ladefoged 1967, p. 85)

To a great extent the procedure discussed above was used in the present study.

Ladefoged's work deals with the Cardinal vowels produced by phoneticians, i.e. vowels in isolation and of a specific predetermined quality since the speakers are all trying to match an agreed quality. My concern is not so much in differentiating between the different vowel classes, but also between the different members of the same vowel class. Thus I am dealing with very small differences that are significant but not fully illustrated by the formant peaks in a clear-cut manner. As Ladefoged (1967, p. 74) points out, it is impossible to decide the formant centres if they are too close to each other or too low in intensity.

7.5. The Present Spectrographic Study

I decided to make a spectrographic analysis of the monophthongs in different contexts in order to investigate their formant structure and the relationship between monophthongs of each set in terms of their formant structure.

I made several wideband and narrowband as well as section spectrograms of each of the eleven monophthongs described in chapter 5 , in different contexts as spoken by from two to four speakers. The vowels studied are all stressed except for some examples of /u/ which are discussed accordingly.

The word list, together with the phonemic transcription and the gloss appears below in figure 7.1. The words are laid out more clearly by the context for which they were chosen, in figure 7.2. The contexts can be listed as follows, where P refers to a labial context, T an alveolar and K a velar context and v refers to the vowel studied. (1) P v P (2) P v T (3) P v K (4) T v T (5) T v P (6) T v K (7) K v K (8) K v P (9) K v T. In some cases no words were found that fitted the selected context. Nonsense words were used instead. These are indicated by a preceding *. Where the nonsense words were considered unnatural, in that the vowel was too long, these were not used - hence the gaps in figure 7.2.

The results of some of the work is presented and discussed below. It should be stressed that although a great deal of generalization was necessary, the results were not all consistent. Naturally, it would require a great deal more than a short section like this to cover the problems involved. However, it is hoped that enough evidence is presented to substantiate the description of the eleven Maltese vowels in terms other than duration.

FIGURE 7.1.

Word-list with phonemic transcription and English gloss for a spectrographic study of Maltese monophthongs.

No.	Orthography	Phonemic Transcription	Gloss
/i^{j}/			
1.	pipa	'pi^{j}pa	pipe
2.	irbit	irbi^{j}t	ties
3.	bidha	'bi^{j}da	lay it!.
4.	bid	bi^{j}t	lay !
5.	peter	'pi^{j}ter	-name-
6.	pika	'pi^{j}ka	competition
7.	titlu	'ti^{j}tlu	title
8.	tip	ti^{j}p	kind, sort
9.	intik	in'ti^{j}k	I give you
10.	irkik	ir'ki^{j}k	-nonsense wd.
11.	pkik	*pki^{j}k	-nonsense wd.
12.	irkib	ir'ki^{j}p	riding
13.	gowlkeeper	gow'ki^{j}per	goalkeeper
14.	keith	ki^{j}t	-name
/i:/			
15.	bieb	bi:p	door
16.	pied	pi:t	foot(measure)
17.	biedha	'bi:da	he laid it
18.	bied	bi:t	he laid
19.	piegi	'pi:gi	pleats
20.	dieta	'di:ta	diet
21.	ktieb	kti:p	book
22.	tiekol	'ti:kol	you eat
23.	kieku	'ki:ku	if
24.	kiep	*ki:p	-nonsense wd.
25.	skiet	ski:t	silence
/i/			
26.	pipistrel	(pipi'strel)[1]	bird
27.	pitter	'pit:er	to paint
28.	bidtha	'bit:a	I laid it
29.	bidt	bit:	I laid
30.	spikka	'spik:a	to shine
31.	titla	'titla	to go up
32.	tippoza	(tip:o:za)	you pose
33.	tikka	'tik:a	a dot
34.	kikkra	'kik:ra	a cup
35.	kiber	'kiber	to grow up
36.	kitla	'kitla	kettle
/e:/			
37.	pepe	'pe:pe	name
38.	beghetni	'be:tni	he sold me
39.	pek	*pe:k	-nonsense wd
40.	theda	'te:da	you while away your time
41.	dehra	'de:ra	appearance
42.	ceda	'tʃe:da	to give in
43.	deheb	de:p	gold
44.	teghemha	'te:ma	he tasted it
45.	bibljoteka	bibljo'te:ka	library
46.	kek	*ke:k	-nonsense wd
/e/			
47.	pepe	pe'pe	snobbery
48.	Peppu	'pep:u	-name
49.	pett	pet:	sole
50.	bekka	'bek:a	he made s.o. cry
51.	beka	'beka	he cried
52.	thedda	'ted:a	he was threatened
53.	thedded	'ted:et	you threaten
54.	imtedd	im'tet:	lie down
55.	derra	'der:a	he got s.o. used to
56.	tebgha	'teba	stain
57.	temma	'tem:a	to force-feed
58.	debba	'deb:a	mare
59.	martek	('martek)	your wife
60.	harkek	('harkek)	he fined you
61.	rikeb	('rikep)	he rode
62.	curkett	tʃur'ket:	a ring
63.	sikket	('sik:et)	to silence s.o
/a:/			
64.	papra	'pa:pra	duck
65.	papa	'pa:pa	Pope
66.	baghat	ba:t	to send
67.	patri	'pa:tri	a priest
68.	maghna	'ma:na	with us
69.	xpaka	*'ʃpa:ka	-nonsense wd
70.	tatu	'ta:tu	she gave him
71.	imtaten	im'ta:ten	sheep

1. Words enclosed in round brackets indicate that the vowel in question is unstressed. These were studied initially but were not considered in the averages in Figure 7.6.

<u>FIGURE 7.1</u> (page 2)

	Orthography	Phonemic Transcription	Gloss
72.	irtab	ir'ta:p	soft
73.	khaki	'ka:ki	khaki
74.	imkatar	im'ka:tar	hankies
75.	qagħad	ʔa:t	he stayed
76.	għala	'a:la	why
/a/			
77.	papa	pa'pa	father
78.	papocc	(pa'potʃ)	slipper
79.	bgħatt	bat:	I sent
80.	manna	'man:a	bread
81.	patti	'pat:i	pay back!
82.	xpakka	'ʃpak:a	to burst clothes
83.	tata	ta'ta	goodbye
84.	tapp	tap:	water tap
85.	takkuna	ta'k:u^{w}na	heel
86.	makakk	ma'kak:	cunning
87.	kappell	(ka'p:el:)	hat
88.	kattar	'kat:ar	to increase
89.	imkattar	im'kat:ar	increased
90.	qatt	ʔat:	never
91.	Alla	'al:a	God
/o:/			
92.	poplu	'po:plu	nation
93.	bogħod	bo:t	far away
94.	bok	*bo:k	-nonsense wd.
95.	irtgħod	ir'to:t	to shiver
96.	sogħod	so:t	firm
97.	sogħda	'so:da	firm (fem.)
98.	domna	'do:mna	medallion
99.	tokis	'to:kis	cinema
100.	koka	'ko:ka	cook (fem.)
101.	kok	ko:k	cook
102.	skop	sko:p	aim
/o/			
103.	poppa	'pop:a	prow
104.	bott	bot:	tin
105.	bokkin	(bo'k:i^{j}n)	cigarette holder

	Orthography	Phonemic Transcription	Gloss
106.	tgħodd	tot:	you count
107.	sodd	sot:	you plug
108.	sodda	'sod:a	bed
109.	domna	'domna	we stayed long
110.	tobgħod	'tobot	you hate
111.	tokk	tok:	place name
112.	tokka	'tok:a	pen cap
113.	kokka	'kok:a	owl; to crouch
114.	kopp	kop:	net
115.	kotra	'kotra	crowd
/u^w/			
116.	pupa	'pu^{w}pa	doll
117.	but	bu^{w}t	pocket
118.	lampuka	lam'pu^{w}ka	fish name
119.	tut	tu^{w}t	blackberries
120.	tubu	'tu^{w}bu	tube
121.	intuk	in'tu^{w}k	we give you
122.	zkuk	tsku^{w}k	branches
123.	xkupa	'ʃku^{w}pa	broom
124.	kutra	'ku^{w}tra	blanket
125.	kul	ku^{w}l	eat!
126.	sur	su^{w}r	wall
127.	tul	tu^{w}l	height
/u/			
128.	pupazz	(pu'pats)	puppet
129.	buttuna	(bu't:u^{w}na)	button
130.	bukkun	(bu'k:u^{w}n)	a big mouthful
131.	tuttu	'tut:u	horse (babytalk)
132.	dubbiena	(du'b:i:na)	fly
133.	irtukkar	(irtu'k:a:r)	touching up
134.	kukka	'kuk:a	egg (babytalk)
135.	xkupilja	(ʃku'pilja)	brush
136.	skutella	(sku'tel:a)	bowl
137.	kull	kul:	every
138.	sur	sur	Mister
139.	tull	tul:	material for veils

FIGURE 7.2. Word-list by phonetic context and by vowel for a spectrographic study of Maltese monophthongs.

CONTEXT	/iʲ/	/i:/	/i/	/e:/	/e/	/a:/	/a/	/o:/	/o/	/uʷ/	/u/
P_P	ˈpiʲpa	bi:p	(pipistrel)[2]	ˈpe:pe	peˈpe ˈpep:u	ˈpa:pra ˈpa:pa	paˈpa (paˈpoʃ)	ˈpo:plu	ˈpop:a	ˈpuʷpa	(puˈpals)
P_T	irˈbiʲt ˈbiʲda biʲt ˈpiʲter	pi:t ˈbi:da bi:t	ˈpit:er ˈbit:a bit:	ˈbe:tni	pet:	ba:t ˈpa:tri ˈma:na	bat: ˈman:a ˈpat:i	bo:t	bot:	buʷt	(buˈt:uʷna)
P_K	ˈpiʲka	ˈpi:gi	ˈspik:a	*pe:k	ˈbek:a ˈbeka	ˈʃpa:ka	ˈʃpak:a	*bo:k	(bok:iˈn)	lamˈpuʷka	(buˈk:uʷn)
T_T	ˈtiʲllu	ˈdi:la	ˈtitla	ˈte:da ˈde:ra ˈtʃe:da	ˈted:a ˈted:et: imˈtet: ˈder:a	ˈta:tu imˈta:ten	taˈla	irˈto:t so:t ˈso:da	to:t: sot: ˈsod:a	tuʷt	ˈtut:u
T_P	tiʲp	kli:p	(tiˈp:o:za)	de:p ˈte:ma	ˈteba ˈtem:a ˈdeb:a	irˈta:p	tap:	ˈdo:mna	ˈdomna ˈtobot	ˈtuʷbu	(duˈb:i:na)
T_K	inˈtiʲk	ˈli:kol	ˈlik:a	bibljoˈte:ka	(marˈtek)	-	(taˈk:uʷna)	ˈto:kis	tok: ˈtok:a	inˈtuʷk	(irˈtuk:a:r)
K_K	*irkiʲk *pkiʲk	ˈki:ku	ˈkik:ra	*ke:k	(ˈharkek)	ˈka:ki	maˈkak:	ˈko:ka ko:k	ˈkok:a	lskuʷk	ˈkuk:a
K_P	irˈkiʲp ˈkiʲper	*ki:p	ˈkiber	-	(ˈrikep)	-	(kaˈp:el:)	sko:p	kop:	ʃkuʷpa	(ʃkuˈpilja)
K_T OTHERS	kiʲt	ski:t	ˈkilla	-	tʃurˈket: (ˈsik:et:)	imˈka:lar ʔa:t ˈa:la	ˈkal:ar imˈkal:ar ʔal: al:a	-	ˈkolra	ˈkuʷtra kuʷl suʷr tuʷl	(skuˈtel:a) kul: sur tul:

(1) P = labial; T = Alveolar or palatal; K = Velar. (2) Words in brackets show unstressed vowels.

7.6. Analysis of the Spectrograms made for this study

Great care was taken in determining the formant centre of the first three formants. A sheet of tracing paper was placed over each spectrogram. Lines were drawn from the middle of each calibration mark (which occurred at every 500 Hz.) from the right hand side to the left so that a series of seven parallel lines from 500 Hz. to 3500 Hz. were made. This made it easier to measure the formant centre accurately.

The section spectrograms constituted the major piece of evidence although the wideband and narrowband spectrograms were used for subsidiary clues and pointers in the final analysis. The sections were made at a halfway point through the duration of the steady state portion of the vowels, or, in the case of very unstable vowels, at a point in the middle of the vowel. Often, sections were made at various points in order to measure the extent of formant movements on either side of the point at which the 'major' section was taken. The centre of the formants in all cases can therefore be said to have been located by eye, measured in millimetres and then converted to the frequency value in Hertz. Again, great care was taken over the measurements, and these were revised several times. The discrepancy between revised measurements was of the order of about 10 Hz.

In many cases, it was difficult to decide what constituted and/or was not a part of the vowel. Vocal cord vibration did not always begin or end with what appears as the periodic portion of the vowel. In such cases there was a certain amount of arbitrariness in deciding upon the beginnings and endings of the vowel. Two or more additional sections were therefore made in these situations.

Figure 7.3 Spectrograms of /pi:t/ and /pa:ga/

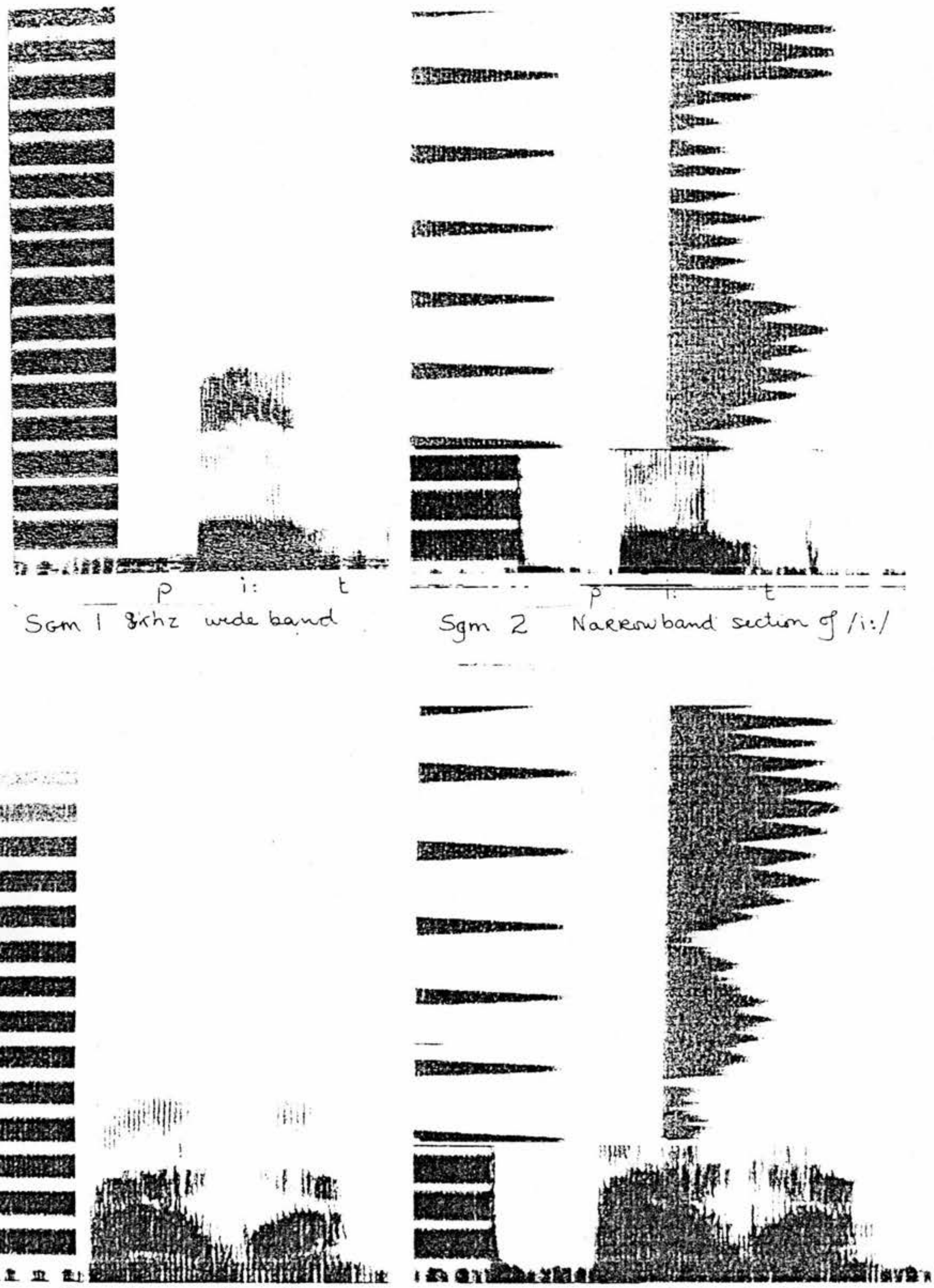
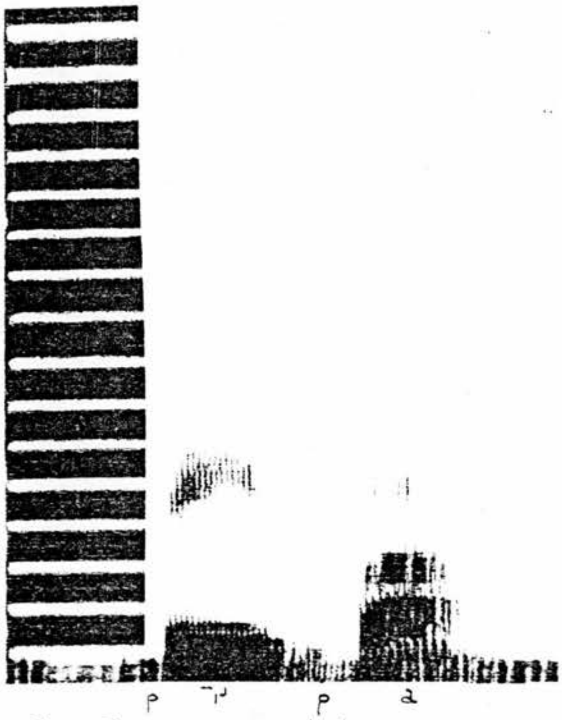
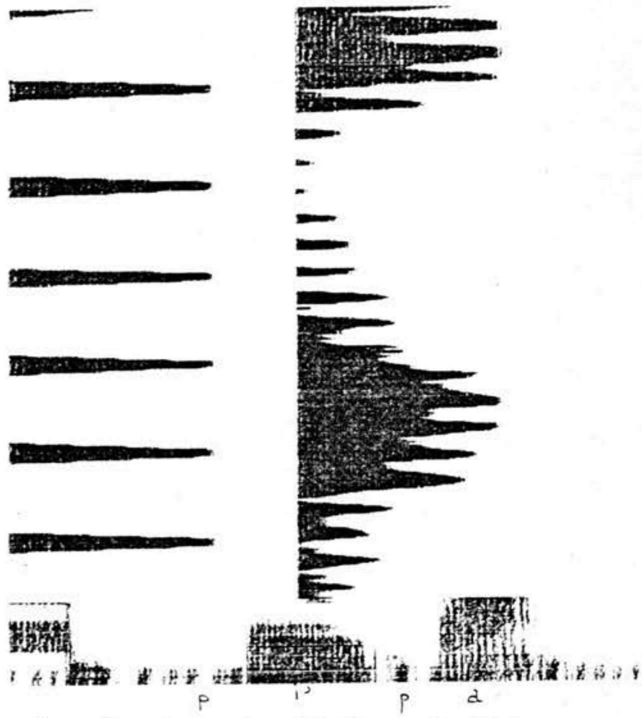


Figure 7.4 Spectrograms of /piᵊpa/ and /buʷt/.

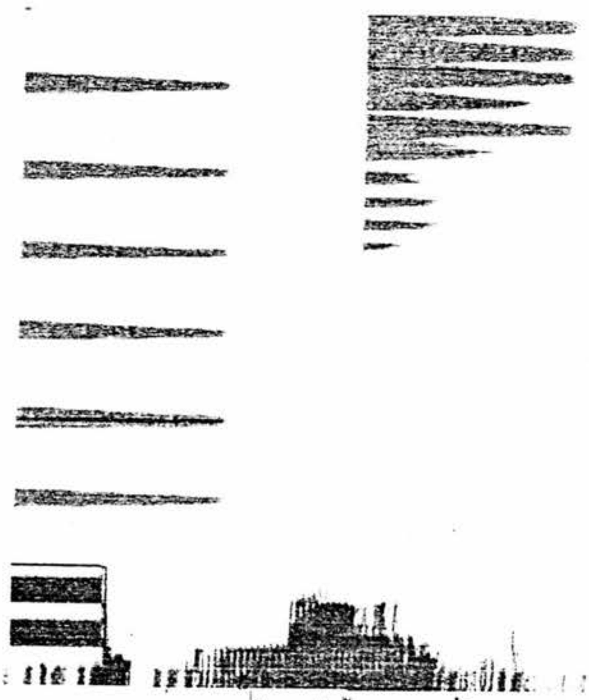


Sgm 5: 8khz wideband



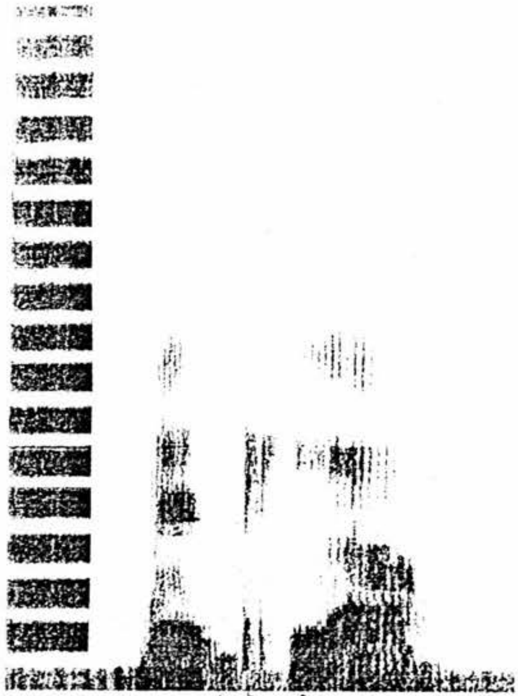
Sgm 6: Narrowband section of /iᵊ/

Sgm 7 8khz wideband

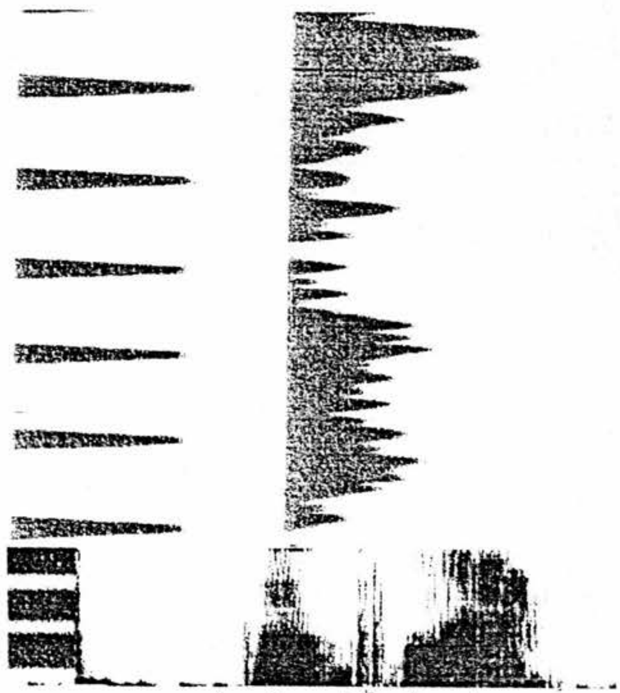


Sgm 8 Narrowband section of /u/

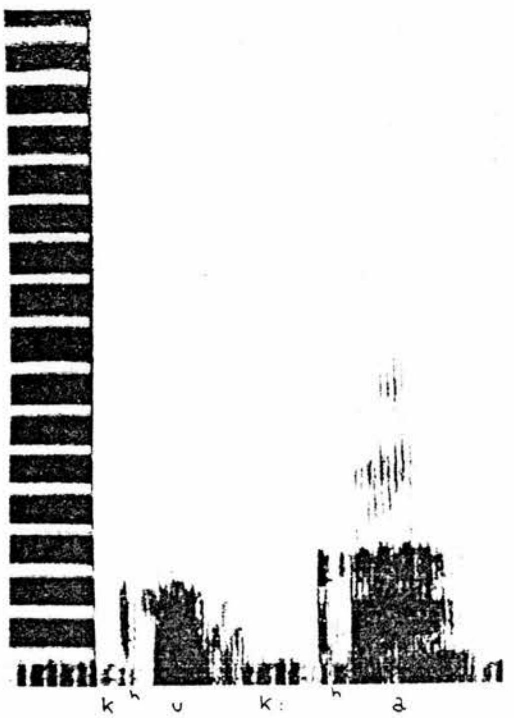
Figure 7.5 Spectrograms of /titla/ and /kuk:a/



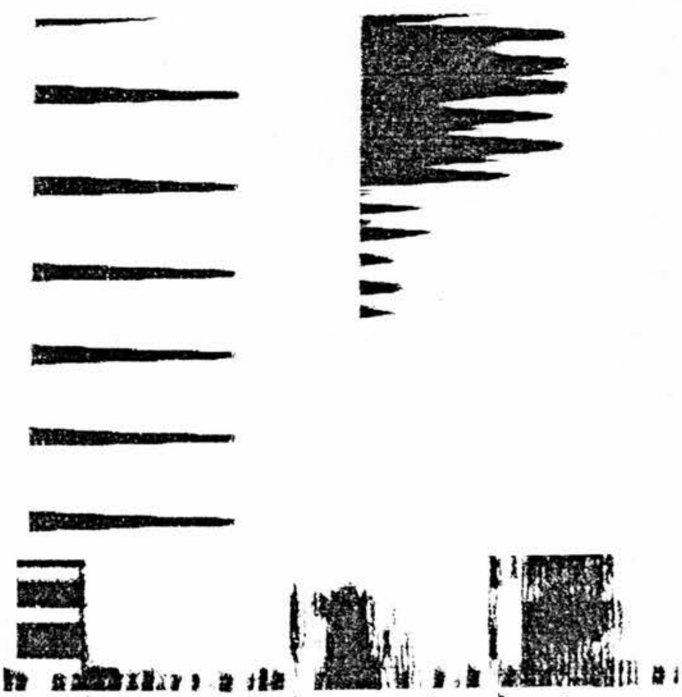
Sgm 9 8khz wide band



Sgm 10 : Narrow band section of /i/ in /titla/



Sgm 11 8 khz wide band



Sgm 12 Narrow band section of /u/ in /kuk:a/

7.7. Presentation of results

The results of the analyses of several spectrograms made - both wideband and narrowband section spectrograms - of the vowels appear in figures 7.6 below. The context within which each vowel occurs appears on the left hand side column of the tables. The data shown include the formant-peak frequency measured at the centre of the most steady-state portion of each of the vowels studied. The relationship between the acoustic and the auditory data is summarized in 7.10 and fig.7.7.

7.8. Discussion of data analyses

It is interesting to note:

1. At a first consideration, there are several inconsistencies within the same phoneme used in different stressed syllables by the same speaker, e.g. /i^j/ by informant 1 is characterized by formant 1 frequency 322 Hz. in <tip> as 385 Hz. in <peter>

2. When each vowel phoneme is contrasted with the other or others in the same vowel set within a phonetic context that is reasonably well matched, there is usually a consistent acoustic difference between them. There are some exceptions, however. For example, /i/ in /titla/ has a higher F_1 than /i^j/ in /ti^{j}tlu/ for informant 1, although /i^j/ is usually characterized by a lower F_1 than /i/.

3. All the averaged results, at whatever stage (i.e. for each speaker, for all speakers together) show the same consistent differences even if these are rather small, and seemingly insignificant at times.

The following generalizations can be made for each vowel set:

FIGURE 7.6 Formant-Centre Values in Hertz for the Maltese Monophthongs.

The values for each vowel set appear side by side. The vowel in each case appears on the left-hand side. The Informant used also appears on the left-hand side marked: Inf. 1, 2, 3, or 4.

Figure 7.6 (page 1): /i^j/, /i:/ and /i/ in stressed syllables

/i^j/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 1	/pi'pa/	357	2410	2962	
	/irbi't/	340	2480	2678	
	/bi'da/	357	2560	2940	
	/bi't/	337	2400	2840	
	/pi'ter/	385	2420	2800	
	/pi'ka/	347	2420	2760	
	/ti'tlu/	375	2440	2827	
	/ti'p/	322	2500	2712	
	/inti'k/	357	2400	2905	
	/irki'p/	357	2577	2800	
	Informant 1 Average	353	2461	2822	2108

/i:/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 1	/bi:p/	357	2404	2577	
	/pi:t/	357	2360	2690	
	/bi:da/	357	2400	2580	
	/bi:t/	322	2480	2730	
	/pi:gi/	322	2500	2780	
	/di:ta/	347	2340	2827	
	/kti:p/	357	2481	2721	
	/ti:kol/	357	2440	2750	
	/ki:ku/	357	2462	2674	
	Informant 1 Average	348	2430	2703	2082

/i/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 1	/bit:a/	411	2000	2620	
	/bit:/	468	2080	2700	
	/pit:er/	411	1959	2700	
	/spik:a/	357	2038	2500	
	/titla/	337	1958	2731	
	/tik:a/	393	2260	2712	
	/kik:ra/	393	2500	2860	
	Informant 1 Average	396	2114	2689	1718

Figure 7.6 (page 2): /i^j/, /i:/ and /i/ continued.

/i^j/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf 2	/pi'pa/	317	2221	2519	
	/irbi't/	278	2370	2460	
	/pi'ka/	305	2193	2690	
	/ti'tlu/	339	2269	2655	
	/ti'p/	337	2167	2688	
	/inti'k/	312	2160	2660	
	/irki'k/	280	2395	2800	
	/gowl ki'per/	355	2360	2680	
	/ki't/	337	2375	2680	
	Average	312	2279	2648	1961
Inf. 3	/pi'pa/	357	2572	2904	
	/ti'tlu/	357	2400	2750	
	/pki'k/	286	2654	2904	
	Average	333	2542	2853	2209
Inf 4	/pi'pa/	393	2664	-	
	/ti'tlu/	429	2923	3154	
	/irki'k/	384	-	-	
	Average	402	2794	3154	2392

/i:/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf 2	/bi:p/	306	2250	2702	
	/pi:t/	340	2212	2538	
	/pi:gi/	357	2193	2530	
	/di:ta/	347	2360	2680	
	/kti:p/	357	2317	2673	
	/ti:kol/	347	2271	2667	
	/ki:ku/	357	2250	2720	
	/ki:p/	357	2385	2705	
	/ski:t/	357	2220	2625	
	Average	347	2273	2649	1926
Inf. 3	/bi:p/	357	2702	-	
	/di:ta/	393	2846	2971	
	/ki:ku/	393	2500	2962	
	Average	381	2683	2967	2302
Inf 4	/bi:p/	410	2448	2846	
	/di:ta/	430	2884	3087	
	/ki:ku/	466	2423	2875	
	Average	435	2585	2936	2150

/i/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 2	/piter/	455	1848	2461	
	/spik:a/	467	1769	2269	
	/titla/	467	1960	2600	
	/dit:a/	440	2000	2557	
	/tik:a/	464	2048	2500	
	/kik:ra/	352	2100	2540	
	/kiber/	467	2167	2560	
	/kitla/	375	2060	2560	
	Average	436	1994	2506	1558
Inf. 3	/titla/	411	2000	2667	
	/kik:ra/	393	2430	2808	
	Average	402	2215	2738	1813
Inf. 4	/titla/	420	2170	2910	
	/kik:ra/	455	2529	2923	
	Average	438	2350	2917	1912

Figure 7.6

(page 3)

/e:/ and /e/ in stressed syllables.

/e:/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 1	/de:ra/	575	2200	2860	
	/pe:pe:/	528	2080	2580	
	/pe:pe:/	464	2096	2760	
	/be:tni/	464	2040	2800	
	/pe:k/	449	2060	2654	
	/te:da/	500	2292	2630	
	/te:da/	446	2231	2683	
	/de:p/	449	2100	2860	
	/te:ma/	525	2188	2709	
	/ke:k/	446	2096	2692	
	Average	476	2138	2723	1662
Inf 2	/pe:pe:/	556	1960	2462	
	/be:tni/	510	2056	2555	
	/pe:k/	570	2000	2420	
	/te:da/	622	2000	2620	
	/ʧe:da/	525	1940	2308	
	/de:p/	536	2000	2460	
	/biblio te:ka/	464	2000	2460	
	/ke:k/	464	2180	2560	
	Average	531	2017	2480	1486
Inf 3	/pe:pe:/	536	1943	2693	
	/te:da/	446	2097	2750	
	Average	491	2020	2722	1529

/e/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 1	/pepe/	519	1896	2240	
	/pep:u/	500	1870	2538	
	/pet:/	449	2060	2640	
	/bek:a/	593	1920	2500	
	/ted:a/	554	2188	2750	
	/ted:et/	481	2209	2900	
	/imtet:/	464	2034	2808	
	/teba/	472	1917	2600	
	/tem:a/	536	1980	2692	
	/der:a/	572	1938	2847	
	Average	514	2002	2651	1488
Inf. 2	/pep:u/	572	1412	2400	
	/pet:/	556	2000	2440	
	/beka/	588	1750	2230	
	/imtet:/	570	1958	2667	
	/teba/	643	1740	2538	
	/deb:a/	589	1740	2620	
	/ʧorket:/	518	1808	2423	
	Average	577	1773	2474	1196
Inf. 3	/pepe/	553	1885	2673	1332

Figure 7.6

(page 4)

/a:/ and /a/ in stressed syllables.

/a:/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf 1	/pa:pra/	620	893	–	
	/pa:pa/	645	1125	2458	
	/ba:t/	631	1096	2500	
	/pa:tri/	566	837		
	/ʃpak:a/	590	857		
	/ta:tu/	519	1020		
	/imta:ler/	627	1157	1539	
	/irta:p/	575	855	1460	
	/imka:lar/	650	982	1385	
	/a:la/	650	982	1300	
	/ʔa:t/	654	1260		
	/ma:na/	535	1231		
	Average	605	992	1742	387
Inf 2	/pa:pra/	715	1262	2385	
	/pa:tri/	668	1231	2500	
	/spa:k/	643	1262	2262	
	/ʃpa:ka/	590	1225	2327	
	/pa:ga/	715	1193	2154	
	/imta:ler/	679	1411	2577	
	/irta:p/	679	1423	2640	

/a/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf 1	/papa/	631	1097	2166	
	/bat:/	528	1060	2459	
	/ʃpak:a/	536	1000	1193	
	/tata/	500	987	1680	
	/tata/	571	857	1597	
	/tap:/	576	875	1424	
	/makak:/	500	1000	1337	
	/imkat:ar/	594	985	1500	
	/al:a/	650	1130	1280	
	/ʔat:/	655	1212	1385	
	/man:a/	669	1039	–	
	Average	589	1080	1602	491
Inf. 2	/pat:i/	715	1187	2560	
	/tap:/	715	1300	2077	
	/kat:ar/	607	1231	1462	
	/imkat:ar/	612	1393	2280	
	Average	662	1278	2735	616
Inf. 3	/tata/	572	1692	2616	1120

Figure 7.6 (page 5): /a:/ continued.

/a:/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 2	/ta:k/	768	1230	2577	
	/ka:p/	687	1240	2616	
	Average	683	1275	2449	592
Inf 3	/pa:pra/	643	1361	-	
	/im ta:lei/	695	1500	2654	
	Average	669	1431	2654	762

Figure 7.6

(page 6)

/o:/ and /o/ in stressed syllables.

/o:/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 1	/po:plu/	464	786	1731	
	/bo:t/	520	800	1231	
	/bo:t/	558	731	1212	
	/bo:k/	536	796	1203	
	/irto:t/	446	876	-	
	/do:mna/	481	962	1289	
	/ko:ka/	472	808	1262	
	/ko:ka/	505	837	1160	
	/ko:k/	466	786	-	
	/so:t/	470	1077	-	
	/so:da/	459	855	1183	
	Average	487	847	1284	360
Inf. 2	/po:plu/	571	857	1557	
	/bo:t/	536	786	1327	
	/bo:k/	555	855	2540	
	/irto:t/	500	1000	2620	
	/to:kis/	447	893	1500	
	/ko:k/	437	1000	1980	
	/sko:p/	572	1020	1750	
	Average	506	909	1911	403

/o/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf. 1	/pop:a/	500	830	1729	
	/bot:/	536	786	1270	
	/bot:/	478	800	1270	
	/tot:/	455	893	-	
	/domna/	500	850	2540	
	/kok:a/	537	893	1423	
	/kok:a/	537	875	1423	
	/kok:a/	575	949	-	
	/sot:/	537	1040	1366	
	/sod:a/	537	1058	-	
	Average	514	894	1574	380
Inf. 2	/pop:a/	554	822	2520	
	/tobot/	626	780	2660	
	/tot:/	571	840	2690	
	/tok:/	607	1206	1923	
	/tok:a/	500	1250	2423	
	/kok:a/	464	959	1900	
	/kop:/	607	1037	2510	
	/kotra/	464	1107	2400	
	Average	575	1001	2379	4·26

Figure 7.6 (page 7)

/u^W/ in stressed syllables and /u/ in stressed and unstressed syllables.

/u^w/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf 1	/pu^{w}pa/	332	760		
	/bu^{w}t/	296	715	1019	
	/ɫam pu^{w}ka/	322	750		
	/tu^{w}t/	339	848	1296	
	/tu^{w}bu/	322	786	1185	
	/intu^{w}k/	314	847		
	/tsku^{w}k/	322	812		
	/ʃku^{w}pa/	331	804		
	/ku^{w}tra/	322	821	1000	
	/ku^{w}ɫ/	322	717	1160	
	/su^{w}r/	275	930		
	/tu^{w}ɫ/	280	819		
	Average	316	801	1131	485
Inf. 2	/pu^{w}pa/	304	714	1296	
	/bu^{w}t/	287	722	1157	
	/ɫam pu^{w}ka/	278	701	1077	
	/tu^{w}t/	287	854	1214	
	/tu^{w}bu/	295	723	1192	
	/intu^{w}k/	287	786	1192	
	/tsku^{w}k/	298	762	1192	
	/ʃku^{w}pa/	327	927	1135	
	/ku^{w}tra/	304	732	1111	
	Average	296	769	1174	473

/u/	Phonemic Transcription	Formant 1	Formant 2	Formant 3	Formant 2 minus Formant 1
Inf 1	/tut:u/	375	930	1115	
	/kuk:a/	468	786	1130	
	/kuɫ:/	411	780	1173	
	/sur:/	430	968	–	
	/tuɫ:/	448	857	1200	
	/pupats/	448	857	–	
	/but:u^{w}na/	421	857	–	
	/buk:u^{w}n/	429	–	–	
	/dub:i:na/	466	750	1185	
	/irtuk:a:r/	482	–	–	
	/ʃkupilja/	430	857	–	
	/skutel:a/	448	893	–	
	Average Stressed	406	864	1155	458
	Average Unstressed	446	843	–	397
Inf. 2	/tut:u/	482	708	1130	
	/kuk:a/	462	808	–	
	/pupats/	411	679	1212	
	/but:u^{w}na/	389	648	1173	
	/buk:u^{w}n/	407	676	1222	
	/dub:i:na/	411	804	1077	
	/irtuk:a:r/	411	696	1096	
	/ʃkupilja/	394	780	–	
	/skutel:a/	398	833	1126	
	Ave Stressed	472	758	1209	286
	Ave Unstressed	403	731	1150	328

Vowel set /i^j/ /i:/ /i/

Formant 1 is lowest for /i^j/, higher for /i:/ and highest for /i/, except for Informant 1 - but the F_1 and F_2 difference is still highest for /i^j/ for this informant.

Formant 2 is highest for /i^j/, lower for /i:/ and lowest for /i/, except for Informant 3.

Formant 3 is highest for /i^j/, lower for /i:/ and lowest for /i/, except for Informant 3.

Formant 2 minus Formant 1 is highest for /i^j/, lower for /i:/ and lowest for /i/, except for Informant 3.

Vowel set /e:/ /e/

Formant 1 is lower for /e:/ and higher for /e/.

Formant 2 is higher for /e:/ and lower for /e/.

Formant 3 is higher for /e:/ and lower for /e/.

Formant 2 minus Formant 1 is higher for /e:/ and lower for /e/.

Vowel set /a:/ and /a/

Formant 1 is higher for /a:/ and lower for /a/.

Formant 2 is lower for /a:/ and higher for /a/.

Formant 3 is higher for /a:/ and lower for /a/, except for subject 2.

Formant 2 minus Formant 1 is lower for /a:/ and higher for /a/.

Vowel set /o:/ /o/

Formant 1 is lower for /o:/ and higher for /o/.

Formant 2 is lower for /o:/ and higher for /o/.

Formant 3 is lower for /o:/ and higher for /o/.

Formant 2 minus Formant 1 is lower for /o:/ and higher for /o/.

Vowel set /u^w/ /u/

Formant 1 is lower for /u^w/ and higher for /u/.

Formant 2 is lower for /u^w/ and higher for /u/.

Formant 3 is lower for /u^w/ and higher for /u/.

Formant 2 minus Formant 1 is higher for /u^w/ and lower for /u/.

7.9. Interpretation of the Acoustic Data

7.9.1. The Relationship of Formants to Vocal Tract Shape

Delattre 1951 draws the following conclusions regarding the roles of the first three formants of speech sounds:

1. Formant one frequency rising relates directly to the overall opening of the oral tract "as measured for instance by the distances between the upper and lower incisors or by the distances between the highest point of the tongue and the point of the palate closest to it - in other words, the general width of the structures"(Delattre 1951, p. 867). The higher the frequency of Formant one, the wider is the overall opening and vice versa.

2. Formant two frequency lowering is directly related to front cavity lengthening, i.e. tongue backing which "is not measured by how far back the highest point of the tongue is, ... but by how far back-and-up the tongue as a whole is retracted ... it

is felt kinesthetically much better than the highest point of the tongue" (ibid. p.869). Lip rounding also has a lowering effect on Formant two.

3. Formant three mostly contributes to intelligibility, especially in cases where Formant two is high. Formant three frequency rising also corresponds to velum lowering, whereas Formant three frequency lowering corresponds to tongue tip raising as in retroflexion.

A greater distance between the first two formants corresponds to tongue fronting whereas a smaller distance refers to tongue retraction. A decrease in the distance between all the formants is usually the result of close and protruded lips whereas an increase in the distance corresponds to larger lip opening.

Since it is the entire size and shape of the vocal tract that is responsible for the formant pattern of a vowel-sound, no formant can be said to correspond to a specific part of the vocal tract in a one-to-one relationship. Moreover, it is possible for two factors to produce counter effects. An important articulatory difference, such as greater lip protrusion, may not be as easily identifiable from the formant analysis. Most acoustic studies of human languages do agree, in general terms, about assigning formants one and two respectively to the height and length of the vocal tract. In other words, Formant one corresponds, in general, to the opening of the vocal tract; Formant two corresponds to the length of the vocal tract.

7.9.2. The Maltese Vowels

The following conclusions can be drawn if we apply Delattre's discussion of the way the acoustic data relates to articulatory phenomena:

1. Overall Openness, i.e. general width of the structures:-

/i/ is more open than /i:/ which is more open than /i^j/
/e/ is more open than /e:/
/a:/ is more open than /a/
/o/ is more open than /o:/
/u/ is more open than /u^w/.

2. Frontness or backness of articulation, measured by how far back-and-up the tongue as a whole is retracted, and lip rounding:-

/i^j/ is more front than /i:/ which is more front than /i/
/e:/ is more front than /e/
/a/ is more front than /a:/
/o/ is more front than /o:/, or less lip-rounded
/u/ is more front than /u^w/, or less lip-rounded.

This, in fact, fits the articulatory description given earlier in terms of the traditional parameters, except for the relationship between /e/ and /e:/. The acoustic data have been plotted on a logarithmic scale along their Formant 1 and Formant 2 frequency values in figures 7.7 and 7.8, after Fry 1979 and others. A configuration very similar to that of the Cardinal vowel chart (figure 5.1) can immediately be seen.

The graph shows a very clearly marked frequency-area separation for the vowel sets from each other. Although the /u/ - /u^w/ and /i^j/ - /i/ - /i:/ distinction is also very obvious, there is a less marked differentiation of the vowels /i^j/ and /i:/ which I feel are more qualitatively distinct than any of the other three vowel sets. One possible reason for this is the degree of lip spreading that seems to be a more inherent part of the /i^j/ type articulation than the /i:/ type. This ambiguity in the acoustic data for the front close vowel set is one of the main reasons why synthetic data was considered for the investigation of the qualitative differences between members of this set.

7.10. The Relationship between the Acoustic and the Auditory Data

The measured acoustic differences between the vowels studied correspond significantly to the articulatory and auditory differences already discussed, except for /e/ and /e:/. Figure 7.7. below shows the average frequency values for Formant 1 and for Formant 2 plotted on the horizontal axis and on the vertical axis respectively for the two main informants used for the study. The close relationship between the acoustic and the auditory analyses of the vowels can be seen when comparing Figure 7.7. with Figure 5.1., reproduced again below. Figure 7.8. shows the average frequency values for Formant 2 minus Formant 1 and for Formant 1 plotted on the horizontal axis and on the vertical axis respectively for the two main informants used for the study.

FIGURE 7.7. The Maltese monophthongs plotted on a logarithmic scale - the average frequency value of Formant 1 by the average frequency value of Formant 2.

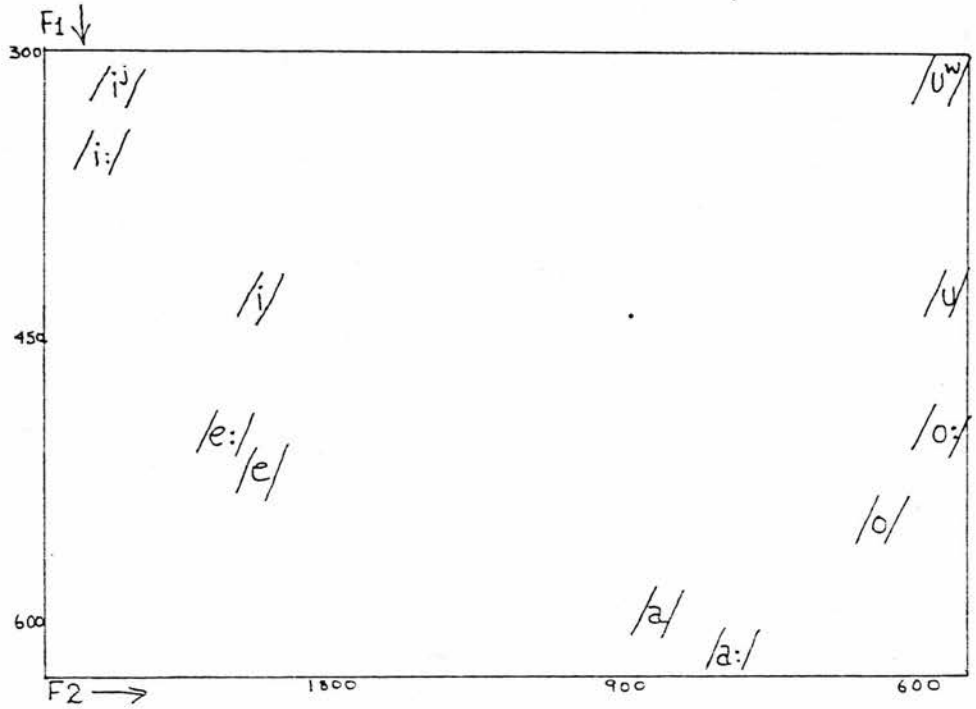


FIGURE 5.1. The relative auditory qualities of the Maltese vowels with reference to the Cardinal Vowel system. Circles indicate the area of variation involved between speakers.

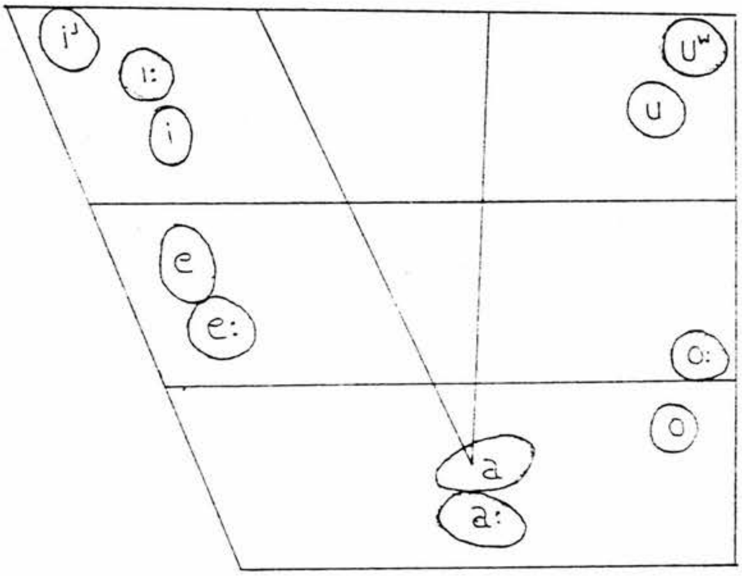
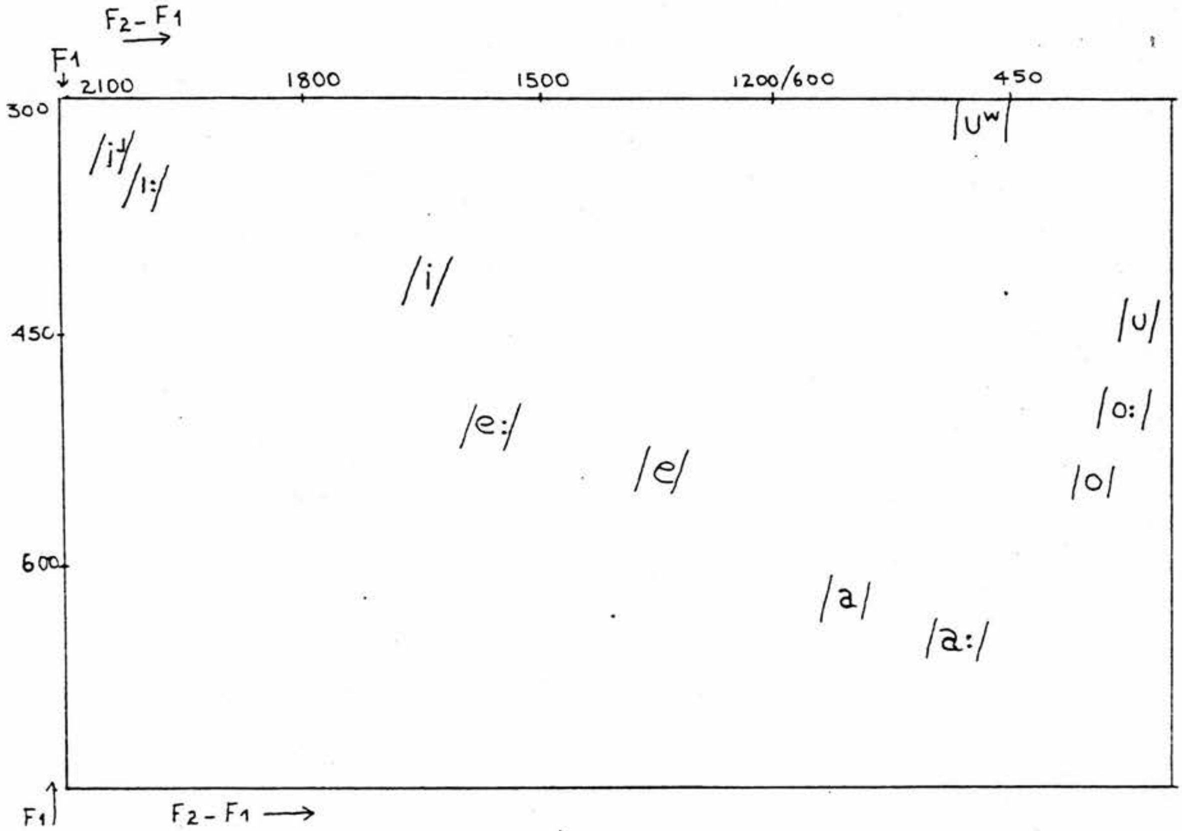


FIGURE 7.8. The Maltese monophthongs plotted on a logarithmic scale - the average frequency value of Formant 2 minus that of Formant 1 by the average frequency value of Formant 1.



Chapter 8

A Test in Speech Perception:

The Roles Played by Formant Structure and Duration.

8. Purpose of Experiment

This section describes an experiment carried out to investigate the roles of vowel quality and vowel duration as perceptual cues in the discrimination and identification of Maltese vowels.

8.1. Hypothesis

The basic hypotheses for this experiment were (1) that quality played a more important role than duration in Native Speakers' differentiation of the front vowels /i/, /i^{j}/, /i:/, and between the back vowels /u/ and /u^{w}/; (2) that quality played as important a role as duration in native speakers' differentiation between the members of the three remaining sets: /e/, /e:/; /a/, /a:/; and /o/, /o:/.

To test these hypotheses a number of minimal word sets was chosen for synthesis. The test was set up in such a way as to allow specific questions to be asked as follows:

1. Can vowel duration act as the only cue to the identity of a vowel? i.e. Does duration give the listener sufficient information to identify a word when the qualitative differences and consonant duration differences between the members of pairs or sets of words have been neutralized?

2. Can formant structure (corresponding to vowel quality) act as the only cue? i.e. Does formant structure provide sufficient information on its own when the duration of the vowel and consonants has been neutralized?

3. Can consonant gemination (of the arresting consonant of the syllable) act as the only cue when both vowel quality and vowel duration are non-distinctive?

4. In the examples where the formant structure is not appropriate to any one vowel but is "neutralized" so that the vowel quality is not identical to that of either vowel which of the three factors: vowel quality, vowel duration, consonant gemination, is more important, if any? Is it possible to establish a hierarchical relationship in terms of more and/or less important cues?

5. At what stage of gradual neutralization is the traditional 'short vowel' mistaken for the traditional 'long vowel' and vice versa? In other words, is there a specific formant structure and/or duration that is more exclusive to a specific vowel as part of its essential characteristic? Only a tentative answer can be provided by this study to this question.

8.2. Data for Synthesis

A number of words were synthesized on the synthesizer attached to the Computer at the University of Edinburgh Phonetics Laboratory (See Appendix C). Only the essential information for the steady state portion of the phonetic elements was changed. The values for transitions, amplitude and rank, and the rules for working these out were kept the same throughout. The information fed into the computer was based on the analysis of spectrograms of Maltese vowels within stressed syllables of a specific type (see previous chapter). This information consisted of:

(a) the fundamental frequency for every 10 milliseconds of each element;
(b) the steady state of formants one, two and three;
(c) the duration of the steady state of the vowels and of the consonants.

It was decided to concentrate on one factor at a time when synthesising the members of the same vowel set.

In most cases, more attention was paid to the raising and lowering of formant 1 in distinguishing between the vowels. The position and movement of formant 1 corresponds most closely to overall opening of the vocal tract. A change in formant 1 also produces a change in the separateness of formant 1 and formant 2. This $F_1 - F_2$ difference is related to tongue fronting/ retraction, i.e. the greater the difference between F_1 and F_2, the more fronted is the tongue and the larger, usually, is the lip opening. These correspondences are, however, only general ones and must be considered as such. Sometimes separate articulatory phenomena may combine to cancel each other out in terms of acoustic effect produced, e.g. a very front close vowel. This would show even more clearly the difficulty of relating spectrographic data to articulatory information.

8.3. Idealization of Data

Some idealization of the (spectrographic) acoustic data was necessary for various reasons:

1. to provide consistent data as input to the computer;
2. to fit into the inbuilt limitations of the speech synthesizer;
3. to bring down the several possible variations and to test only one factor at a time with everything else being equal;
4. to limit the test in size in order to reduce experimental fatigue and distorted results consequent to it.

An attempt is made here to provide the relevant information from the acoustic study of the vowels together with a discussion of how this information was converted into values suitable for synthesis. It is hoped that reference to the correspondence between the acoustic information introduced here and the articulatory description in the preceding pages will provide ample justification for the synthetic speech experiment that follows.

FIGURE 8.1.A. The values in Hertz of the first three formants of all of the synthesised vowels used on the SID experiment.

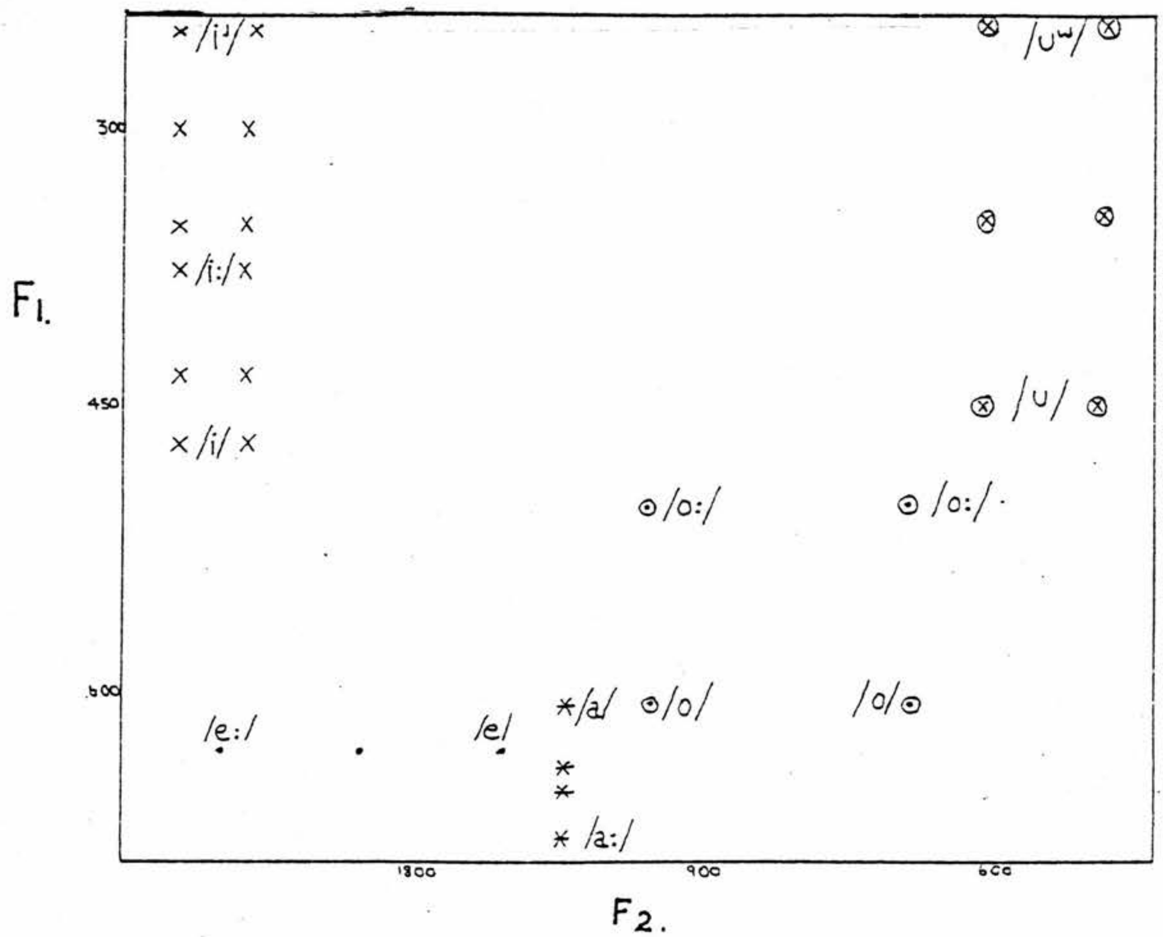
	FORMANT 1	FORMANT 2	Formant 3	F.2 minus F1
/iʲ/	249	2125	2480	1876
	249	2280	"	2031
	298	2125	"	1827
	298	2280	"	1982
	350	2125	"	1775
	350	2280	"	1930
/ɪ:/	375	2125	"	1750
	375	2280	"	1905
	427	2125	"	1698
	427	2280	"	1853
/i/	477	2125	"	1648
	477	2280	"	1803
/e/	676	1595	2780	919
	676	1900	"	1224
/e:/	676	2205	"	1529
/a/	626	1450	2480	824
	676	"	"	774
	701	"	"	879
/a:/	750	"	"	700
/o:/	500	980	"	480
	500	1300	"	800
	626	980	"	354
/o/	626	1300	"	674
/uʷ/	249	760	"	511
	249	901	"	652
	350	760	"	410
	350	901	"	551
	452	760	"	308
/u/	452	901	"	449

FIGURE 8.1.B. The average formant values for the monophthongs from all the data used for the spectrographic analysis for speakers one and two.

	Formant 1.	Formant 2	Formant 3	F2 minus F1
/iʲ/	333	2370	2735	2037
/i:/	348	2352	2676	2004
/i/	416	2054	2598	1638
/e:/	504	2078	2602	1574
/e/	546	1888	2563	1342
/a:/	644	1134	2096	490
/a/	623	1179	2169	556
/o:/	497	878	1598	381
/o/	545	948	1977	403
/uʷ/	306	784	1152	478
/u/ Stressed	439	811	1182	372
/u/ Unstressed	425	787	1150	362

FIGURE 8.1.C.

The vowel formant values for Formant 1 and Formant 2 used in the speech synthesis on SID plotted on a logarithmic scale.



Legend:

x = formant values for stimuli in the /iʲ/, /i:/ and /i/ range;
• = formant values for stumuli in the /e:/ and /e/ range;
✱ = formant values for stimuli in the /a:/ and /a/ range;
⊙ = formant values for stimuli in the /o:/ and /o/ range;
⊗ = formant values for stimuli in the /uᵂ/ and /u/ range.

8.4. <u>The Acoustic Data and the Speech Synthesis Data</u>

The values acting as input for the formant frequencies of the vowels synthesized can be viewed as related to those resulting from the analysis of data spoken by the subjects here although no particular speaker's utterances are used.

The vowel distinctions made are the same as those discussed in chapter 5. For example, the main articulatory differences between /u/ and /u^{w}/ are lip rounding and a closer tongue position for /u^{w}/. Both of these cause differences in the shape of the vocal tract. Since the front section is elongated but closed up more at the back, Formant 1 is lowered. For this reason, versions of the same word are synthesized with varying Formant 1 values so that there are polar examples close to the two distinct vowels (or three in the case of the front close vowels), as well as 'neutralized' examples with intermediate Formant 1 values.

Figure 8.1A and 8.1B illustrate the different values for the synthetic vowels and for the two main informants.

Since the exact location of the formant frequencies of the vowels differs for each speaker, the synthesized speech could be considered as yet another speaker with a different vocal tract but having corresponding patterns of frequencies for the vowels produced.

<u>/i^{j}/ /i:/ /i/</u> - Formant 1 rises from 249 Hz. for /i^{j}/ to 375 Hz. for /i:/ to 477 Hz. for /i/. This corresponds to the gradually opener quality of /i/ in comparison with /i:/ and of /i:/ in comparison with /i^{j}/. A resulting smaller separation between Formants one and two also corresponds to a less front position or relatively greater tongue retraction.

<u>/e:/ /e/</u> - This is the only vowel set synthesised with a constant first formant and a varying

second formant. The reason for this is that there is not such a clear distinction on the formant patterns of the opener three sets of vowels as there is for the two close sets. Thus, the three alternatives were used in synthesising these three sets:-

1. a constant Formant 1 and a changing Formant 2 (/e/ /e:/);
2. a constant Formant 2 and a changing Formant 1 (/a/ /a:/); and
3. a mixed attempt as for the close vowels (/o/ /o:/).

In the case of /e:/ and /e/, Formant 2 is lowered from 2205Hz. for /e:/ to 1595Hz. for /e/. In this way /e/ is synthesised as a more back vowel than /e:/, and also possibly more open. The difference between these two vowels is hardly significant auditorily, except in terms of a tenser articulation for /e:/. This is only an attempt to consider a rather vague qualitative difference.

<u>/a:/ /a/</u> - Formant 1 is lowered from 750Hz. for /a:/ to 626 Hz for/a/, indicating a more close and more front articulation for /a/ than for /a:/ which is therefore a relatively more back open vowel.

<u>/o:/ /o/</u> - Formant 1 rises from 500Hz for /o:/ to 626 Hz for /o/ in an attempt to simulate a more open position for /o/. Formant 2 also changes in the synthesised vowels from 980Hz for/o:/ to 1300Hz for /o/. The resulting greater Formant 1 - Formant 2 space relates to a relatively greater degree of fronting for /o/ than for /o:/. This is really the result of a more open lip protrusion and, therefore, a greater lengthening of the front area of the vocal tract.

<u>/u^W/ /u/</u> - Formant 1 rises from 249Hz for /u^W/to 452 Hz for /u/, since /u^W/ is a more close vowel than /u/. Formant 2 at 760Hz and 901 Hz is used for synthesising both vowels. Formant 1 for /u^W/ is at the

same level as for /i^j/ indicating the closeness of both these vowels and the relatively greater opening for the other vowels in the sets. The values used for the synthesis of the two close back vowels result in a smaller Formant 1 - Formant 2 distance for /u/, which would relate to more tongue retraction. However, since a smaller Formant 1 - Formant 2 also relates to articulation with close protruded lips - which is even visibly greater for /u^w/ - this Formant 1 - Formant 2 separateness cannot be considered significant.

8.5. Procedure for Synthesizing the Test Data

It was possible to ask specific questions because all factors other than the one under investigation could be kept constant by means of synthesis in the following way:-

(a) When vowel duration was the factor to be investigated: the releasing and arresting consonants of the words in the set were synthesized in identical manners. The releasing consonants were of the same quality and duration; the arresting consonants were of the same quality and duration. The vowels were identical as to formant structure, but varied in duration. Variations occurred in steps of 4, 8, 12, or 8, 12, 16 units, corresponding to 20 to 40 milliseconds in real time, depending on the word set. Thus different versions of the same word were synthesized, identical in all ways excepting vowel duration. The hypothesis was that if in the case, for example, of the vowels /i/, /i:/ and /i^j/, vowel duration is more important than vowel quality, then there would be a majority response for /i/ when the vowel was short and for /i^j/ and/or /i:/ when the vowel was long in the case of the front close vowel set (and similar responses for the other vowel sets).

(b) When formant structure (i.e. vowel quality) was the factor to be investigated: versions of the same word were synthesized in such a way that only the formant structure of the vowel was varied, thus keeping the duration constant for both consonants and vowels. (See 8.4 for a discussion of the formants varied and the formants kept constant.) The hypothesis was that if formant structure/vowel quality is more important than duration, then there would be a majority response for /i^j/ when Formant 1 was 249 Hz., Formant 2 2280 Hz. Formant 3 2480 Hz.; a majority response for /i:/ when Formant 1 was 375 Hz., Formant 2 2280 Hz. and Formant 3 2480 Hz.; and a majority response for /i/ when Formant 1 was 477 Hz., Formant 2 2280 Hz., and Formant 3 2480 Hz., with split responses when intermediate values were used, distributed according to vowel duration, i.e. short duration being identified as /i/ and longer vowels being identified as /i:/ or /i^j/ in the case of the same close front vowel set.

(c) When consonant duration was the factor under investigation: Since the study of Maltese phonology reported in chapter 3 shows the high degree of occurrence of consonant gemination immediately following 'short vowels', and single or short consonants immediately following 'long vowels', consonant gemination was singled out as a possible though unlikely cue to the perception of 'short vowels'. Versions of the same words were synthesized with all elements identical in both quality and duration except for the arresting consonant which was varied in length. If consonant duration is more important than vowel quality and vowel duration, then a majority response for /i/ would be obtained for all of the words with a longer arresting-consonant duration, and there would be a majority response for /i:/ and/or /i^j/ when the arresting consonant was short (again taking the front-close vowel set as an example).

8.6. The Test

The synthesized words were presented to Maltese subjects in the form of two separate forced-choice word identification tests.

The first test included examples of words with the front vowels /i/, /i:/ and /i^j/ and the back vowels /u/ and /u^w/. The second test included the examples of the three remaining sets /e/ /e:/, /a/ /a:/ , and /o/ /o:/.

At the beginning of the test explicit instructions were given as follows:

> This is an identification test. You will hear a set of words. You are asked to mark which word you have heard on the answer sheet. Put a cross next to the word you identify. You will hear each word twice. It will be identified by a number. This number corresponds to the number on your answer sheet.

Instructions preceded each set of words as follows:

> The first (second... etc.) set of words consists of different versions of the words hiet meaning 'he sewed', hit meaning 'you sew' (imperative) and hitt meaning 'I sewed'. Please identify which word you hear. (Or sur meaning 'wall', etc.)

All instructions were given in English (including the number identification). It has been argued and shown experimentally (Ladefoged 1967, Lehiste 1968) that a listener immediately sets up for himself a frame of reference in which to place the speaker's vowels and hence decide on his vowel system in order to enable him to identify the vowels he hears. By giving the subject no prior knowledge of the speaker's utterances, he is forced to make up his frame of reference from the experimental data - since the examples in the instructions given in Maltese are different from those synthesized. This could have resulted in a lack of consistency between the first few examples, i.e. before the frame of reference was decided upon by the subjects, and the rest of the test. For this reason a comparison was made between the first few responses to set 1 and the other responses, and between the responses of set 2 and those of set 3 (for the vowels /u/ and /u^w/) since the latter sets are rather short. No inconsistency is apparent that would justify eliminating these examples from consideration. (See discussion below.)

The test made use of a forced-choice response technique. This was used in order to ensure:

1. that the subjects concentrated on only the minimal distinctions connected with the vowels;
2. that the subjects did not judge (and/or were not distracted by) the quality of the consonants other than the duration of the arresting consonant;
3. that the subjects were not influenced by such factors as unlikeliness of occurrence of a particular word, frequency of word-usage that is likely to differ amongst subjects and thus produce a distortion in the results.

These factors seem to play an important role when subjects are asked to decide creatively (tabula rasa, as it were) what the word they are presented with is, and when they have to decide on the meaning of the word heard. But because of the forced-choice technique used here, the subjects were responding to the following question for each stimulus: "Do you identify this word you hear as <hiet> <hit> or <hitt> (<tul> or <tull> , etc.)?" and not "Which vowel or which word do you hear?"

Test 1 consisted of 155 synthesised test items or words, and Test 2 of 96 test items. Each test word was presented twice after being identified by the number that corresponded to the order in which it occurred.

The items of a particular vowel set within a particular word-frame were all presented in succession but in random order before a new word-frame with a different or an identical vowel-set was introduced.

Specifically, Test 1 consisted of the following:

29 versions of the /i/ /i:/ /i^j/ vowel set within the frame /h V t/;
12 versions of the /u/-/u^w/ vowel set within the frame /s V r/;
12 versions of the /u/-/u^w/ vowel set within the frame /t V tu/;
35 versions of the /i/ /i:/ /i^j/ vowel set within the frame /z V t/;
28 versions of the vowel set /i/ /i:/ /i^j/ within the frame /b V t/;
13 versions of the /i/ /i^j/ part of the vowel set /i/ /i:/ /i^j/ within the frame /p V ter/;
12 versions of the /i/ /i:/ part of the /i/ /i:/ /i^j/ vowel set within the frame /s V ket/;
15 versions of the /u/-/u^w/ vowel set within the frame /t V l/.

Test 2 consisted of the following test items:

21 versions of the /o/ /o:/ vowel set within the frame /b V t/;
12 versions of the /a/ /a:/ vowel set within the frame /t V ta/;
24 versions of the /e/ /e:/ vowel set within the frame /t V ma/;
18 versions of the vowel set /a/ /a:/ within the frame /r V t/;
21 versions of the /o/ /o:/ vowel set within the frame /s V t/.

The purpose of presenting the synthesised words in two separate tests which were administered on two separate days was to avoid experimental fatigue on the subjects' part. Test 1 was 29 minutes long whereas Test 2 was 14 minutes long. However, only 28 of the 37 native speakers of Maltese who served as subjects for Test 1 turned up to do Test 2.

Test 1 may have been rather tiresome for the subjects. There does not seem to be a practical solution to the problem of test duration. Test 2, being shorter, led to difficulties , as for example, in the interpretation of the results for the items testing the vowel set /e/ /e:/ within only one frame /t V ma/. (See 8.9.10)

8.7. Layout of the results, analysis and discussion.

The results are set out in tables in Appendix D. The statistical results are presented first in Appendix D.2. These are followed by tables consisting of the responses to the tests in Appendix D.3. These responses are categorized according to: (a) formant structure, (b) vowel duration, (c) consonant duration. This categorization brings out more clearly the results produced when a specific factor is at work (and everything else is equal) and consequently, shows which factor plays the larger role.

The statistical analysis is presented in the next section. The relative significance of the various factors involved in the perception test is discussed.

The results for each vowel set are next discussed independently and a general conclusion drawn. This is followed by a discussion of various considerations relevant to the perception test in general.

8.8. Statistical Analysis of Results

8.8.1. Test Used

I decided to analyse the results of the SID experiment statistically, using the BMDPIR Multiple Linear Regression Test on the Edinburgh University Computer. The programme was written by the Health Sciences Computing Faculty of the University of California, Los Angeles (1979). Anne Anderson, of Edinburgh University Linguistics Department, helped me with all my statistical data set-up and interpretation.

Since the number of subjects differed in the two parts of the experiments, the results from the nine subjects, who did not perform the second part of the test, were not used for statistical analysis. This enables more standardized comparisons to be made across tests.

Although several sophisticated tests can be worked out from the Multiple Regression Programme, since the relatively more straightforward tests of significance supply the necessary information regarding the contribution of the variables to the score for each vowel, these are the only ones presented and discussed here.

8.8.2. Presentation of Results

The results of the statistical tests are presented in tables in Appendix D, Figures D2.1 to D2.5. The classification of the results is explained in the introduction to the results in the Appendix.

The classification of the responses to the perception test prior to statistical analysis was made to account for a number of factors, namely:

1. The overall differences in the perception of close versus open vowels. This allows a clear distinction between the results for:
(a) the long vowel /i:/;
(b) the long and close vowels /i^j/ and /u^w/;
(c) the short and less close vowels /i/ and /u/;
(d) the long vowels /o:/, /a:/ and /e:/;
(e) the short vowels /o/, /a/, and /e/.

2. Any widely different results for the first set in the test, and the other remaining sets which might be due to accommodation to experimental conditions. Thus, the results for the vowel /i:/ in the context /h V t/ are singled out from the results for the same vowel /i:/ in the contexts /b V t/ and /z V t/.

3. Any significant differences for particular vowel sets which might be due to some factor outside of the vowel quality and vowel duration or consonant duration of the synthesised stimuli themselves. In an experiment of this kind, involving not only the many variables in speech perception, but also those of speech synthesis, factors other than the experimental variables may be operating, and such factors could contribute to the results. For example, in the case of the responses for the words containing the vowels /e/ and /e:/, there is less consistency in the subjects' responses than for the other words in the tests. This may be due to the fact that the set containing these words was too long and tedious. However, it is more probable that the poor quality of the synthesised nasals in the context /t V ma/ was responsible for this subject variability. (See section 8.9.10 for a discussion of the responses for the /e/ - /e:/ vowel set.)

8.8.3. <u>The Independent Variables</u> considered in the analysis in relation to the score for each stimulus were:

VQ : Vowel quality is coded as 1 = wrong, 2 = intermediate, 3 = correct. This means that the wrong, intermediate or correct formant structure for that particular vowel was used to synthesise the stimulus that received the score under consideration.

PV : Particular vowel is coded as 1 = vowel /i:/, 2 = all the long vowels apart from /i:/, 3 = the short vowels.

VD : Vowel duration in milliseconds as used in synthesising each stimulus.

VDC : Vowel duration correctness is coded as 1 = wrong, 2 = intermediate, 3 = correct (as for VQ).

CD : Consonant duration in milliseconds as used in synthesising each stimulus.

CDC : Consonant duration correctness is coded as 1 = wrong, 2 = intermediate, 3 = correct (as for VQ).

The multiple regression tests allow the following questions to be asked:

1. How highly associated are the variables with each other?

2. In each test, which variable is most highly related to a high score; which variables make a significant contribution to the score and which variables do not?

3. What percentage of the variants are being

accounted for?

4. How much is accounted for by the results? - How predictable are these results in terms of data beyond the sample used in the present test?

8.8.4. Results

1. The Correlation of the variables can be seen in figures D2.1 and D2.3 in Appendix D2. The matrix shows the significance level for each set. There is a highly significant association $> .01$ between the following variables:

Vowel Quality with the score for /i:/, /i^j/, /i/, /u/ and /u^w/;

Vowel Quality with the particular vowel for all vowels except /i^j/ and /u^w/;

Vowel duration correctness with the score for all vowels except /i^j/ and /u^w/;

Vowel duration correctness with vowel duration for all vowels;

Vowel duration correctness with consonant duration and consonant duration correctness for /i:/,/i^j/,/i/, /u/ and /u^w/;

Consonant duration correctness with the score for /i:/, /i/ and /u/;

Consonant duration correctness with vowel duration for /i:/, /i^j/, /i/, /u^w/ and /u/;

Consonant duration correctness with vowel duration correctness for /i:/, /i^j/, /i/, /u/ and /u^w/;

Consonant duration correctness with consonant duration for all vowels;

Additionally to the association with the above variables, consonant duration is associated highly significantly $> .01$ with the score for /i:/,/i/ and /u/.

Consonant duration with vowel duration for /i:/, /i^j/, /i/, /u^w/ and /u/;

Consonant duration with vowel duration correctness and consonant duration correctness also for /i:/, /i^j/, /i/, /u^w/ and /u/;

Vowel duration with the score for all vowels except /i^j/ and /u^w/, but greatest for /e/,/e:/, /a/, /a:/, /o/ and /o:/;

Vowel duration with vowel duration correctness for all vowels;

Vowel duration with consonant duration for /i:/,/i^j/, /i/, /u^w/ and /u/.

A graphic description of these associations appears in figure D2.5 in Appendix D2.

2. The contribution that the variables made to the scores is highly significant in the following ways:

The contribution of vowel quality is highly significant ($p > .01$) in the cases of vowels /i:/, /i^j/, /i/, /u^w/ and /u/;

The contribution of vowel duration is highly significant ($p > .01$) in the cases of vowels /e:/, /e/, /a:/, /a/, /o:/,and /o/.

Particular vowel (i.e. vowel type) is also highly significant in the score for /i/ and /u/, whereas vowel duration correctness is significant (but not as much as vowel quality and particular vowel) for /i/ and /u/.

3. The results for the Multiple Regression Square test show that a high percentage of the variants are accounted for by the results of the statistical test as a whole. This implies that no other variants other than those included for analysis (vowel quality, vowel duration, etc.) need be considered as possible contributors to the score.

4. The F-Ratios show that there is a high probability that similar results would be obtained even if the data were to be extended, i.e. the results are repeatable and not due to chance.

8.8.5. The results clearly indicate that the subjects were making use of vowel quality to discriminate between /i:/, /i^j/ and /i/, and between /u^w/ and /u/, but that they used vowel duration as a cue in discriminating between /o:/ and /o/, /a:/ and /a/, /e:/ and /e/. However, vowel duration also played an important role especially in the case of the short vowels /i/ and /u/, but that this was not as significant a contributor as vowel quality. Consonant duration seems to play a role - but not a significant one - in the subject's identification of the stimuli. Vowel quality also plays a consistent role - but below the significance level - in the discrimination of the more open vowels. There is no doubt, however, that, as far as this experiment is concerned, subjects make use of different cues in identifying the close vowels from each other and the open vowels from each other. This seems to support the description of the vowels in this thesis, namely, that the vowels - but especially the close vowels - are different not only in their duration but also in their formant structure/vowel quality.

8.9.1. Before going on to discuss the results further, I must define some terms I have adopted to facilitate reference to the synthesised words and avoid repetition of the exact formant structure and duration each time a response or a stimulus word is referred to:

<u>Target</u> : when a vowel is said to be the test target, it means that the formant structure considered as characterizing that vowel has been used to synthesise it, but that the duration of the vowel is not necessarily that with which that vowel is usually associated.

A <u>near-target</u> : means that the formant structure of the synthesised word does not characterize any particular Maltese vowel, but lies somewhere between two vowels, hence approximating to those two vowels as far as quality is concerned.

<u>Confusion</u> : is used here to indicate that a majority response is achieved for a particular vowel when that vowel was not the target or near-target. When a split response is achieved for a near-target, it is not considered as a confused response since two vowels are close but not identical to the vowel of the synthesised word in vowel quality.

The results for each vowel set will now be discussed.

8.9.2. <u>The front-close vowels</u> (with ref. to Fig. D3.1-D3.11)

The results for the monosyllabic words, which constitute the major part of the final close vowel data, will be considered first. The shorter groups of multi-syllabic words are used to test two of the three vowels at a time.

/iʲ/ - A significant response for /iʲ/ was achieved whenever /iʲ/ was the test-target, that is when the stimulus word had an F_1 [1] of 249 Hz., an F_2 of 2280Hz., and an F_3 of 2480 Hz. The varying duration values for both vowels and consonants did not affect the identification of this vowel. Thus, in Fig. D3.6, significant responses can be clearly seen when the responses are classified according to the formant structure of the vowels. However, it is evident from figure D3.7 that there is no significant response for /i^j/ at any specific vowel or consonant durational value.

A significant response for /i^j/ was achieved when /i^j/ and /i:/ are the near-targets at 298/350 Hz. for Formant 1, 2280 Hz. for Formant 2 and 2480 Hz. for Formant 3, except where the duration of the vowel is very long at 160 msec. This appears to be very significant (see under /i:/). It seems that when a major difference between two vowels has been neutralized the other important differential cues are made use of. Thus, a significant response for /i^j/ occurs at all the varying duration conditions except for the very long duration of 160 msec. When the near-target is closer to /i:/ than to /i^j/, the majority response for /i^j/ occurs only at vowel duration of 80 msec. However, a split response occurs under similar conditions when Formant 2 has the value of 2125 Hz.

There is an insignificant - and therefore an unnoteworthy - response for /i^j/ in all other conditions except for some examples where the target is /i:/ and the arresting consonant is long (or geminated) and the vowel is short - two conditions that are not characteristic of /i:/. In these cases there is a slight deviation in response. In fact, a deviation away from /i:/ response to /i^j/ response occurs when the vowel duration for /i:/ target-words is short. However, at vowel duration 120 msec. and 160 msec., the response is hardly deviant from an /i^j/ response and so cannot be classified as a

1. F_1 refers to Formant 1, F_2 to Formant 2 and F_3 to Formant 3.

confusion. The status of responses for /i:/ and target /i:/ will be discussed below.

Without having to make any allowances whatsoever for test conditions, it seems reasonable to conclude that the word with traditional 'long vowel' /i^j/ was not identified only under appropriate duration conditions. In fact, Fig. D3.7 shows no consistent response for /i^j/ under any specific vowel duration whereas a definite consistent response for /i^j/ can be seen in figure D3.6 within specific formant structure conditions. This leads to the conclusion that /i^j/ is perceived as qualitatively distinct from what has been considered its short counterpart /i/ and also from /i:/. In fact, it is clear from Fig.D3.7, that there is only an insignificant response for /i^j/ when the target was /i/, and for /i/ when the target was /i^j/.

8.9.3. <u>/i:/</u>

A significant response for /i:/ was achieved only when both the formant structure and the vowel duration values closely corresponded to the values associated with the vowel. Thus a very significant response for/i:/ was reached when the values for Formant 1 was 375 Hz, Formant 2 was 2280 Hz.,Formant 3 was 2480 Hz., and when the arresting consonant was short and the vowel long at 120 msec. or 160 msec. When both vowel and consonant duration values were favourable, a significant response for /i:/ was achieved at the very-near vowel target. Thus, significant responses can be quite clearly seen from both Fig. D3.6, D3.7, but not from Fig. D3.10, since more than one factor seems to be important in perceiving the vowel /i:/.

One point that may be worth making is that when the vowel is very short and the target is /i:/, the response is usually split between /i:/ and /i^j/ and not with /i/, except when the consonant is long. If the difference between $/i^j/$ and /i/ is basically a difference in duration, then the response should have been split between /i:/ and /i/ since the shortest duration is characteristic of /i/ and not $/i^j/$.

/i:/ also achieves a significant response when the target is /i/, but the vowel is long at 120 or 160 msec. and the consonant is short.

It seems from the above that a combination of the cues of formant structure, vowel duration and consonant duration are required to produce a significant response for /i:/. It could be concluded that when $/i^j/$ and /i:/ are in competition, vowel quality dominates as the distinctive feature; when /i:/ is in competition with /i/, then vowel duration and consonant duration, or, possibly, vowel duration in relation to the duration of the following consonant are more important cues for distinguishing between these two vowels. This is quite consistent with the description of these vowels given in the previous section. It was noted there that the vowel /i:/ bears a similar relation to /i/ as the longer vowels bear to the shorter ones in the cases of the three sets /e/ /e:/, /a/ /a:/, and /o/ /o:/. On the other hand, $/i^j/$ bears the same relationship to /i/ as $/u^w/$ does to /u/. As was pointed out earlier, there is only an insignificant response for $/i^j/$ when the quality target was /i/, although a split response should have been achieved if durational differences were more significant than qualitative differences. For the same reason, there was only an insignificant response for /i/ when $/i^j/$ was the target.

8.9.4. /i/

A significant response for /i/ was achieved when the target was /i/ and the vowel duration was 80 msec. Even in these cases, there is some inconsistency in the responses. On the whole, however, Fig. D3.6 and D3.7 show a significant response for /i/ when the target is /i/ and the vowel is short and the consonant long.

Since there is no /i/ response for target /i^j/, then the distinction between these two vowels can be said to be one of quality. There is at least a minor qualitative difference also between /i:/ and /i/ since there is no significant response for /i/ at target /i:/ and the vowel duration is short, although there is a split response in some of these cases, especially when a short vowel is coupled with a long arresting consonant. However, this could be a negative cue in that a long arresting consonant indicates that the vowel is definitely not (or probably not) /i:/, rather than that it indicates /i/.

Vowel duration is a very important distinction between /i/ and /i:/, since when /i:/ and /i/ are both near-targets the significant response is for /i:/ when the vowel is long. However, since the significant response is not /i/ when the vowel is short (everything else being equal) then duration is not sufficient on its own as a cue to the identification of /i/.

8.9.5. /i/, /i:/ and /i^j/

The results considered so far all involve monosyllabic words, namely /b{i, i:, i^j}t/, /h{i, i:, i^j}t/, /z{i, i:, i^j}t/. Two further sets of words were also tested in order to investigate the similarities and/or differences resulting when only two close front vowels were in competition with each other. These were /i:/ and /i/ in /si:ket/, /siket/ and /sik:et/, and /i/ and /i^j/ in /pit:er/ and /pi^jter/.

The responses for the two sets of words are rather less clear-cut than the responses to the previous sets[1]. (See figures D3.3, D3.8 and D3.9.)

(a) /i:/ and /i/ in /si:ket/, /siket/ and /sik:et/: Figure D3.8. shows that the only very significant response that occurs is in favour of /i/ when the vowel is short and the consonant is long, and for /i:/ when the vowel is long and the consonant short, irrespective of vowel target quality. However, there is a significant response for /i:/ at target /i:/, but this is slightly undermined by the split response achieved for /i:/ with /i/ when the target is /i/.

These results nevertheless confirm the previous ones in that a combination of favourable conditions seems to determine the selection of /i:/ versus /i/ and vice versa. This is also the case when consonant gemination is taken into account. It is interesting that there should be a 100% response in favour of /i/ when all these conditions are favourable.

(b) /i/ and /i^j/ in /pit:er/ and /pi^{j}ter/: Figure D3.9 again illustrates results similar to those achieved for the monosyllabic stimuli. A very significant response in favour at /i^j/ at target /i^j/ and at near-target /i^j/ as well as at target /i:/ - target /i:/ is not given as a possible response.

However, at target /i/ the response is split between /i/ and /i^j/. Since, as has already been discussed, duration is an important factor in the identification of /i/, then these results are consistent with the previous ones. Duration, moreover, does not play an important role here. A very significant response in this respect occurs in favour of /i^j/ even when the vowel is very short, i.e. 80 msec.

1. Only 28 subjects gave responses to the /siket/, /si:ket/, /sik:et/ set; 2 subjects did not respond to /pit:er/, /pi^{j}ter/ set.

8.9.6. The close back vowels (with reference to Figures D3.12 - D3.15 in /$su^{w}r$/, /sur/, /$tu^{w}tu$/, /tut:u/, /$tu^{w}l$/, /tul/

/u^{w}/

Figure D3.12 shows the responses in real values and percentages for the vowels /u/, /u^{w}/. Figure D3.13 shows the values of the formant structure and duration of the synthesized vowels /u/ and /u^{w}/.

A significant response for /u^{w}/ occurs at the /u^{w}/ target, that is, with Formant 1 at 249 Hz., Formant 2 at 760 Hz., and Formant 3 at 2480 Hz. at most of the duration values of vowel and consonant. There are a few exceptions (not evident in the total mean). Figures D3.14 and D3.15 show a very significant response for /u/ at target /u^{w}/ irrespective of other factors. A significant response for /u^{w}/ also occurs when the vowel duration is 120 msec. In fact, the classification of responses on the basis of duration values shows a marked increase to respond with /u^{w}/ when the vowel is longer. However, apart from the cases where the vowel is very long (and even here, the response in favour of /u/ is not negligible), the responses are split.

8.9.7. /u/

Significant response for /u/ at target /u/ occurs except in some cases where the word /tuttu/ is concerned, i.e. when a disyllabic word is involved. The mean response /u/ for target /u/ remains very significant nevertheless, over all vowel duration values, as is shown in Figures D3.14 and D3.15.

The near-target cases are very informative. A split response can be seen from a classification of responses based on formant structure. These show a growing tendency towards /u^{w}/ rather than towards /u/. When the responses are classified according to duration differences a significant response for $/u^{w}/$ occurs at vowel duration 120 msec. and 80 msec. A nearly equal response for the two vowels results in the cases where the vowel is short and the consonant is long. A strong tendency to a /u/ response is seen when the vowel is short and the consonant is also short.

It seems, then, that formant structure is a very important cue in determining the identity of the close back vowels $/u^{w}/$ and /u/. Duration is also a significant cue, but only secondary to vowel quality. Duration is not sufficient, on its own, to signal the presence of $/u^{w}/$ versus /u/, and vice versa.

8.9.8. The Vowels /o/ and /o:/ in the words /bo:t/, /bot:/; /so:t/, /sot:/, with reference to figures D3.16 to D3.20.

Figure D3.16 shows the responses in real values and percentages for the words containing the test vowels /o/ and /o:/.

Figure D3.17 shows the formant structure and duration values of the synthesized vowels /o/ and /o:/.

From Fig. D3.18 - D3.20 , it can be seen that a significant response for /o:/ was achieved at target formant structure /o:/ only when the duration of the vowel was long or very long, i.e. at 100 or 120 msec., whether or not the arresting consonant was normal or geminated. However, a significant response for /o:/ was also achieved at intermediate-target formant structure (F_1 : 500 Hz., F_2 : 1300 Hz., and F_3 : 2480 Hz.) when the vowel was long or very long, and in the case of /b V t/ a significant response was achieved for /o:/ even when the arresting consonant was geminated and the vowel was of intermediate-target structure of F_1 : 626 Hz., F_2 : 980 Hz , and F_3 : 2480 Hz.

A significant response also occurred for /o:/ at the /o/ target when the vowel duration was long or very long, in the case of /b V t/ but not for /s V t/. A split response was also achieved in the case of /b V t/ with target /o/ formant structure and normal vowel duration, i.e. 80 msec., and in the case of /s V t/ when the vowel duration was long or very long, and the arresting consonant was of normal duration.

A significant response for /o/ was achieved when formant structure was target /o:/ but the vowel duration was very short, and when the vowel duration was normal and the arresting consonant was geminated. At target /o/, a significant response was achieved for

/o/ when the vowel duration was very short or normal (except when the consonant was geminated in the case of /b V t/) and also when the vowel duration was normal and the arresting consonant was either long or geminated, i.e. 90 or 120 msec. For /s V t/, a significant response /o/ was achieved only when the vowel was very long but the consonant was geminated. At intermediate target, a significant response for /o/ was achieved when the vowel was very short and when the vowel was of normal duration and the consonant was long or geminated, and when the vowel was normal and the consonant normal duration in the case of /s V t/ only.

Significant split responses occurred in general at one vowel's target formant structure when the vowel duration was either too long or too short for that vowel.

Figures D3.18 - D3.20 show that a significant response occurs for /o/ when the vowel duration is short or when the vowel duration is normal and the consonant is long or geminated; for /o:/ when the vowel duration is long or very long and the consonant duration is normal or geminated.

However, there is also a significant split response in favour of the target vowel at the correct formant structure (61% to 64%) which cannot be overlooked.

It can be said, in conclusion, that the vowels /o/ and /o:/ are differentiated primarily on the basis of their duration, but that their qualitative differences are also relevant.

8.9.9. The Vowels /a/ and /a:/ in the words /ta:ta/, /tata/; /rat:/, /ra:t/ , with reference to Figures D3.21 to D3.25.

Figure D3.21 shows the responses in real values and in percentages for the words containing the test vowels /a/ and /a:/.

Fig. D3.22 shows the formant structure and duration values of the synthesized vowels /a/ and /a:/.

From the classification of responses in figures D3.23-D3.25, it is clear that a significant response for /a:/ is achieved irrespective of formant structure so long as the vowel is long or very long, whether the arresting consonant is of normal or geminated duration. A significant response is achieved for /a/ when the vowel is short, also irrespective of formant structure, and also when the vowel duration is normal if the consonant is geminated (except for /r V t/). A significant response at intermediate target is achieved for /a/ in the case of /t V t a/ where consonant gemination is not relevant, when the vowel duration and consonant duration are normal.

It appears that the vowels /a/ and /a:/ are differentiated primarily on the basis of vowel duration.

8.9.10. The Vowels /e/ and /e:/ in the words /te:ma/, /tema/, /tem:a/, with reference to figures D3.26 to D3.30.

Figure D3.26 shows the responses in real values and percentages for the words containing the test vowels /e/ and /e:/. Figure D3.27 shows the formant structure and duration values of the synthesized vowels /e/ and /e:/.

Fig. D3.27 - D3.30 show that there is a very significant response (67% in real terms) for /e:/ when the vowel duration is very long and the duration of the arresting consonant is normal or geminated, at formant structure target /e:/. There is a significant response for /e/ in most other cases.

The results for this vowel set are ambiguous, possibly because of the three-way choice. There is no significant response for /e:/ except in the two above-mentioned cases. The results for this vowel set are certainly not as clear-cut as for the other vowel sets. SID[1] is designed in such a way that it seems unable to produce authentic sounding nasals. This may be the cause of the subjects' confusion here. This is the only set in this second test in which 7 blanks occurred as answers, i.e. 26%, to some of the test words. However, it is also worth noting that qualitatively, these two vowels are the least distinguishable of the five Maltese vowel sets.

I should point out here that these vowels, /e/ and /e:/, are not related to each other in the same way along the acoustic parameters (see chapter 7) as they are along the auditory and articulatory parameters discussed in chapter 5. This inconsistency is shown if figure 7.7 is compared to figure 5.1.

1. SID : Speech Imitation Device, see Appendix C.

8.9.11. Conclusion

The hypothesis expounded at the beginning of this section, regarding the roles of duration and formant structure in the identification of Maltese vowels seems justified. However, some modification of the second hypothesis could be made. It appears from the test carried out that:

1. /u/ and /u^{w}/, as well as /i/, /i^{j}/ and /i:/ are perceived as qualitatively different over and above being quantitatively different;

2. /o/ and /o:/, /a/ and /a:/, and especially /e/ and /e:/ are perceived as quantitatively different.

Durational differences between the vowels in (1) are relevant but not primary; whereas qualitative differences play a very minor role, if any, in the differentiation of the vowels in (2).

This experiment could be extended to investigate this hypothesis further, as well as to study the informational value of certain selected frequencies in Maltese utterances.

8.10. Further Considerations

8.10.1. Construction of a vowel framework by the listener

There have been several explanations for the fact that sounds considered as phonetically identical by speakers are often clearly acoustically distinct. Joos (1948) theorized that the listening process is a rapid construction of a vowel pattern within which the listener can locate the sounds that each speaker makes. The listener sets up this acoustic vowel frame within receiving just a few of the speaker's utterances. Hence, however strange a speaker's usage may seem, understanding him becomes an easier task as the listener becomes more adept at placing the sounds within the pattern, hence identifying separate vowel categories, e.g. /ae/ versus /a:/ category, depending on a spatial relationship to the points on the vowel frame that is established for that speaker. In other words, the listener establishes the speaker's vowel range.

This process is closely related to articulation because the listener uses his complete knowledge of how the sounds are produced. Of course, there is no awareness of the process on the listener's part. Yet that lack of awareness does not dismiss the possibility of such a construction of a vowel framework.

Joos 1948 also suggests that there is a projection in the listener's mind of the incoming patterns in such a way that he can track the sounds he hears to the total frame he possesses, i.e. he converts the incoming sounds into his own articulatory habits. It is this conversion technique that enables him to understand a vast number of speakers in spite of the widely varying speech traits. As a result:

> "the only kind of phonetic imitation that is any longer possible to him is the kind known as SOUND SUBSTITUTION which basically means the elimination of personal peculiarities by the CONVERSION technique ..."

> "The amount of acoustic discrepancy that can be and regularly is taken care of by the CONVERSION technique - whatever that may be - is very large. Even among adults it is rather greater than the average distance from one phone to its nearest neighbour on the formant chart." (Joos 1948, p.64)

Ladefoged and Broadbent (1957), too, show that the:

> "linguistic information conveyed by a vowel sound does not depend on the absolute values of its formant frequencies, but on the relationship between the formant frequencies for that vowel and the formant frequencies of other vowels pronounced by that speaker." (Ladefoged and Broadbent 1957, p.98)

When the same test words were introduced by a different version of an introductory sentence, different results were produced such that, e.g. the same test word was identified as /bit/ by 87% of the subjects when it was preceded by one version, and /bet/ by 90% of the subjects when it was preceded by another version in which Formant 1 varied over a lower range.

The same experiment also indicated that a time lapse between the introductory sentence and the test word decreases this influence. Little is known about the implications of such a phenomenon. However, it was decided for the experiment reported in this chapter, that no introductory sentence should be used. Instructions are given in English to avoid biasing the results according to the instructions. It was more likely that the subjects would form their own conclusions from the test data alone.

> "Taken all together, the results of this test show quite conclusively that the linguistic information conveyed by a given vowel is partly dependent on the relations between the frequencies of its formants and the frequencies of the formants of other vowels occurring in the same auditory context." (Ladefoged 1967, p.113-114)

On the basis of the above arguments, it was hypothesized that if a qualitative difference were utilized (or even utilizable) by the native speakers of Maltese, then they could be seen to operate in the test word. However, the task was to discriminate between vowels that were close to each other on the vowel scale and not between vowels that were located at very different points on the scale.

8.10.2. Artificiality of Experimental Conditions

Every experiment on human speech begs the question of naturalness. No experiment using synthetic speech can claim a perfectly controlled degree of naturalness because it can never really simulate a real speech event. Apart from the fact that synthetic speech itself is being used, other factors must also be considered and accounted for:

1. It is not a communication act and therefore is much more demanding on the subject who is being deprived of the redundant features that makes communication flow.

2. No subject is ever really asked to decide between minimal pairs without any further cues. Naturally, these cues have been omitted deliberately in order to establish the possibility of using other cues in the absence of contextual ones (both linguistic and extralinguistic). Nevertheless, the unnatural conditions should not be underestimated.

3. The tests ensure that the probabilities of the listeners' expectations are not encouraged by any cues and that, in fact, one stimuli can as easily occur as another: the stimuli are presented randomly in the hope that any carry-over principle is not introduced.

Having established that the stimuli were both intelligible and acceptable by linguistically naive speakers of Maltese (see Pilot Study, Appendix D - D1) no further discussion is merited on the unnaturalness of the speech stimuli. Speech synthesis was the only suitable experimental technique that enabled one factor at a time to be singled out, with everything else being equal. It is only necessary for synthetic stimuli to be acceptable as 'possible utterances' of the language.

The argument here, is that, in spite of the above factors, native speakers were being asked to perform a specific task: to use (or not to use) the features of formant structure and duration to distinguish stimuli. If they can perform the task, then it is reasonable to hypothesize that they are performing the same task when confronted with similar listening tasks in real speech events.

8.10.3. Perception is a very complex affair that cannot be explained away by saying that a listener identifies a vowel from another according to a specific cue. Therefore, it is not reasonable to say that a test such as this identifies the information that the listener picks up during a normal speech event. It may well be that various short cuts are taken and that different speakers make use of different short cuts. We are all acquainted with the listener who is very slow and the one who is very quick when it comes to grasping spoken utterances, especially when distorting factors are present.

It is possible, therefore, to formulate varying hypotheses as to how a listener identifies speech sounds (singly or as meaningful units, probably the latter). We could say, for example, that the listener could have an economic device whereby, having identified the vowel area (e.g. close-back vs. close front) he will simply say '/u/ unless $/u^w/$'; that is, always /u/ unless lip rounding occurs (just to use the example of an easily identifiable feature). The listener is not aware of identifying a feature, but will certainly perform the identification. In short, instead of working in a vacuum: 'Which vowel is this?', the listener either notices a distinctive feature or does not. If he does, he decides in favour of $/u^w/$, otherwise /u/. This means that one member of a vowel set could be filed by the listener as marked and the other as unmarked. For example, the formant structure of $/i^j/$ identifies it from the other close front vowels, but a longer duration marks /i:/ from /i/, or a shorter duration marks /i/ from /i:/ - after having established the absence of the marked feature identifying and characterising $/i^j/$.

Only the relative contribution of the formant structure and the duration of the element to word and/or vowel intelligibility and identifiability can be tested in the present experiment. No further commitment can be made to the field of speech perception.

8.10.4. The Use of Minimal Pairs

As already mentioned (Introduction, 3.1), redundancy occurs in language at all levels of coding and structuring. It is important to isolate factors singly if ambiguous results are to be reached in experimental studies as the one described above. However, the non-naturalness of the situation cannot be under-estimated. It seems necessary at this point to consider some real-life phenomena that accompany qualitative and durational differences in vowels occurring in so-called minimal pairs.

One very significant factor is the arresting consonant. Its durational values are also ironed out in the test by being tested in isolation as a cue to vowel identification. Although (both from the test and from basic native speaker intuition) this seems to be not such an important cue in itself, there are other factors associated with it that may determine the native speaker's identification of a particular member of a minimal set. One such factor is the vowel-consonant link in a word. The bondage of the arresting consonant to the preceding or following vowel is usually tied up with syllable structure. When the consonant following the vowel in question belongs to the following syllable, there is no vowel-consonant bondage, although there will still be a vowel-consonant transition. If the consonant is the arresting consonant of the vowel in question and partly or wholly 'belongs' to the preceding syllable (depending on whether geminate or single) then the vowel-consonant bondage is much greater. As a result, the vowel-consonant transition could be said to be more abrupt such that the vowel may not fully reach its target before moving on to the following consonant. It may seem totally a question of equating factors. However, in the words studied here, it is not easy to decide on the syllable structure. Such words, like:

<tegħema>		<temmha>
/te:ma/		tem:a
<dehra>	<dera>	<derra>
/de:ra/	/dera/	/der:a/

and so on, differ in their vowel-consonant bondage in the way suggested. A geminate consonant appears as intermediate between a consonant that belongs exclusively to the preceding or the following consonant.

PART IV

CONSONANTS

This part is divided into two chapters. Chapter 9 discusses the place and manner of articulation of the Maltese consonants as articulated in various phonetic contexts. The data for the study of aspiration is included in Appendix D. Sample electrokymograms of some of the consonants studied appear in Appendix G. Chapter 10 is a brief study of the duration of consonants based on electrokymographic data listed in Appendix E.

Chapter 9

The Description of Maltese Consonants

9.1 The Phonetic Realizations of Consonant Phonemes

I would now like to consider some phenomena characterizing consonants in connected speech. The present study of the consonants in various phonetic contexts is based both on personal observation as well as on electrokymographic studies. Samples of the electrokymograms used are presented in Appendix G - specifically, G2. They will be referred to in the text where relevant.

The combinatorial restrictions of Maltese consonants have already been dealt with in Chapter 4 section 7. I am concerned here only with some of the consonant combinations because they appear to me to of particular phonetic interest.

Section 9.2. deals with the oral stop consonants. It includes a detailed study of the aspiration of the voiceless oral stops /p/, /t/ and /k/. Section 9.3. deals with the nasals. Section 9.4. deals with affricate phonemes. Section 9.5. deals with the fricative phonemes. Section 9.6. deals with the approximant consonant phonemes.

In the course of this chapter, I have adopted some abbreviations for the sake of convenience. Thus, oral stops are referred to as P. So,

$$P \longrightarrow /p, b, t, d, k, g, ʔ/.$$

Nasals are referred to as N. So,

$$N \longrightarrow /n, m/.$$

9.2.1. The Phonetic Realizations of the Oral Stop Consonant Phonemes

9.2.1. Place of Articulation

The consonants /p/ and /b/ are produced as labial oral stops. Although it is probably true of all or most labial stops, it is important to note that the labial closure effected here is usually different from that effected in neutral rest position. Fig. 12.4, 12.7 and 12.8, vgm. 1a, 1b, 8 to 12a, b, in Part V illustrate the marked differences between these two closure types. There is tension in the lips that differs depending on the vowels or consonants that follow. In general, the tension produces some creases of the lips even beyond the outer vermilion edge. The lips are always different from neutral; they are thinned and spread when anticipating a spread segment, horizontally contracted and puffed out when anticipating labial and labialized segments. They also move into intermediate states in front of less spread or less rounded segments. Since the tongue is not involved in the articulation of these sounds, it usually assumes the shape necessary for the articulation of the sound that follows the labial segment. The essential visual features are discussed in chapter 12.

The realizations of the phonemes /t/ and /d/ are articulated with the tip and blade of the tongue forming a central stricture at the alveolar ridge, and in some cases, at the upper front teeth as well. The overall tongue shape is flat or very slightly cupped. /t/ and /d/ are here considered as flat apical advanced alveolar stops.

The main stricture for some of the realizations of /k/ and /g/ occurs just forward of the post palatal region but usually extends as far back as the velar region. The advanced articulation occurs in the context of front vowels, whereas the more retracted articulation occurs in other contexts. The back of the tongue is bunched up or convexed towards a relatively massive contact-area of the palate, making much firmer lateral than central contact with the palate. Hence, /k/ and /g/ realizations include convexed dorsal post-palatal and velar stops.

The glottal stop in Maltese is often produced with simultaneous slight constriction of the pharynx, especially when it occurs word-initially or word-finally. I believe that there is hardly ever any pharyngeal constriction when the glottal stop occurs intervocalically. Maltese /ʔ/ is produced with a firm closure of the glottis. It is always audibly released, in the same environments as are the other voiceless oral stops, even when it occurs in clusters. Its duration is comparable to that of the other stops.

9.2.2. Phonetic Characteristics of Oral Stop Clusters

Oral stops in Maltese are always audibly released and almost always aspirated if voiceless (but see 9.2.4) when they occur singly, whether word-initially, -medially or-finally. This also holds good when they occur with other consonants in clusters in any of these positions. When the consonant cluster consists of two stops (P + P) one of three things can happen:

1. In careful and normal colloquial speech and sometimes in fast colloquial speech as well, each of the two stops is made and audibly released. The voiceless stops are generally aspirated in any position.

2. In fast colloquial speech, a double stricture

can occur, that is, a stricture at two places of articulation with a simultaneous audible release.

3. In fast colloquial speech, the stricture of the first stop is very relaxed and is released inaudibly during the closure stage of the second plosive. When the labial is the 'inaudible' one, the effect is like that of lip opening at the initiation of a speech act. The velar stop and the glottal stop in all the data considered, and from my observations, have always been audibly released and are characterised by a minimal average duration of 29 msec. voice onset time.

These events are all illustrated in electrokymograms in Appendix G - in G.2.

For some Maltese speakers, the initial cluster /tl-/ is phonetically realized as [kl-] ; hence for these speakers in this structure, the /t/ - /k/ opposition is neutralized.

9.2.3. Phonetic Variants of /ʔ/

I believe that the production of the glottal stop has sociolinguistic implications: long, firm closure and release is considered 'neutral', whereas a light or short closure and/or inaudible release, marks the Maltese speaker who wishes to present himself as having English as a first and Maltese as a second language. The attitude is characteristic of a small number of speakers who still associate the use of English with education and general prestige, and Maltese as the 'vulgar' tongue.

In words and utterances beginning with a vowel, a glottal stop is often produced. The duration of the stop phase of the glottal stop is comparable to that of the other oral stops. Its distribution is not limited either: it operates in the same places in structure as the other stops, with the difference that it does not participate in voicing harmony, i.e., it can be followed and preceded by both voiced and voiceless consonants. It can be geminated in the same way as the other consonants (although I cannot find examples of word-initial gemination preceded by the epenthetic vowel /i/). It is always audibly released even when it occurs in clusters.

9.2.4. Aspiration of the Maltese plosives /p/, /t/, /k/

Aspiration is here defined as the voiceless period from the release of a stop to the following voiced segment. I carried out a study of the duration of the aspiration of the three Maltese oral voiceless stops /p/, /t/, /k/, from electrokymographic tracings of several utterances, as spoken by myself. Sample electrokymograms are reproduced in Appendix G - specifically in G2.5.

The data consisted of words within the frame sentence:

<Erġa għidli ________ issa.>
/erdʒaidli ________ is:a/
(Gloss: Repeat ________ now.)

This context provided a voiced element at either end of the word to be analysed, thus making measurements easier. The data was selected to provide examples of the plosives under analysis in several contexts, namely:

1. Monosyllables - syllable initial and syllable final;

2. Multisyllabic words - stressed and unstressed syllables;
   - syllable initial and syllable final;

3. Consonant clusters - i.e. followed by another consonant;

4. Geminates

5. In specific vowel contexts, i.e. followed or preceded by all the Maltese vowels in turn; also separated according to whether they are followed or preceded by a "long" or "short" vowel.

6. In Miscellaneous contexts.

7. In continuous speech: Two short pieces of continuous speech by the same speaker were also considered as supplementary data.

The Purpose of this Study was to determine:

1. Whether unvoiced plosives in Maltese are always, never, or only occasionally aspirated, and if so, when.

2. Whether there is a systematic distinction between these plosives in terms of aspiration and/or the duration of aspiration, and, if there is such a distinction, what are the determining factors.

3. Whether aspiration is related to intelligibility.

The data is presented in Appendix E.
A summary of the average duration of aspiration in the data analysed appears in figure 9.1 to 9.4.

FIGURE 9.1

Summary of the duration of aspiration (in milliseconds) of Maltese /p/, /t/, /k/

The context is specified on the left hand side. The duration of aspiration is given first for /p/, /t/ and /k/ together, and then separately.

Context	/p,t,k/	/p/	/t/	/k/
Miscellaneous	25	14	29	33
Monosyllabic:-				
i. Syllable-Initial	45	35	49	52
ii. Syllable-Final	37	29	40	43
Multisyllabic Stressed Syllables:-				
i. Syllable-Initial	33	32	32	36
ii. Syllable-Final	52	48	43	65
iii. Syllable-Boundary	52	42	39	75
Unstressed Syllables:-				
i. Syllable-Initial	26	16	30	32
ii. Syllable-Final	28	25	22	36
Consonant Clusters	47	48	51	42
Geminates	31	26	30	38
Different Vowels:-				
(i) i, ie, i:	35	21	39	46
(ii) e, e:	30	20	38	33
(iii) a, a:	30	20	33	37
(iv) o, o:	30	31	34	26
(v) u, u:	25	38	40	31
"Long" Vowel	38	30	43	40
"Short" Vowel	27	17	32	32
		29	37	41

FIGURE 9.2

Average duration of aspiration (in milliseconds) of Maltese /p/, /t/ and /k/ differentiated according to the specific vowel contexts:

(No distinction is made here between stressed and unstressed vowels, monosyllabic or multisyllabic contexts.)

Vowel Context	/p/,/t/,/k/	/p/	/t/	/k/
/i/, /i:/, /ie/	35	21	39	46
* (1)	44	30	45	57
/e/, /e:/	30	20	38	33
*	33	22	32	45
/a/, /a:/	30	20	33	37
*	29	22	33	33
/o/, /o:/	30	31	34	26
*	37	44	30	
/u/, /u:/	37	39	40	31
*	44	35	45	53

(1) * indicates nonsense words.

FIGURE 9.3

Rank-ordering of contexts in which aspiration occurs, from most to least.

The figures refer to the duration of aspiration in milliseconds, for /p/ /t/ /k/ in each of the contexts specified.

/p/		/t/		/k/	
Consonant Clusters (all types)	48	Consonant Clusters	51	Syllable Boundary-Stressed	75
Syllable-Final Stressed	48				
Syllable Boundary-Stressed	42	Syllable Initial-Stressed	49	Syllable Final-Stressed	65
Context-vowel /u/ /u^w/	38	Syllable final-Stressed	43	Syllable Initial-Monosyllabic	52
		Context "long" vowel	43		
Monosyllabic Syllable-Initial	35	Context vowel /u/ /u^w/	40	Vowel context /i/ /i^j/ /i:/	46
		Syllable final-monosyllable	40		
Syllable Initial-Stressed	32	Context vowel /i/ /i^j/ /i:/	39	Syllable final-Monosyllabic	43
		Syllable Boundary-Stressed	39		
Context-vowel /o/ /o:/	31	Context vowel /e/ /e:/	38	Consonant Clusters	42
Context-Long Vowel	30	Context vowel /o/ /o:/	34	Context-Long Vowel	40
Monosyllable Syllable Final	29	Context vowel /a/ /a:/	33	Geminates	38
Geminates	26	Context "short" Vowel	32	Vowel context /a/ /a:/	37
		Syllable Initial Stressed	32		
Syllable Final Unstressed	25	Geminates	30	Syllable Initial-Stressed	36
		Syllable Initial-Unstressed	30	Syllable Final-Unstressed	36
Context-vowel /i/ /i^j/ /i:/	21	Miscellaneous	29	Vowel context /e/ /e:/	33
				Miscellaneous	33
Context-vowel /e/ /e:/ /a/ /a:/	20	Syllable Final Stressed	22	Syllable Initial Unstressed	32
				Context-short vowel	32
Context-Short Vowel	17			Vowel context /u/ /u^w/	31
Syllable Initial Unstressed	16			Vowel context /o/ /o:/	26
Miscellaneous	14				

FIGURE 9.4

Rank-ordering of contexts in which aspiration occurs from most to least, for /p/ /t/ and /k/ together.

1. Stressed - Syllable Final

2. Consonant clusters

3. Monosyllabic - Syllable initial

4. Long vowel context (i.e. before the long vowel)

5. Monosyllabic - Syllable Final

6. /i/, /i:/, /ị/ context

7. Stressed - Syllable initial

8. Geminates

9. /e/ /e:/, /a/ /a:/, /o/ /o:/ context

10. Short vowel context (i.e. before short vowel)

11. Unstressed - syllable final

12. Unstressed - syllable initial

13. /u/ /u:/ context, and Miscellaneous.

The data contains relatively few examples of unaspirated voiceless plosives in Maltese. "Unaspirated" is here defined as zero to 14 milliseconds of aspiration to distinguish between the duration likely to be perceived. The words in which the plosives were unaspirated are:

Monosyllabic:	Syllable-initial	/p/ in	pat:
		/k/ in	ka:p
Multisyllabic:	Stressed syllable:		
	- syllable-initial	/p/ in	'pesta
		/t/ in	pas'taɾt
		in	impus'tuɾ
	- syllable-boundary controversial		
		/p/ in	id:'ispɾa
	Unstressed:		
	- syllable-initial	/p/ in	pas'taɾt
		in	pa'potʃ
		in	pipis'tɾel
		/t/ in	'pesta
		in	tak'wista
Geminate:		/p/ in	t^{h}ap:
		in	'ʃap:ap
		/t/ in	i't:af:i

Others (appearing under "specific vowel context" and "miscellaneous" in data):

/p/ in	pit:^{h}eɾ
in	pit'ats
in	spik:^{h}a
in	pik:u^{w}n
in	k^{h}ap:el
in	spa:k
in	ʃpak

/k/ in skoːp
in ʃkuˈpʰilja
in skuˈtʰelːa
/p/ in parˈtʰiˑtʰ
in ˈtʰpatːʰi
in tʰpaˈtʰiˑja
/t/ in jifˈtakar
in lisˈtorja
in basˈtuʷn
in oˈpʰːost

Of these 31 words, 14 have a similar context not accounted for in the analysis so far, i.e. Fricative, usually /s/, preceding plosive. Three of the words (counting as 5 examples of plosives) are practically unaspirated and could be considered as "unusual" articulations. Of the rest, 5 of the plosives are followed by the shortest vowel /i/, and 4 are geminates. The remaining are followed by the vowel /a/. All of the examples outside of the "fricative context" are examples of plosives within closed syllables. However, there are several words sharing these same features in the data with aspirated plosives.

In general, the data shows that the voiceless plosives /p/, /t/, /k/ are generally aspirated in all contexts. The exceptions, discussed above, are not consistent enough to provide evidence for contextual restrictions on aspiration. Aquilina (1973, p.4)'s statement:

> " [p] and [t] are pronounced without any aspiration"

must, therefore, be incorrect. It seems, in fact, that /p/, /t/ and /k/ are almost always aspirated. The reservation "almost" is important not only because of the exceptions of unaspirated plosives, but also because aspiration is not necessarily a linguistically significant feature in Maltese - unless it can be proved as important in relation to intelligibility, at least, or closely related to some other phonetic feature.

Although the examples of unaspirated plosives have been considered as exceptions, there is a fine line of distinction between these and the less-aspirated plosives in the data. We can see, for example, that 19 out of 32 exceptions involve a /p/ - which is the least aspirated of the plosives. 11 of the remaining 13 involve the cluster [fricative + plosive].

There is a great amount of systematic differentiation between degrees of aspiration in the rest of the data. figure 9.1., below illustrates the various degrees of aspiration for the plosives /p/, /t/ and /k/ separately. The categorization of the data into sixteen set classes need not, of course, restrict speculation about possible factors influencing aspiration. These categories are, nonetheless, meant to focus on important determining factors. These will, therefore, be considered before any others.

(a) The classification of plosives according to place of articulation (i.e. as opposed to treating them as a homongenous group) seems a significant one. There is a consistent difference between the duration of aspiration of /p/, /t/, /k/ - with /p/ having the least amount of aspiration and /k/ the greatest amount in almost all of the examples in the data. The few exceptions involve the groups of words which have been classed according to "place" of articulation, i.e. front to back and open to close. These exceptions are:

(i) /k/ has less aspiration than /p/ and /t/ when followed by the back vowels /u/, /u:/, /o/ and /o:/;

(ii) /k/ has less aspiration than /t/ when followed by the half open vowels /e/ and /e:/;

(iii) /k/ has less aspiration than /p/ and /t/ when followed by another consonant;

Also,

(iv) /t/ has less aspiration than /p/ in syllable final and less clear-cut syllable-boundary position in stressed syllables, as well as in syllable final position in unstressed syllables.

(b) We could say that there is some type of physical limitation - or pure phonetic conditioning - on aspiration in terms of manner of articulation of the following segment. This could be the reason - although one must be wary of such generalizations - for the fact that the duration of aspiration is consistently unusually great for all three plosives in the context where one of /m/, /n/, /l/ and /r/ immediately follows. This may be a language-specific occurrence. Segmentation is made even more difficult by the possibility that the initial articulation of these consonants could be being articulated without voice. The reason for my concluding this is that (1) the duration of the voiced part of these consonants is unnaturally short; (2) air flow out from the nose for the nasals starts well before any larynx tracing (for voice); (3) the typical sudden depression for a tapped /r/ often precedes voicing. These considerations make it difficult to decide where aspiration ends and the consonant begins (an obvious limitation of such segmentation).

(c) We could say, in general terms that plosives in column A below usually have a greater amount of aspiration than those in column B:

A	B
Stressed Syllables	Unstressed Syllables
Syllable Final	Syllable Initial
Monosyllabic (initial)	Multisyllabic (initial)
Multisyllabic (final, stressed)	Monosyllabic (final, stressed)
Consonant Clusters (i.e. plosive + consonant)	Single Consonants

(d) Vowel type and vowel length do not seem to exert great influence on aspiration, except in the case of the short vowel following /p/. More data might show that such an influence may be limited to the vowel /i/, the shortest of the whole set (according to other EKG tracings). There is some systematic differentiation depending on the place of articulation of the plosive with respect to that of the following vowel. Nonetheless there is no outstandingly long or short duration for any specific set of vowels.

(e) The data for geminates is not large enough[1] to allow detailed investigation. There is evidence, nonetheless, that points to a lesser duration of aspiration for geminate plosives than for single syllable-initial or final plosives in stressed syllables. It may indicate that, if aspiration is an important feature for intelligibility in the case of voiceless plosives, it may in fact alternate as a clue to the identity of a plosive, with the duration of the stop phase.

(g) The continuous speech data (listed in Appendix E .) , on the whole, provides confirmation of the results from the controlled data (i.e. words in

1. I could not find enough examples.

isolation or within set phrases). Namely,

> /k/ is more strongly aspirated than /t/ and /t/ is more strongly aspirated than /p/.

This does not seem to be the case with sample (i) which shows little differentiation for the place of articulation category. However, it happens that 7 out of 13 of the examples for /p/ involve the context p + r /l . These 7 examples have an average duration of 41 msec. when considered separately. The remaining 6 have an average duration of 21 msec. - which is compatible with the greater part of the data. This, in itself, confirms the data under the category "Consonant clusters", but especially the discussion on the context:

$$\text{plosive} + \left\{\begin{matrix} m \\ n \\ l \\ r \end{matrix}\right\}$$

In the attempt to differentiate several categories, exhaustiveness has, to some extent, been sacrificed. There are indications, from the exceptions for example, that:

(a) many more consonant clusters ought to be considered;
(b) more data is needed to support or disprove the above observation about the effect of /m/, /n/, /l/, /r/ on aspiration;
(c) more examples of geminates differentiated according to different places in word structure are needed.

One of the problems underlying this type of discussion is that it assumes a clear-cut approach to the notion of syllables. Not only is this notion unclear in itself, but Maltese presents innumerable problems in this area.

9.3. The Phonetic Realisations of the Nasals

9.3.1. Place of Articulation

The consonant /m/ is a labial nasal stop in Maltese. The same type of labial closure is effected for /m/ as for the oral stops /p/ and /b/. (See above, 9.2.1)

Maltese /n/ is realised as a flat apical advanced alveolar nasal stop. It is articulated with the tip and blade of the tongue forming a central stricture at the alveolar ridge, and sometimes at the upper front teeth additionally. The overall tongue shape during the articulation is flat or very slightly cupped.

The nasals /m/ and /n/ almost always lose their characteristic place of articulation when they precede either the stops or the labio-dental sounds /f/ and /v/. They assimilate in this way:-

/m + f/ ⟶ [ɱf]	/m + v/ ⟶ [ɱv]
/n + f/ ⟶ [ɱf]	/n + v/ ⟶ [ɱv]

and

/n + p/ ⟶ [mp]	/n + b/ ⟶ [mb]
/m + t/ ⟶ [nt]	/m + d/ ⟶ [nd]
/n + k/ ⟶ [ŋk]	/n + g/ ⟶ [ŋg]

9.3.2. Devoiced Variants of the Nasal Phonemes

The nasals /m/ and /n/ are often partially devoiced in a voiceless context, but especially a bilaterally voiceless context; they are also at least partially voiceless when they follow the voiceless aspirated plosives /p/, /t/, and /k/. In these instances, voicing occurs only through part of the duration of the nasal.

9.3.3. Nasal and Oral Plosion

The events that occur during a P + N articulation depend mostly on the place of articulation of the two potential segments. In the case of homorganic sequences i.e, /p + m/, /b + m/, /t + n/, and /d + n/, the oral plosive can be:

(1) orally released and followed by a nasal stop: $P^{(h)}N$;

(2) simply released nasally: P^{N};

(3) (in the case of a voiceless oral plosive) released both nasally and orally, and the nasal is often extensively devoiced: $P^{N}\mathring{N}$.

In the case of non-homorganic events, the oral stop is usually orally released and followed by a voiced nasal, as in (1) above. However, it is not uncommon to find non-homorganic P + N sequences, e.g. /p/ + /n/ or /t/ + /m/, with nasal plosion of the oral stop in some speakers. The tendency, however, is to release the first stop orally when it is not homorganic with the nasal.

9.4. The Phonetic Realizations of The Affricate Phonemes

9.4.1. Place and Manner of Articulation of /tʃ/, /dʒ/, /ts/.

The stricture for /tʃ/ and /dʒ/ realizations occurs at the back end of the alveolar ridge, or in some cases, half way along the alveolar ridge. The active articulator is largely the tongue blade, but often, the tongue tip is also involved. There is a greater degree of cupping for /tʃ/ and /dʒ/ than for /ts/ (see below) due to the more retracted tongue-palate contact for /tʃ/ and /dʒ/. Hence, /tʃ/ and /dʒ/ in Maltese are here considered as cupped lamino-post-alveolar affricates.

The stricture for /ts/ occurs at the alveolar ridge and at the post-alveolar region of the palate.

The tongue tip is the active articulator. The tongue is cupped in all contexts. Therefore, /ts/ is usually realized as a cupped apical alveolar affricate.

Labialization can be considered as the secondary articulation for /tʃ/ and /dʒ/ since it occurs consistently - for some speakers but not for all - with the articulation of these consonants.

The stop and release phases of the affricates are durationally comparable to separate consonants of the stop and fricative type respectively, though slightly shorter (see Chapter 10 on Consonant Duration). The stricture remains closer for the second phase than that usually required for the fricative /ʃ/ and the fricative /s/, but it is not possible to determine this experimentally.

9.4.2. <u>Devoiced Variants of /dʒ/.</u>

The affricate /dʒ/ very rarely occurs fully voiced in the data examined. There does not seem to be consistent voicing throughout the duration of either the stop phase or the fricative phase. I have not been able to find any strict relationship between the voicing or voicelessness of this affricate and the contexts in which it occurs.

The duration of the affricates is interesting in that the stop phase is usually of longer duration when the affricate is geminated - but there are quite a few exceptions to this. Electrokymograms illustrating the occurrence of /dʒ/ can be seen in Appendix G2.3.

9.5. The Phonetic Realizations of the Fricative Phonemes

9.5.1. The Phonetic Variants of /h/

The fricative /h/ is more "mobile" than any of the other consonants in terms of place of stricture. In several phonetic analyses of other languages, this type of fricative is dealt with as the voiceless version of the vowel that follows it. This seems a suitable way of describing it in Maltese. Although its occurrence is not limited to this context (/h/ + vowel), it still anticipates the next vowel and is very much influenced by the place of articulation of the following consonant, when it occurs in a cluster, Its place of articulation varies as follows:

1. Post-palatal (sometimes even palatal) in the context of /i/, /i:/ and /i^j/.
2. Velar in the context of /e/, /e:/ and all the consonants with a front-of-velar stricture if followed by any of the front vowels. (/h/ can occur as C_1 of a consonantal cluster).
3. Glottal or pharyngeal (these variants are not usually used by the same speaker) in the context of the open and back vowels, or the velar or glottal consonants even if followed by front close or half-close vowels.

The shape of the tongue differs depending on the place of stricture. It is usually convexed in relation to the palate at the place of articulation.

/h/ is frequently voiced when it precedes a voiced consonant or occurs medially between two voiced consonants, except those that do not participate in the voicing harmony, namely /m, n, l, r, w, j/. (See Appendix G2.4).

9.5.2. The Phonetic Variants of /f/ and /v/

The labio-dental fricative realizations are often articulated with the lower lip introverted such that the upper front teeth are in contact with the vermilion part[1] of the lips as in a biting gesture. (See Figure 12.30 vgm. 23 and 24 a and b.) The upper lip is often moved upwards and outwards away from the upper teeth although it is not a necessary articulator. The tongue anticipates the sound that follows to some extent. The essential visual features are discussed in Part V.

9.5.3. The Phonetic Variants of /s/ and /z/

The stricture for the realizations of /s/ and /z/ occurs just at the end of the alveolar ridge at the start of the slope towards the deepest part of the palate. The tongue tip is the active articulator. The rest of the tongue is grooved. /s/ and /z/ are therefore realized as grooved, apico retracted-alveolar fricatives.

9.5.4. The Phonetic Variants of /ʃ/

The stricture for /ʃ/ realizations occurs in the post-alveolar region. The active articulator is the tongue tip and blade. Many Maltese speakers have a consistent secondary articulation of labialization with /ʃ/ , as with the affricates /tʃ/ , and /dʒ/. /ʃ/ is, therefore, normally realized as a labialized cupped apico-laminal post-alveolar fricative.

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1. The division is marked in Figure 12.2 in Part V, by the line $C_1 - B_1 - C_2$.

9.6. The Phonetic Realizations of the Approximant Phonemes

9.6.1. The Phonetic Variants of /w/ and /j/.

The stricture for /w/ realizations is one of open approximation at the lips as well as at the velum. The lips are rounded and protruded tensely outwards in a very distinctive posture. (See Part V for a more detailed discussion of the visual features.) The tongue is convexed such that the back of the tongue approximates to the velum whereas the tongue tip is close to the floor of the mouth when anticipating back vowels, but further away and more towards the palate when anticipating front vowels. The jaw is almost closed during the articulation of /w/.

The stricture for /j/ realizations is one of open approximation in the palatal - in some cases, the pre-palatal- region. The active articulator is the front of the tongue. The sides of the tongue at the back are supported by the upper and back molar insides. The lips are usually spread, but their position is dependent on the phonetic context.

/j/ and /w/ are always realized as voiced.

9.6.2. The Phonetic Variants of /l/

Stricture for /l/ realizations occurs at the end of the alveolar ridge as for /s/ and /z/. For some speakers, there is a right-sided, and for others a left-sided, lateral air flow instead of a bilateral one. The active articulator here is mostly the tongue tip or the tongue tip and blade. The tongue is cupped. Hence, /l/ is normally realized as a cupped apico- or apico-laminal alveolar (or retracted alveolar) lateral approximant.

Partial devoicing of /l/ can occur in the context of a preceding and a following voiceless consonant. However, /l/ is rarely voiceless for the entire duration of the articulation.

The events in a syllable-initial consonant cluster with /l/ are worthy of note here. A P + /l/ in careful and normal colloquial speech can be a sequence of a centrally released plosive followed by a lateral approximant. In the context of a voiceless, audibly released plosive, the lateral is also voiceless or only very weakly voiced except towards the end of the articulation. The air-stream release is very turbulent when the lateral is voiceless. In the case of an alveolar plosive, the lateral is usually voiced almost immediately so that, in fact, it is easier to segment the process here into two separate events as: $\stackrel{P}{V}$ + /l/. Very often, however, the central stricture for the lateral approximant takes place simultaneously with or during the stricture for the plosive so that, in fact, the lateral air-stream occurs audibly with the release of the plosive.

The analysis of this type of articulation shows that it is very difficult to segment the process into P + /l/ since what we really have is a complete stricture at two places of articulation (the place for the plosive and the alveolar ridge), release of the stricture for the plosive, and turbulent lateral air flow as the alveolar-stricture is maintained. This could be represented as P^L if this means that the stricture for the lateral must be simultaneous or at least overlapping in time with that for the plosive. The general tendency is to release the plosive laterally as the central stricture is being made for the lateral approximant. This leads to a sequence of events with only partial overlap.

Whatever the context in which it appears, /l/ is always a clear alveolar lateral.

9.6.3. The Phonetic Variants of /r/

The allophones of /r/ are produced with slightly retroflexed (curled back) tongue tip which, as the active articulator, forms a stricture at the end of the alveolar ridge towards the post alveolar region.
/r/ is usually produced as [ɽ] in intervocalic position when it is also a geminate consonant, and as [ɻ] in other contexts. However, some speakers use [ɽ] and [r] respectively, instead in the same contexts. There are some speakers for whom [ɻ], [ɽ] and [r] occur as free variants. For some Maltese speakers /r/ realizations consistently have a secondary articulation of labialization. Hence the allophones of /r/ include labialized, slightly retroflexed, apico post-alveolar (or retracted alveolar) approximants or taps, and occasionally trills.

In the context of both a preceding and a following voiceless consonant /r/ realizations are often at least partially devoiced.

9.7. Voicing Harmony of Maltese Consonants

The phenomenon of obligatory voicing/devoicing of Maltese consonant sequences and clusters has already been mentioned in chapter 3 and in the present chapter. The general rule for Maltese agreed on by all linguists can be restated as:
Consonants occurring sequentially without an interrupting vowel must agree in the voicing feature; they are all voiced or all voiceless, depending on whether the last consonant in the sequence is voiced or voiceless. This applies to all consonants except /m, n, r, l, h, ʔ, j, w /.

My own observations indicate that, in fact, this voicing harmony extends at least partially also to /h, m, n, l, and r/.

Chapter 10

Consonant Duration

10. Duration

10.1. Electrokymographic tracings are used in this section to investigate the average duration of different consonants. Knowledge of the duration of segments is useful in itself as a basis of comparison as well as for a study of syllable and utterance total duration. This is an important aspect of natural rhythm, to which this study is making a contribution by setting up the basic groundwork more explicitly than has so far been done.

One informant was used for this study. The data consists of samples of words with:

1. Word-initial, word-medial and word-final consonants;

2. Single consonants, geminates and consonant clusters;

3. Voiced and voiceless consonants;

4. Stops, fricatives, affricates and approximants.

It is not possible to consider an equal number of words under each category because: (a) it is not possible to accurately and reliably measure voiceless segments at the beginning or end of words or utterances. I have included those voiceless consonants where I felt confident about the measurement. Placing them in phrases often disqualifies them as utterance-initial, apart from the problems of false pauses that distort real duration (see section 6.2); (b) it is usually very difficult to reliably segment approximants and voiced fricatives from the following or preceding vowel or from some other voiced segments in electrokymographs.

The results appear in figures 10.1 to 10.5. Detailed lists of the data can be found in Appendix F. The data is discussed below. Sample electrokymograms are presented in Appendix G - specifically G.3.

10.2. Segmentation Problems

Various difficulties prevented me from sorting out my data into further subgroups in order to differentiate between as many phonological conditions as possible. The main difficulties were the following:

1. Some voiced consonants, for example /z/, /v/, as well as /ʔ/, cannot be easily segmented from the vowels simply from electrokymographic tracings. Since a very large number of words is involved, it would have been impracticable to make spectrograms of the words.

2. Some voiceless consonants, especially fricatives, cannot be reliably measured when they occur word-initially and word-finally. One way of making measurements possible is by contextualizing the word. However, this presents additional problems since artificial pauses are often introduced between the test frame and the word investigated. (These problems are also discussed under Vowel Duration, section 6.2.)

3. Some sounds are not very productive in Maltese, e.g. /g/, /ts/ - and therefore cannot be measured in many environments.

4. It is often difficult to determine the beginning and end of words in the tracings. Consistency in decision regarding segmentation does, however, decrease the amount of error here.

10.3. Presentation of Electrokymographic Data

I have presented the data in three separate tables to allow easy access to the basis of the generalizations that I am about to suggest. The full data appears in Appendix F. The contexts differentiated here will be referred to as follows:

IS : Word-initial single consonant;
MS : Word-medial single consonant;
FS : Word-final single consonant;
IG : Geminated consonant preceded by word-initial /i/;
MG : Word-medial geminated consonant;
FG : Word-final geminated consonant;
ICl : Word-initial consonant in a cluster;
MCl : Word-medial consonant in a sequence;
FCl : Word-final consonant in a cluster.

The duration of the plosives includes only the stop phase and not the duration of aspiration which is considered separately in chapter 9, section 9.2.4.

Geminated consonants have been considered as making up two consonants in terms of the averages. This does not, however, imply that I consider them phonetically as repeated articulatory events. Affricates have been excluded from this because they rarely are of the duration of two separate consonants when they are geminated.

The tables are set up as follows:

Figure 10.1. : The average duration in msec. for each consonant occurring singly, and distinguished in terms of its position in the word;

Figure 10.2. : The average duration for each consonant occurring geminated and distinguished in terms of its positions in the word;

Figure 10.3. : The average duration for each consonant occurring in a consonant cluster, distinguished in terms of its position in the word.

Figure 10.4. : The average duration for each consonant (in msec.) in each of the nine contexts, presented side by side in the same table.

Figure 10.5. : The average duration for each consonant in each context presented together with the absolute average for each consonant and the absolute average duration for consonant types, namely nasals, liquids, voiced stops, voiceless stops, voiced fricatives, voiceless fricatives, and affricates.

10.4. Some Generalizations about the relative duration of consonants

The data, as presented in the three tables, lends itself to the following generalization. Affricates, however, are excluded from these generalizations. They are considered separately (see B below).

A. Conclusions with reference to figures 10.1. to 10.3.

1. The fricatives are of longer duration than any other consonant type, whatever the context (affricates are not considered here).

2. Most consonants are longer when they occur word-finally than when they occur singly or in consonant clusters, but not always when they are geminated.

3. Geminated consonants are often longer when they occur word-medially.

4. The duration of geminated consonants is approximately twice that of single consonants; single consonants are of approximately the same duration whether or not they occur in a cluster.

	Initial Single	No.of words	Medial Single	No.of Words	Final Single	No.of Words	Average Single	No.of Words
/m/	79	27	97	25	114	27	97	79
/n/	81	22	92	38	99	23	91	83
/r/	85	8	64	6	155	1	101	15
/l/	83	5	76	6	80	2	80	13
/b/	103	41	74	22			89	63
/d/	89	24	80	24			85	48
/g/	90	3	69	8			80	11
/ʔ/	74	4	61	9	103	11	79	24
/p/	81	28	89	19	106	33	92	80
/t/	69	27	87	25	121	41	92	93
/k/	68	26	89	25	96	27	84	78
/z/	119	5	150	3			135	8
/v/		0		0				0
/s/	140	21	143	22	177	11	153	54
/f/	154	14	122	10	170	3	149	27
/ʃ/	182	6	143	16	142	14	156	36
/h/	179	9	124	7		0	152	16
/dʒ/	73+60	12	80+60	4	143+170	3	99+97	19
/tʃ/	75+62	13	78+85	4	53+118	3	69+88	20
/ts/			83+100	9			83+100	9

<u>Figure 10.1</u>

The average duration in msec for each consonant occurring singly and distinguished in terms of its position in the word.

	/# i__ Geminate	No.of words	Medial Geminate	No.of words	Final Geminate	No.of words	Average Geminate	No.of words
/m/		0	172	9	175	5	174	14
/n/		0	228	6	177	5	203	11
/r/		0		0		0		0
/l/		0	143	3		0	143	3
/b/		0	164	17			164	17
/d/	139	12	170	11			155	23
/g/		0		0				0
/?/		0		0	158	2	158	2
/p/	100	3	150	24	171	8	140	35
/t/	137	14	186	29	182	26	168	69
/k/	108	2	161	29	152	12	140	43
/z/		0	140	1			140	1
/v/		0		0				0
/s/	184	9	233	18		0	209	27
/f/		0	190	14		0	190	14
/ʃ/	211	4	216	7		0	214	11
/h/		0	204	4		0	204	4
/d /		0	63+70	8		0	63+70	8
/tʃ/	127+63	5	135+92	10	104+95	5	122+104	20
/ts/			109+109	8			109+109	8

<u>Figure 10.2.</u>

The average duration of geminated consonants distinguished in terms of position in the word.

	Initial Cluster	No.of words	Medial "Cluster"	No.of words	Final Cluster	No.of words	Average Cluster	No.of words
/m/	83	20	91	20	116	6	97	46
/n/	99	13	91	23	115	11	102	47
/r/	73	4	76	16		0	75	20
/l/	70	1	105	7		0	88	8
/b/	94	11	78	11			86	22
/d/	80	17	70	8			75	25
/g/	55	1	71	8	110	1	79	10
/?/	67	5	45	2		0	56	7
/p/	76	23	76	25	105	1	86	49
/t/	74	24	80	32	111	7	83	63
/k/	74	33	74	27	75	4	74	64
/z/	150	1	140	4			145	5
/v/	100	1	125	2			113	3
/s/	171	22	126	24	161	11	153	57
/f/	168	5	152	16		0	160	21
/ʃ/	148	8	145	13		0	147	21
/h/		0	127	6	153	2	140	8
/d /		0	95+85	2		0	95+85	2
/ʧ /	67+77	5	43+75	2		0	55+76	7
/ts/			112+98	3			112+98	3

Figure 10.3.

Average duration for each consonant occurring in a consonant cluster, distinguished in terms of its position in the word but not as to order of consonant in the cluster.

FIGURE 10.4 (p.1) Consonant Duration: Summary 1

Average duration in msec. for each consonant as it occurs singly, geminated and in a cluster in each of the word positions (a) initially, (b) medially and (c) finally.

Abbreviations used: I = Initial; M = Medial F= Final
S = Single; G = Geminated;
Cl = in a Cluster[1]

IG refers to geminated consonants preceded by the epenthetic vowel /i/ only, in word-initial position. (See 4.7.2., p.50)

		Word Initial		Word Medial		Word Final		Average I, M, F	Average I, M, F S, G, Cl	Average for classes of conson.
p	S	81	64	89	79	106	96	92	80	
	G[1]	100		150		171		140		
	Cl	76		76		105		86		
t	S	69	70	87	88	121	104	92	86	(1) p, t, k, ʔ 84
	G	137		186		182		168		
	Cl	74		80		111		83		
k	S	68	63	89	81	96	81	84	96	
	G	108		161		152		140		
	Cl	74		74		75		74		
ʔ	S	74	71	61	53	103	87	79	73	
	G					158		158		
	Cl	67		45				56		
b	S	103	99	74	79			89	85	
	G			164				164		
	Cl	94		78				86		
d	S	89	77	80	80			85	79	(2) b, d, g 81
	G	139		170				155		
	Cl	80		70				75		
g	S	90	73	69	70			80	80	
	G									
	Cl	55		71		(110)		79		
s	S	140	124	143	126	177	169	153	129	
	G	184		233				209		
	Cl	171		126		161		153		

1. As already discussed, MCl is to be read as sequence of consonants in word-medial position without reference to syllable boundary/division.

FIGURE 10.4. (p.2)

		Word Initial		Word Medial		Word Final		Average I, M, F.	Average I,M,F,S,Z,Cl	Average
f	S	151		122		170		149		
	G		161	190	116		170	190	125	
	Cl	168		152				160		(3) s, f, ʃ
ʃ	S	182		143		142		156		127
	G	211	135	216	126		142	214	129	
	Cl	148		145				147		
h	S	179		124				152		
	G		179	204	114		153	204	124	
	Cl			127		153		140		
z	S	119		150				135		
	G		135	140	108			140	105	(4) z, v
	Cl	150		140				145		109
v	Cl	100		125				113	133	
tʃ	S	75 + 62		78 + 85		53 + 118		69 + 88		
	G	127 + 63	90+67	135 + 92	85 + 84	104 + 95	79 + 107	122 + 104	82+89	
	Cl	67 + 77		43 + 75				55 + 76		(5) tʃ, ts 90+92
ts	S			83 + 100				83 + 100		
	G			109 + 109	101 + 102			109 + 109	101 + 102	
	Cl			112 + 98				112 + 98		
dʒ	S	73 + 60		80 + 60		143 + 170		90 + 97		(6) dʒ
	G		73 + 60	63 + 70	79 + 72		143 + 170	63 + 70	86 + 84	86+84
	Cl			95 + 85				95 + 85		
m	S	79		97		114		97		
	G		81	172	90	175	101	174	92	
	Cl	83		91		116		97		(7) m, n 96
n	S	81		92		99		91		
	G		90	228	103	177	98	203	99	
	Cl	99		91		115		102		
l	S	83		76		80		80		
	G		77	143	81		80	143	78	
	Cl	70		105				88		(8) l, r 83
r	S	85		64		155		101		
	G		79		70		155		88	
	Cl	73		76				75		

FIGURE 10.5 CONSONANT DURATION : SUMMARY 2

Absolute average duration in msec. for each consonant

	Initial	Medial	Final	Single	Geminate	Cluster	Absolute	Averages
p	64	79	96	92	140	86	80	84
t	70	88	104	92	168	83	86	
k	63	81	81	84	140	74	96	
ʔ	71	53	87	79	158	56	73	
b	99	79	-	89	164	86	85	81
d	77	80	-	85	155	75	79	
g	73	70	-	80	-	79	80	
s	124	126	169	153	209	153	129	127
f	161	116	170	149	190	160	125	
ʃ	135	126	142	156	214	147	129	
h	179	114	153	152	204	140	124	
z	135	108	-	135	140	145	105	109
v	100	125	-	-	-	113	113	
tʃ	90 + 67	85 + 84	79 + 107	69 + 88	122 + 104	55 + 76	82 + 89	90 + 92
ts		101 + 102		83 + 100	109 + 109	112 + 98	101 + 102	
dʒ	73 + 60	79 + 72	143 + 170	99 + 97	63 + 70	95 + 85	86 + 84	
m		90	101	97	174	97	92	96
n	90	103	98	91	203	102	99	
l	77	81	80	80	143	88	78	83
r	79	70	155	101	-	75	85	

5. There is no consistent correlation between duration and place of articulation.

6. There is a tendency for voiced plosives to be of longer duration than voiceless plosives.

B. <u>Conclusions with reference to figures 10.4 and 10.5</u>

These two tables contain the same information displayed differently to allow easy reference to be made to the absolute averages in figure 10.5 and clearer reference to averages by word-position in figure 10.4.

The same generalizations reached from the data in figures 10.1 to 10.3 are confirmed here. In addition, the overall averages indicate that, in terms of duration the consonants can only be divided into three classes: affricates, fricatives and plosives, from longest to shortest duration respectively.

Affricates are distinguishable from the other consonants mostly in the way they vary in duration when they occur geminated. Whereas other consonants are usually about twice the length when they are geminated (in comparison with their duration as single consonants), affricates can be either only relatively longer, or the stop phase can be twice as long in duration whereas the fricative phase remains the same or is slightly longer, than the duration of the corresponding stops and fricatives. The duration of a single fricative is shorter than the average duration of a stop added to the average duration of a fricative in a single affricate segment. In its geminated form, an affricate is never as long as the added duration of a geminated stop plus a geminated fricative.

PART V

VISIBLE PATTERNS IN SPEECH

PART V

VISIBLE PATTERNS IN SPEECH

This final part is a study of the visible patterns in both prolonged[1] articulation and in connected speech, making use of photographic and cinematographic techniques, as well as of a new experimental set-up. The objectives set are: to discuss parameters relevant in distinguishing visible patterns of speech, to study these patterns in prolonged articulation and to test the application of this prolonged articulation study to that of connected speech.

The first chapter in the study - chapter 11 - discusses recent various studies of lip and jaw movements in speech as well as the experimental techniques used.

Chapter 12 is a study of visible patterns in prolonged articulation. A great deal of attention is given to comparing the patterns of the two informants studied.

Chapter 13 studies the visible patterns in connected speech. This final chapter also deals with the limitations of the study and explores further possibilities. It suggests the possible application of the study to lip reading methodology, especially in the hierarchical organisational units in visible speech.

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1. **Prolonged** articulation refers to the situation where a speaker is asked to maintain a sound or make it longer than it would be in natural speech.

Chapter 11

Review

11.1. Introduction

This final part deals with the visible patterns in speech. The framework for carrying out an investigation of visible speech patterns in citation forms and in connected speech-forms is twofold: firstly, to fill in a third much-needed dimension in my general phonetic description of Maltese; and secondly, to provide some data upon which a theoretical framework for the analysis, understanding and teaching of lipreading of Maltese can be developed.

This chapter consists of a review of the literature that is relevant both as background and also directly to my own investigation of visible patterns in speech. Most studies make use of electromyography and cine-fluorography because the main purpose of the studies is usually the investigation of muscular activity (e.g. in Gay etal 1974, Perkell 1969). Other studies deal with the contribution of the lips to the acoustics of speech (e.g. Fromkin 1964, Linker 1981). Studies more directly related to external and visible patterns usually deal with the perceptibility or visual accessibility of speech sounds. These are summarized at the end of the review.

The terminology used in traditional phonetics to refer to lip positions is considered and disambiguated in terms of the labelling system adopted for this study. This accounts for the three-dimensionality of the patterns studied and also distinguishes between terms referring to the activity or position of the lips themselves from the space through which the teeth may be seen when the lips move apart from each other. This is done by adopting Laver's 1975 parametric descriptions of labial configurations to deal with what he calls "interlabial space".

The study of lip positions by means of still photography and video recording is described and the data are analysed in the last two chapters that follow this. In chapter 13 , a comparison is made between the two types of data and a discussion of possible generalizations about visible patterns in spoken Maltese forms the conclusion.

It should be noted here that I do not intend to make sweeping generalizations in the course of the study. I hope that by means of the present review, I can place the main studies reported in the final two chapters in their proper perspective.

This review ends with a consideration of the terminology used so far in various phonetic studies to refer to lip positions and lip movements.

11.2. Studies: Electromyographic and Cinefluorographic Studies

Results of electromyographic studies form an important background to the present study. Three main areas of interest are: (1) the muscles that are actively involved in speech to produce movement of the jaw and the lips; (2) the differences in muscular activity during the production of visually similar sounds or 'homophenes' (a term used by most writers on lip-reading); (3) the activity of the lips during a sound for which such activity is not essential and with which the sound is not usually associated as, for example, lip rounding for /t/ in [ʃit̼ɨiʲt] .

(1) We already know a great deal about the complex muscle groups involved in lip and mandible movement during speech. However, not a great deal has been done on the individual activities of single muscle groups.

This is partly because of the problems involved in performing electromyographic investigations.

(2) Some studies have dealt with possible differences in the amount or patterning of muscular activity between sounds. Harris et al (1965), for example, measured the electromyographic output of lip muscles during the production of /p/, /b/, /m/, /mp/ and /mb/. Although they found an "average tendency for 'tense' sounds to be produced more forcefully than 'lax' ... this tendency is present only for some subjects and when large numbers of responses are averaged. It is not large enough to serve as the basis for a phonemic distinction based on muscular effort" (Harris, K.S. et al, 1965), thus leaving the difference between [p] and [b] to be attributed to other visual factors such as timing - factors apart from non-visible events.

(3) Very interesting and more directly relevant are the studies in labialization as secondary articulation. Harris 1977, for example, measured the electromyographic activity of the orbicularis oris muscle during the articulation of English nonsense words /pasup/, /patup/, /patsup/ and /pastup/, and found that electromyographic activity preceded the acoustic activity for the vowel. McAllister et al (1974) also measured electromyographic activity of the orbicularis oris muscle and found that the onset of activity of the orbicularis muscle differed for back and front vowels in English in that it was later for the back vowels than for the front.

Gay 1977 shows that labial muscle activity is often increased in fast speech whereas lingual muscle activity decreases. This means that more effort at a faster speed is involved in labial activity for these labial consonants.

Fujimura 1961 shows a distinction in the activity of the lips in the production of oral labial stops and nasal consonants, in the speed of the lip opening process. This "tissue deformation" will be discussed in relation to speech versus rest position in the analysis of my own data.

The unit over which co-articulatory lip activity can occur is a controversial matter.

Gay 1977 found that intervocalic consonants affected coarticulation in that they prevented the onset of lip rounding from occurring before the closure for the consonant was completed. Kozhevnikov and Chistovich (1965) suggest that the syllable constitutes the extent of anticipatory labial activity. Daniloff and Moll (1968) show that English syllable and word boundaries do not prevent anticipatory lip protrusion which can in fact occur across four consonants preceding the rounded vowel. The lip-rounding gesture in their studies for most utterances occurred during the closure movement of the first consonant in the consonant sequence preceding the vowel /u/, i.e. often considerably before the start of articulatory movement for the first consonant, "whether or not the consonants form an acceptable syllable initial blend in English" (Daniloff and Moll, 1968, p.714). This is consistent with my own findings in Maltese (see 13.10).

Studies such as this lead to a consideration of the size of production unit involved. For English, a discrete phonemic unit or a syllabic unit is usually posited. If coarticulation is not restricted by unit boundaries, such as those of syllable or word, then it leads to the positing of a unit larger than a syllable but not including two syllables, as a unit over which production is organized. The results of recent studies such as those just mentioned seem to indicate that forward, anticipatory coarticulation for vowels can start just after, but not during, the production of the preceding vowel, that is over all the preceding consonants if no movement is required for the consonants that is incompatible with that required for the oncoming vowel.

This finding appears consistent with the finding that it is the slow extrinsic muscle system that accounts for vowel production, whereas consonants rely on the activities of both the extrinsic and intrinsic muscle systems (Perkell 1969, p.65).

There does not seem to be a necessary simultaneity in movements of different articulators for following sounds. Daniloff and Moll (1968) conclude that:

> "it does not appear that there is a close relationship between the lips and tongue in achieving or undershooting targets ..." (Daniloff and Moll 1968, p.715).

They also show that the lips do not 'take off' from a position of rest; a retracted position seems to serve as a "basis for lip movement during speech" (ibid. p.716), and,

> "it may be that protrusion starts more readily from certain articulatory contexts than from others, e.g. a command for protrusion might produce a faster and earlier response when the lips are retracted, as for /ɛ/, than when nonretracted, due to muscular tension available in the retracted lips which would add to the initial protrusion response" (ibid. p.716).

These studies have abundant implications for the various proposed models of speech production. This highly relevant topic is outside the scope of this work. However, it is important to say that the above studies, as well as the observations from my own study, indicate that a model of speech production can be acceptable only if it allows for coarticulation effects to the extent of explaining the diphthongal type of movement proposed by Oehmann 1967, a movement discussed in relation to my Maltese data in 13.13.

11.3. Lip Positions and Acoustics

A number of studies have shown the relationship between lip position and acoustic phenomena (Stevens and House 1955, Ladefoged et al 1978, and others). One very interesting cross-linguistic study is that of Linker 1981, who compares Swedish, Finnish, French, and Cantonese data to that of American English. Linker (1978 and 1981) examines the predictability from acoustic data of lip positions. She investigates the relationships of 17 different lip measures to formant frequency to determine which of the 17 can best be predicted from the formant frequency. The suggested conclusion is that upper lip protrusion measured from the most forward point of lip contact is the best measure of the outer limits of the vocal tract, whereas the worse predicted measure is the protrusion measured as the line from the tooth to the upper lip.

Linker 1981 goes on to investigate whether languages differ in the way they exploit variations in lip position in vowel production. It is interesting to see a study of lip movements in languages that are genetically distinct. Her results indicate that "languages differ greatly in the lip gestures they use to make the same acoustic distinctions among vowels" (ibid. p.28), although they do share a few characteristics. She concludes that:

> "These results tentatively indicate that the relationship between acoustic vowel quality and lip position is, in fact, language-specific, and hence the differences found among similar vowels with respect to the parameters

horizontal opening and protrusion/vertical opening are perhaps not solely due to the fact that the vowels within these systems are different acoustically." (ibid.)

Fromkin's 1964 study was designed to produce data relevant to the construction of a physiological speech synthesizer as well as to determine the relevant parameters for specifying lip positions in American English vowels.

She concludes from her data that "lip positions do serve to distinguish sets of vowels (i.e. the front unrounded vowels from the back rounded vowels) but play little role in distinguishing between the vowels within any one group, except for /u/" (Fromkin 1964, p.220).

Also, "for the vowels /u, ʊ , ɔ , o, a/ the width of opening increases with the height. But for the front vowels, the width of opening remains relatively constant while the height is increased. The central vowels /ʌ/ /ər/ fall somewhere between these two groups" (ibid.). Lip opening is dependent on jaw opening for the front vowels but is controlled by the orbicularis oris for the back vowels.

No simple correlation was found in Fromkin's study between height of lip opening and lip protrusion (they are controlled separately, orbicularis oris versus the mandible). Some correlation was found between protrusion and width of lip opening, which can occur independently of each other.

Fromkin summarizes the muscular actions used in vowels:

1a) The draw-string action of the orbicularis muscle which occurs in the back rounded vowels and to a lesser extent in the central vowels;

1b) the opposite action, involving the flattening and pulling back of the lips by the risorius and zygomaticus muscles in some of the front vowels;

2) the protrusion of the lower lip without much lip-rounding as in /ɔ/;

3) the raising and lowering of the jaw, which has most effect in the front vowels.

11.4. Other Studies

Geissler's 1975 study involved the development of transduction apparatus using synchro-transmitters to investigate vertical and antero-posterior mandibular movements in speech. The data was collected as mingographic tracings of the transduced mandibular movements taking place during certain utterances which were also tape-recorded. He used 54 subjects for his experiment.

Geissler also discusses the mandibular positions used for different speech sounds. He found that tongue height was closely related to mandibular position in vowel articulation. Anterior translation of the mandible for "incisal and alveolingual" consonants was related to incisal occlusion.

Having examined the postural requirements for 19 speech sounds and defining them vertically and horizontally, Geissler makes the following conclusion:

1. The mean range of movement was very small (4.1 mm) although intersubject variation in range was large (from 3 mm to 11.4 mm);

2. Mandibular vertical opening for Vowels varied with tongue height as defined by the Cardinal vowel positions and significant differences were found between several of the vowels;

3. On the horizontal plane, general anterior placement of the mandible for Class II_1(see Geissler 1975, figure2) was significant only for /i, I, ε ,/ and /s, t, d, ð/;

4. The relation between incisal separation and overbite was found only for /s, t, d/;

5. There was no relationship between the positional requirements of surrounding sounds and the variability of consonantal position.

It is interesting to note that Geissler also found some sounds to be associated quite consistently with specific mandibular movements or patterns, whilst others can be produced with virtually any jaw position. Thus he distinguishes between the cardinal or hinge sounds /a, ɑ , i, ε , ɔ / and /s, t, d, f/, and the other sounds, namely /k, h, l, n/, i.e. a distinction is made between recognisable and stable sounds and less stable and less recognisable sounds. Geissler concludes:

> "Indeed it might be true to state that there does not appear to be any truly static position for most, if not all, sounds but rather a range of positions, restricted for some sounds and free for others."
>
> "It is suggested that this freedom is due to lip and tongue flexibility and adaptation such that these structures can extend or contract to produce these particular sounds while the mandible moves from and to other positions required for sound production."

In other words, he suggests that the mandible moves independently in anticipation because the tongue and lips can compensate for the mandible.

Geissler's review of the literature points to the following possibilities:

1. The pattern of mandibular movement is dependent to

a large extent both on the vowel and consonant context. In general, lingual consonants required a close jaw position, but the back lingual consonants, e.g. /k/ did not have a critical jaw position.

2. Jaw opening varies consistently with tongue height. An increasing separation of the jaw resulted for a differentiation of consonant classes, such that dental fricatives, dental stops, labial consonants and velar consonants could be associated with an increasing openness of jaw, in that order.

3. Jaw movement was often completely dependent on adjacent consonants and syllable stress for vowels such as /i, a, u/.

4. Speed of utterance related to range of mandibular movement, i.e. faster speech resulted in a reduced range.

5. There is a possible relationship between incisal occlusion and mandibular movements and between jaw movement area and intermaxillary space (jaw size).

6. /s/ has the "closest speaking space" since the teeth are at their closest for the articulation of this consonant. (Geissler 1975.) Some investigators note anterior translation of the mandible and lip-movement for the articulation of /s/ (excluding Class II - I malocclusion).

These are relevant to my own findings, particularly in the more important dependency of vowel recognition on jaw movement. However, my own data does not isolate jaw movement singly for any consonant articulation. I see jaw movement as a primary parameter in syllable recognition.

11.5. Studies of Lip Patterns

I would like to put forward some final considerations regarding other studies relevant to my own:

1. The visibility of speech is the main theme in the Jeffers and Barley's (1971) discussion on the speech material in their work Speechreading. The book does, of course, discuss several aspects of lipreading very thoroughly. In connection with the actual speechreading material, however, the information is presented in terms of the "visible" versus "invisible" sounds and the visible sounds are then described in terms of the movement that characterizes them in speech, rather than in terms of postures.

2. The invisibility of speech sounds is probably closer to summarizing the 'raison d'etre' for Fisher's (1968) study. Fisher presented 18 hearing-impaired college students with initial and final consonants in an "English-like phonetic environment". They were asked to choose a response from a list given to them, with the correct answers deleted from the possible responses. This allowed Fisher to study the resulting confusion matrices. The confusions were grouped into mutually exclusive classes called "visemes". The resulting linguistic groupings are presented below in comparison with groupings by other authors. His only eccentric grouping is that of [m] with the velar consonants.

Woodward and Barber (1960, p.219) conclude:

> "of those phonetic dimensions which define the significant articulatory differences in English speech, almost all - including articulation type, resonance type, voice, affrication, palatalization, and all areas of articulation except the labial - are virtually neutralized as factors of difference in visual perception."

Woodward and Barber (1960) used monosyllabic nonsense words to test the visual perceptibility of English initial consonants. To determine a rank order of visual perception among phonemes and a hierarchy of visual contrastiveness among phonetic differences, they asked listeners to judge the stimuli as 'alike' or 'different'. No redundant information was made available. The listeners could only base their judgement on the visual information.

In general, consonantal speech sounds used in English have been classified into four main groups in terms of visibility, for the purpose of lipreading. These groups have been usually referred to as follows: (as, e.g. in Woodward and Barber, 1960)

1. Bilabial : /p/, /b/, /m/;
2. Rounded : /w/, /r/ and sometimes /tʃ/, /dʒ/ and /ʃ/;
3. Labio-dental : /f/ and /v/;
4. Non-Labial : all the other consonants with a primary stricture back of front alveolar.

Classes 1, 2 and 3 have been considered as the visible sounds and class 4 as the invisible sounds. Thus, the three visible movements are summarized in Jeffers and Barley (1971) as:

(a) Lower lip to upper teeth (for /f/ and /v/);
(b) Lips puckered (for class 2);
(c) Lips together (for class 1).

11.6. <u>The unit in lipreading/visual perception of speech</u>

This is a very important aspect of any study of the visual aspect of speech, including the present one. Woodward's 1957 study sets up the following objective:

> "to develop a theoretical model for the structure of perception in lip-reading - i.e. a tentative definition of the units of visual perception of oral-aural stimuli, and the relationship among these units in a system of oral-visual communication" (1957, p.4)

Woodward suggests the use of consonant-vowel combinations as distinct from a syllable, but possibly coinciding with it, as perceptual units, and hence the use of a syllabary for transcription instead of a phonemic inventory. (ibid. p.18)

11.7. <u>The relationship of visual-speech units to the oral-aural medium</u>

A final step would be to relate the units proposed to the heard medium. Once again, Woodward's (1957) second objective in her study was:

> "to examine the relationship of the visually-perceived symbols to the oral-aural model - i.e., between the visual perceptibility of spoken English and the linguistic system which underlies English speech."

The relationship is not at all clear, even after very careful investigation of the visual aspect of speech. Having considered and set up a classification of homophenous clusters, Woodward (1957) concludes that:

> "If lip readers are to distinguish among the members of these sets, then, it must be on the basis of phonetic, lexical, or grammatical redundancy, since the articulatory differences among them are not available to visual observation." (ibid. p.16)

These four considerations are basic to my own investigation and will be dealt with in detail.

11.8. Terminology

In the terminology used to describe the lip positions in vowels and consonants, and lip movements in speech, a distinction can be seen in reference to the lips themselves (lip gestures) and the result of their action (lip postures or labial configuration). The general term applied to lip movement is labialization or rounding. Since different emphases and, in some instances, different referents are often involved, the matter must be clarified immediately so that terms used in this study will be unambiguous.

In traditional phonetics there is a differentiation in the lips' functioning as primary articulators in the production of a sound and as secondary articulators. This differentiation is a useful one when it comes to classifying sounds by the place where the greatest degree of stricture is made. However, the distinction does not hold for visible speech patterns. The only distinction that can be made is in the type or degree of labial gesture or posture and whether or not it is recognisable. Thus, whether or not a labial activity is an essential part of the articulation of a sound, as, for example, lip rounding for [w], lip closure for [p], etc. or whether the activity is simply anticipatory or contextual as in [t̫] in [t̫win] makes no difference visibly - both involve lip rounding.

Before going on to discuss lip patterns, I would like to review the terminology used, so far, in phonetic studies of lip movements.

11.8.1. Sweet (1906) defines "rounding" as "a narrowing of the mouth-opening by approximation of the lips". He distinguishes between two main kinds of rounding: <u>inner rounding</u> with "lateral compression of the corners of the mouth and, apparently, of the cheeks as well", and outer rounding when the lips are brought together vertically. Sweet also considers the projection or pouting of the lips to increase the effect of rounding. In addition to this, unrounded vowels can be "made clearer by lip-spreading".

As Laver (1975) points out, Sweet's inner rounding is equivalent to horizontal constriction, and outer rounding (or lip narrowing) to vertical constriction. Pouting would be equivalent to protrusion, whereas lip spreading would be described as horizontal expansion. Constriction and expansion refer to interlabial space.

Jones (1918, 1964, 9th ed.) distinguishes between the following lip positions: spread, neutral and rounded. He further distinguished between open and close rounding. Jones' "open rounding" would be best described as horizontal constriction and vertical expansion with protrusion via upper lip raising and lower lip lowering. His "close rounding" would be described as horizontal constriction and vertical constriction with protrusion via upper lip lowering and lower lip raising.

Abercrombie 1967 considers two main categories of lip positions: (a) rounded, "when the corners of the lips are brought forward", and (b) spread or unrounded, "when the corners of the lips are pulled back". He also considers labialization of other segments besides vowels, which he defines as being equivalent to rounding for vowels. Abercrombie, therefore, would distinguish only between protrusion and horizontal expansion.

Gimson (1970) summarizes open lip position under six headings, in the following way:

1. Lips close together and causing friction. This

would be equivalent to vertical and horizontal constriction with no protrusion;

2. Lips spread and close together, that is, vertical constriction, horizontal expansion and, possibly, retraction;

3. Lips in a neutral or relaxed position. This would be defined as neutral open;

4. Lips wide apart, open, unrounded. This would be equivalent to vertical and horizontal expansion with no protrusion but with jaw lowering, although this is not specified here;

5. Lips close rounded, tightly pursed, small and rounded aperture;

6. Lips open rounded, wide apart but projected and rounded.

The last two categories are roughly the same as Jones' open and close rounding.

It is interesting to note that only Gimson is explicit in mentioning the role of the lower jaw movement in controlling "the gap between the upper and lower teeth and also to a large extent the disposition of the lips". (ibid. p.12)

Ladefoged uses "labialization" and "lip rounding" interchangeably:

> "Labialization, the addition of lip rounding, differs from the other secondary articulations in that it can be combined with any of them; ... nearly all kinds of consonants can have added lip rounding. In a sense even sounds in which the primary articulators are the lips - for example [p, b, m] - can be said to be labialized if they are made with added rounded and protrusion of the lips" (Ladefoged 1975, p.208)

whereas labial is:

> "The physical scale corresponding to this feature is the degree of approximation of the centres of the lips." (ibid. p.262)

Jeffers and Barley (1971, 6th ed.) do not adopt the conventional terminology of general phonetics. They are concerned primarily with lip movements as this consistutes the information available to the lipreader:

> "The speechreader reads visible motor commands, not speech sounds. The movements which he sees are primarily of the lips and jaw, but occasionally of the teeth, tongue, and hyoid bone. They constitute only a fragment, a part of the total complex articulatory motor pattern which occurs when a given sound is formed. Moreover, the fragments which are seen are usually not characteristic of only one sound. From a series of such fragments he must mentally construct the complete speech pattern. The process involves a decision as to which speech sounds were actually seen as well as to which ones belong together." (ibid. p.42)

and,

> "It should be clearly understood that most of the possible or conventional speechreading movements are not stable and may not be present even though the sounds usually associated with them have been made." (ibid.)

They describe lip opening as narrow, that is, with parted lips, as for /u/ or /i/ or moderate as for /ɔ/ or /ɑ/; lip shape is described as puckered as for /u/, back, that is involving upward movement of corners as for /i/, or rounded as for /ɔ/, or relaxed as for /ɛ/.

The general combinations of lip opening (which corresponds to a description of interlabial space) and lip shape (which corresponds to movement in the anterior-posterior dimension) are occasionally given vivid terms such as: the squirrel position for /f/, the kissing shape for /w/, and the fish-mouth movement for /ʃ/. This is similar to Abercrombie's 1967 "candle-blowing" shape for /u/. Such labels are very useful, but it is important for our purposes to maintain a distinction between the three dimensions and distinguish these, in turn, from descriptive terms for interlabial space.

Ohmann 1966 (p.166) distinguishes between two types of labial activities as being physiologically independent:

1. Closing movements in the vertical dimension and width such as are necessary to produce /p, b, m/.

2. Rounding-spreading movements as are necessary for vowel rounding.

The description of muscular activity given at the beginning of this part (11.2, p.227) can be applied to this distinction. The orbicularis oris muscle accounts for most of the closure movements, whereas movements forwards as for protrusion and of horizontal expansion as in spreading require also the quadratus labii superioris and quadratus labii inferioriis. The distinction, however, can only be used here within the context of visible differences.

The fact that even labial consonants such as /p, b, m/ can be rounded further makes it clear that different terms are needed to describe what is going on. First of all, I would like to distinguish between two types of labels:

1. The terms that apply directly to the lips themselves, gestures accounted for by the activities of complex muscle groups. All these have, so far,

been going under the general term "rounding" and the sounds produced with this accompanying gesture as "rounded" or "labialized".

2. The terms used to describe the result of lip gestures in terms of the rima laborium or, in Laver's 1975 term (and adopted here) "interlabial space". Laver thus talks of vertical and horizontal constriction and expansion.

11.8.2. The main reason for strictly dividing terms into types is that we are dealing with three dimensions. The first type, generally referred to as "rounding" will be subdivided into other terms to distinguish between the different activities, both independent and coordinated, of the upper and lower lips in a vertical, horizontal and anterior-posterior dimension, i.e. in three separate dimensions since the vertical and horizontal are not on the same plane. The second set of terms will be used to talk about interlabial space and will allow the description of how this space can be modified not only by the movements of the lips, but also by those of the jaw. The interlabial space can be expanded and contracted simply by jaw lowering and raising with little activity from the lips being involved. In such instances, jaw movement is usually closely related to tongue height required for articulation of the sounds concerned. I will be adopting the terms used by Laver 1975, with modification only of the term 'neutral', for referring to interlabial space.

Thus, the terms used here are:

(1) With reference to lip movement in the <u>vertical dimension</u>:

Upper lip lowering	-	ULL
Lower lip lowering	-	LLL
Upper lip raising	-	ULR
Lower lip raising	-	LLR

The usual combinations of these are ULL plus LLR, and ULR plus LLL.

(2) With reference to lip movement in the horizontal dimension:

Lip spreading	-	LS
Lip contraction	-	LC

Spreading and contraction seem to require both lips moving simultaneously in the same direction in speech.

(3) With reference to lip movement in the anterior-posterior dimension:

Upper lip protrusion	-	ULProtrusion
Lower lip protrusion	-	LLProtrusion
Upper lip retraction	-	ULRetraction
Lower lip retraction	-	LLRetraction

(4) With reference to modifications of the interlabial space:

Vertical Expansion	-	Vert. Exp.
Vertical Contraction	-	Vert. Contr.
Horizontal Expansion	-	Hor. Exp.
Horizontal Contraction	-	Hor. Contr.

with the possible combinations of the horizontal with the vertical modifications.

Finally, it is necessary to define what is meant by neutral since it is assumed that all the movements are movements from some neutral or rest position, and all modifications are changes of a neutral or unmarked space. In the present study, neutral lip position is defined with reference to the neutral lip position for each subject. For the subjects involved in this study it is in fact a closed lip position. It is not enough to say 'closed lip position', so this is illustrated in figure 12.4, p. 253. Neutral, in referring to interlabial space, is either neutral open or neutral closed. This distinction is necessary since in both the subjects studied here, pauses between words, phrases, or sentences can be either. Neutral open is more difficult to define, but Laver's configuration will be adopted. His classification is supplemented here to account for the lateral-view[1] in the data.

1. Lateral-view refers to the view from the side-mirrors.

Chapter 12

Visible Patterns In Prolonged Articulation

12.1. Study I : Prolonged Articulation

The objectives here are: (1) to investigate the parameters necessary for the description of lip positions in prolonged articulation, and (2) to describe the visible lip patterns found in the prolonged articulations of some Maltese sounds, with a view to testing the extent to which these patterns occur in connected speech.

In themselves, descriptions of static postures, of shapes that can be seen at one moment in time are totally unilluminating except as basic data. However, just as the study of place of articulation in phonetics through a study of allophones has proved to be an essential diving board to the understanding of speech sounds, so too, the description of lip postures is also a means to the portrayal of patterns of lip movement in connected speech.

12.2. Studies of lip postures and of mandibular movements in speech (such as Fromkin 1964, Perkell 1969, Geissler 1975, Linker 1978 and 1981) all make use of different but related set-ups for their measurements. These authors have different purposes (see review 11.2-11.4, p.227f); they are not primarily involved in the study of visible patterns. They make use of techniques that require inserting some kind of measuring rod between the speaker's teeth, or spraying the lips with dental impression whilst the speaker is prolonging a sound.

I considered that these devices were inappropriate for my purposes for several reasons:

(1) Although external factors, like the attachment of a splint to the lower teeth with a rod passing through the commissure of the lips did not appear to result in unnatural mandibular movements in Geissler's 1975 study, I believe that any foreign object in a

subject's mouth, however unintrusive it may seem, is bound to interfere with natural lip patterns, since it makes contact with the lips in its exit from between the teeth. Even minimal interference could result in distorted patterns due to the speaker's adaptation behaviour. In the present study, I want to be able to assume that any visible tension or change in the shape of the lips is related to the speech being produced.

(2) Secondly, I needed a set-up which would ensure head and neck stability as well to enable me to obtain simultaneous frontal and lateral-views.

(3) A close examination of lip movement and lip deformation, including minimal changes, excludes the use of anything that might result in altered lip patterns.

Techniques, such as cinefluorography and electromyography, were eliminated from the list of possible techniques since the former excludes the practicability of very extensive data, and the latter would give insight to lip movement, but would add very little to a study of visible speech patterns.

Since none of the experimental techniques previously used suited my purposes, I decided to use a new technique. I shall go on to describe this technique.

12.3. <u>The Apparatus used for the study</u>

To provide valid data for the study of visual speech patterns, new apparatus was built in the Phonetics Laboratory at Edinburgh University by Jeffrey Dodds, technician in the Laboratory, as an improvement over the 'chin-rest'[1] apparatus used previously. The apparatus will be referred to as a visiograph.

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1. See Figure 12.3 p.252

The visiograph (see Figure 12.1) is basically a steel frame that allows an unobstructed view of the subject's face. The advantages of the apparatus are spelled out in its construction. It consists of:

1. An arrangement of steel rods around an unobstructed central space.

2. A perspex forehead and eyebrow rest.

3. Two adjustable lateral mirrors.

4. A sturdy, frontal, horizontal projection for the camera.

5. A camera (for stills, video, or cine).

6. Lights.

The frame fits over an adjustable tripod as shown in Figure 12.1.

The central space allows a full view of all the parts of the face that are important in terms of speech. It does not confine the 'picture' to the lip area alone. The forehead and eyebrow rest allows the subject to take up exactly the same position each time. This provides an optimum degree of standarization in terms of subject-to-camera distance and angle, lighting, and camera settings. It is a comfortable rest that restricts head movement only at the top and allows free movement for speech. The adjustable mirrors provide compensation for the two-dimensionality of photography. Simultaneous frontal and lateral views of the face make up the visiogram. This means that the experimenter is provided with detailed information about the forward and backward movements of the lips and jaw in addition to the dimensions available from frontal views. The camera used is fitted with a long lead and an automatic winder. The long lead enables the experimenter to take

FIGURE 12.1. A Schematic Diagram of the Visiograph

A = Forehead and eyebrow rest;

B = Lateral (side) mirrors;

C = Camera stand.

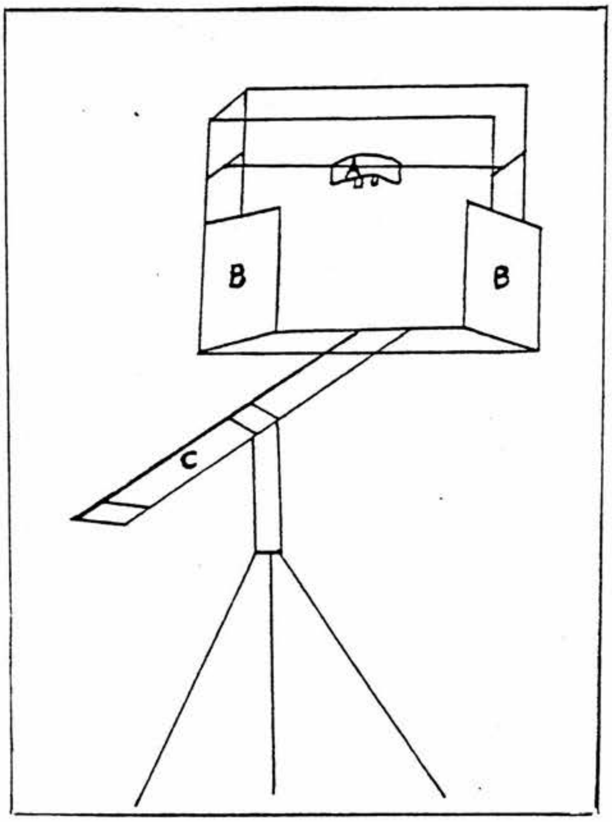


FIGURE 12.2. A Schematic Diagram of a Visiogram

The diagram shows the markings used for the measurements that make up the data for the study of visual patterns in prolonged articulation, i.e. the crosses on the nose and chin, the lines along the lips. The points at which the measurements were taken (E_1 - E_2 , A_1 - A_2 , etc) are also shows. Markings shown as ,......were not found useful and so abandoned. The actual measurements were taken at meeting-point of the lines making up the cross (⟶✕) or the meeting point of two lines in the case of the lips.

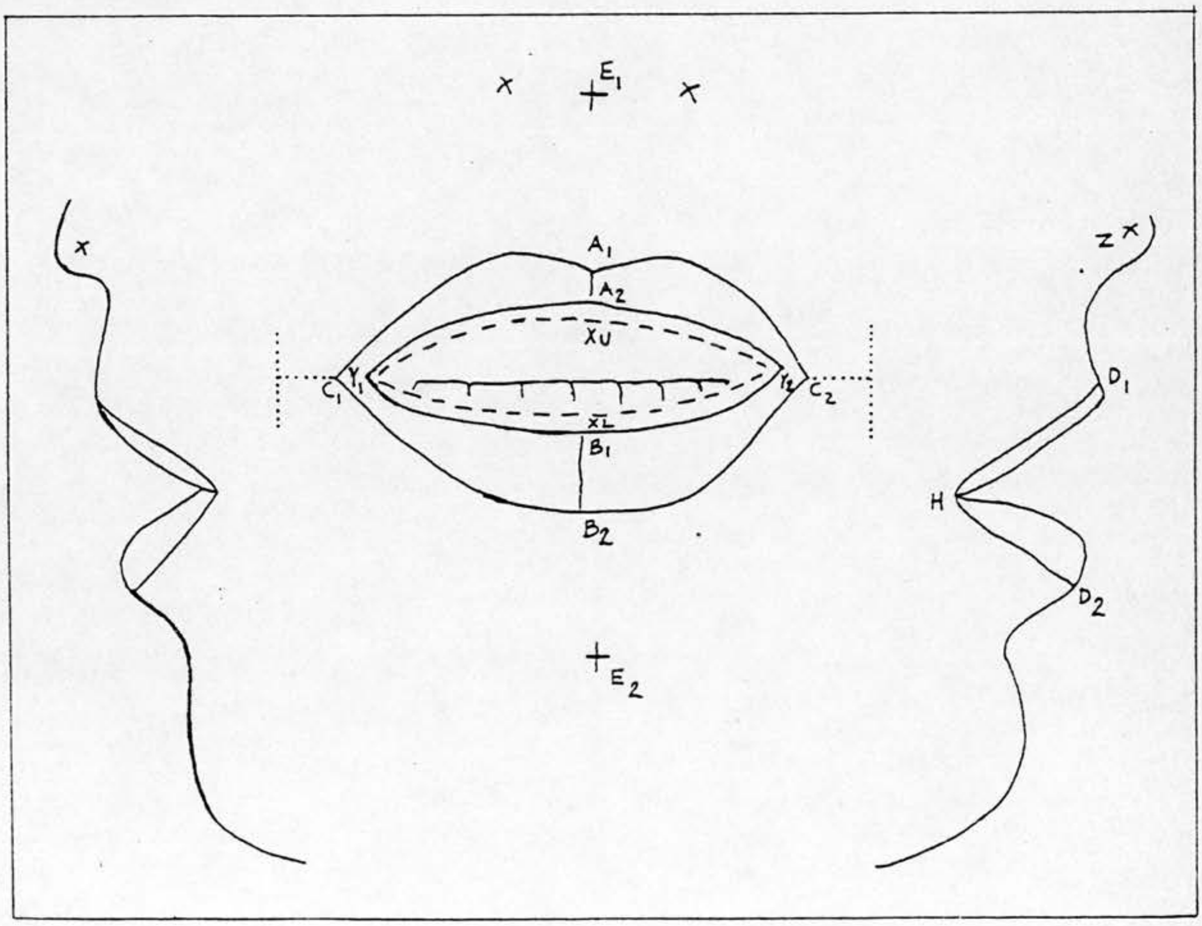


Figure 12.3

Figure 12.3

A previously-used method for obtaining data for studying lip patterns. It would be best described as a "chin-stand". It prevents jaw-movement and therefore interferes with natural speech-movements.

the photographs without obstructing the video camera's view (when simultaneous video recordings are made). The automatic winder prevents any movement of the camera settings or alteration of data resulting from even slight displacement of the apparatus or lights.

Some improvement can still be made to the equipment used to control any side-movements usually caused by the subject having to look down at the written material. Unfortunately, all the ideas that were put forward, such as the use of a dental chair, and ear phones attached to the frame, were not compatible with free natural posture and would inevitably hinder spontaneous speech-determined head movements and replace these with adapted movements related to the experimental set-up and not to speech.

The visiograph provides data about most of the facial areas and parameters relevant to the visual study of speech; hence visiograph not labiograph.

12.4. The Experimental Procedure

For this study, the informant was asked to produce the whole word but to prolong the articulation of the sound underlined in a different colour on the reading card until the click of the camera which indicated that the photograph had been taken. It was not necessary to prolong the articulation of any sound for long because in most cases an automatic winder enabled me to take the photograph very quickly, thus avoiding an unnatural prolonging of the sound.

In order to prevent the speaker from being influenced by the orthography, the data was selected in such a way that no cases of neutralization occurred.

Simultaneous video recordings were made of all the speech materials used for the part of the study involving stills. The video recording camera looked down at the subject over the camera that slid onto the stand of the visiograph. The speech material was subsequently repeated at the end of the session with the video camera at the same angle as the still-camera, which it replaced. Since the simultaneous video recording of the still photography session allowed the click of the camera to be recorded, this supplied me with a counter check as to the point in time at which the photographs were taken, as well as a monitor regarding the naturalness and acceptability of articulation at the time the photograph was taken. Simultaneous video recordings also proved to be a very important and useful guide, as it provided an immediate review of the filming session. Some photographs were repeated when any doubt arose in my mind as to whether or not they had been taken at the right moment, or whether they were exaggerated articulations (i.e. articulatory movements).

Interestingly enough, the same patterns occurred, whether or not the actual degree or amount of movement was exaggerated or not. (This was also noted by Geissler 1975, and Fromkin 1964, about repetitions by the same speaker.)

12.5. It is important to note here that only the right hand image is considered for the lateral-view. Early measurements took account of both sides (i.e. lateral views), but this was considered unproductive and was abandoned.

The visiogram shows a flat image that represents a three-dimensional reality. Hence the need for the side mirrors. The terms vertical, horizontal and anterior-posterior refer to the visiographic representation of the three-dimensional image as follows:

From the frontal view:

↕ vertical

↔ horizontal

From the lateral view:

↔ anterior-posterior

↕ vertical

12.6. The Measurements

1. The measurements taken were studied in terms of which ones characterized different sounds, that is, which ones correlated to the distinctive visual features of the different Maltese sounds studied. (The measurements are shown in figures H1 and H2 in Appendix H after a discussion of the parameters.)

2. The visual patterns for the two speakers were compared in terms of the extent to which each pattern for each speaker deviated from the neutral posture for that particular speaker.

3. The visual features were studied as to their stability in different contexts.

4. The identifiable patterns were studied in terms of their correlation with the phonetic context, that is, whether they related to "part of" an allophone (in terms of its duration, as identifiable from the acoustic data), a full allophone or more than one allophone.

To exploit fully the standardization provided by the visiograph, the subject's face is marked. This allows accurate analysis of several dimensions. Figure 12.2 is a schematic diagram of a visiogram made during the above-mentioned study. The dimension under consideration were: (refer to figure 12.2 for bracketed points of measurement)

1. Frontal overall height (E_1 - E_2).
2. Upper lip and lower lip raising (E_1 - A_1, Z - D_1, B_2 - E_2, Z - D_2).
3. Upper lip and lower lip lowering (same as for 2).
4. Expansion and contraction of upper and lower lip surfaces (A_1 - A_2, B_1 - B_2).
5. Upper lip and lower lip outer protrusion (A_2 - X_U X_L - B_1, H - D_1, H - D_2).
6. Vertical lip-separation (A_2/X_U - X_L/B_1).
7. Horizontal lip-expansion (C_1 - C_2) measured from the corners of the mouth.
8. Horizontal lip-separation (Y_1 - Y_2)

A comparison was also made of the profile patterns - an important dimension in the study of lip and jaw movement. A study of the parts of the tongue and teeth visible, as well as incisal separation, during speech was also found to be informative.

12.7. The present study involved a **preliminary task.** Measurements in millimeters were taken of the following dimensions of each **visiogram** shown in figure 12.2 on page 251 : E_1 - E_2, E_1 - A_1, A_1 - A_2, A_2 - X_U, X_U/A_2 - X_U/B_1, X_U - X_L, X_L - B_1, B_1 - B_2, B_2 - E_2, C_1 - C_2, Y_1 - Y_2, Z - H, H - D_1, H - D_2, D_1 - D_2,

$Z - D_1$, $Z - D_2$.

To do this, each visiogram was traced and measured separately from a life-size projected image. This was possible because a scale was photographed for each camera setting (see figure 12.4A on page 268)

These dimensions refer to the parameters as follows:

$E_1 - E_2$ measures the overall frontal height from the crossing point of the mark on the nose to a similar point on the chin. (see page 251.)

$E_1 - A_1$ measures the distance from the same point on the nose to the uppermost point on the outer point of the line marked along the midline of the lips. It is related to the degree of upper lip raising or lowering in a vertical direction. (See page 251.)

$B_2 - E_2$ is the corresponding line (to $E_1 - A_1$) from the lowermost point of the vertical line painted along the midline of the lips. It is related to the degree of lower lip raising or lowering.

$A_1 - A_2$ measures the vertical height or thickness of the upper lip.

$B_1 - B_2$ measures the vertical height or thickness of the lower lip.

$X_L - B_1$ measures the amount of inner lip visibility in the vertical dimension and therefore relates to degree of curling down of the lower lip.

$A_2 - X_U$ was initially considered but the inner part of the upper lip was only visible in one occurrence of one sound and this was therefore measured along with the upper lip.

$A_2 - X_L$ (or simply $A_2 - X$) measures the vertical extent of lip separation or vertical expansion and constriction of the interlabial space.

$C_1 - C_2$ measures the horizontal distance from the corners of the mouth and is related to lip spreading and lip contraction.

$Y_1 - Y_2$ measures the horizontal extent of the interlabial space. It is a good indicator of area of opening when considered along with $A_2 - X$.

$Z - H$ (for speaker B only) measures the distance from the midpoint of the mark made on the side of the nose to the corner of the mouth on the lateral view. This measurement is mostly useful if considered as the angle it makes with the horizontal plane, thus indicating outward movements (protrusion) and inner movements or retraction of the corners of the mouth.

$H - D_1$ and $H - D_2$ measure the distance, in the anterior-posterior dimension, between the left corner of the mouth and the outermost point of each lip. These could be related to the angle $Z - H$ makes with the horizontal plane to give a more reliable indication of lip protrusion and retraction.

$D_1 - D_2$ measures the distance between the highest outer part of the upper lip and lowest outer point of the lower lip. This indicates not only lip separation but the general shape of the lips, if considered along with other parameters.

$Z - D_1$ and $Z - D_2$ (speaker B only) measure the distance between the point on the mark at the side of the nose to the outermost point of the lips. This indicates raising and lowering of the lips as visible from the lateral view.

I shall now discuss these parameters. The reader will probably find it necessary to use the sample visiogram (sketched diagrammatically) to refer to the parameters AA, AE and so on. This will be found in the pocket attached to the inside back cover. It was necessary to use abbreviations to avoid unwieldy descriptions.

12.8. After a careful analysis was made, the movements indicated in the terminology (see section 11.8.2, p. 244) were selected as observable as movements made to reach the postures described (using the video recording as supplementary data). These movements were therefore considered as worthy of further investigation. The movements are described in detail below.

12.8.1. Description of the Parameters used to account for the three-dimensional data

Vertical expansion or constriction of the interlabial space by means of lower lip lowering or raising, upper lip lowering or raising and by jaw movement.

With a moderate degree of vertical expansion of the interlabial space, it is possible to see the teeth and sometimes the tongue. The opening is seen most clearly from the frontal view. Vertical modification of the interlabial space is achieved both through the activity of the lips as well as by means of jaw movement. Usually, there is upper lip raising and lower lip lowering, as well as jaw lowering for vertical expansion to take place; there is upper lip lowering and lower lip raising for vertical constriction, and often jaw raising. The lips and the jaw can move independently of each other. In vertical expansion, however, from a neutral closed posture, jaw movement can occur independently, but lip movement is almost always accompanied by jaw movement. The relationship of jaw to lip movement can be gathered from the lateral view. Vertical expansion caused mainly by lip movement will result in a larger A_2 - X line than it would for neutral closure, a correspondingly larger E - E line but shorter E_1 - A_1 and B_2 - E_2 lines. Vertical expansion, caused primarily by jaw movement, will affect the E - E line as well as the A_2 - X line, but the E_1 - A_1 and B_2 - E_2 lines will be quite close to neutral closed. Vertical contraction will result in corresponding relations but in the opposite direction, i.e. in decreased measurements.

There are two neutral postures in the vertical dimension: either (1) closed - the posture used here as a reference for degree of opening and degree of closure, since the latter is tenser in speech and therefore different from neutral; or (2) relaxed open, as for pause in continuous speech. This (i.e. (2)) becomes useful in the next study of visual patterns in connected speech, but is not used in this study of prolonged sounds.

It is important to note, further, that either lip can act independently of the other. When they act together, for example in protrusion, the upper lip is raised and the lower lip is lowered, and the dimensions E_1 - A_1 and B_2 - E_2 become smaller and the dimension A_2 - X increases. At the same time, the inner lip beyond the vermilion border is more visible. As the lips curl, the vertical dimensions A_1 - A_2 and B_1 - B_2 may be smaller since the upper lip contracts in width, whilst the lower lip curls over away from the outermost frontal planes, partially visible only from the lateral views. However, the changes in these dimensions can only provide additive clues and probably do not in themselves indicate what sound is being produced. $X - B_1$ usually increases when upper lip raising and lower lip lowering accompany protrusion. $Z - D_1$ and $Z - D_2$, as well as $D_1 - D_2$, in relation to $H - D_1$ and $H - D_2$ provide detailed measurements relating to this parameter and distinguishing between the tension and degree of independent movement of either lip along this parameter.

12.8.2.

Horizontal expansion or constriction of the interlabial space by means of lip spreading or contraction.

This parameter shows the need to distinguish between neutral open and neutral closed. In the vertical dimension there has been no need to distinguish between Laver's vertical expansion and constriction and mine, because vertical expansion and constriction can always be measured in terms of an increasing or decreasing $A_2 - X_L$ line, whatever the neutral configuration. In the horizontal dimension, however, the difference must be clarified. Since there is always some measure of interlabial space in Laver's neutral configuration, there will always be a $Y_1 - Y_2$ measurement. Horizontal expansion cannot occur if there is no interlabial apace. Hence the need to distinguish this parameter from the actual activity of the lips. Lip spreading and lip contraction can still occur with closed lips and serve an important purpose for example in distinguishing between /pi/ /pe/ /pa/ /po/ /pu/ etc. Thus, lip spreading and lip contraction will involve two measurements, the $C_1 - C_2$ and the $Y_1 - Y_2$ line. When $Y_1 - Y_2$ cannot be applied, then it is assumed that there is some type of closure, but the difference in the $C_1 - C_2$ line will reflect phonetically-important differences. When there is some opening, horizontal expansion can be measured directly as the line $Y_1 - Y_2$, thus distinguishing between the continuum wide to narrow vertical opening to be correlated with the measurement $A_2 - X$. It is difficult to measure lateral horizontal opening because of the difficulty of selecting a point at the bottom of the upper lip and top of the lower lip. (Measurements of these points were abandoned early in the analysis, and are not given here.)

12.8.3.

Modification of lip shape in the anterior-posterior dimension by means of lip protrusion and lip retraction (Extroversion/introversion).

Outer, forward lip protrusion constitutes lip movement in the anterior-posterior dimension. It is therefore distinguishable from raising or lowering of the upper and lower lip which involves movement in the vertical dimensions. Lip protrusion and lip retraction, theoretically, can be produced with or without simultaneous horizontal constriction (i.e. of the $C_1 - C_2$ and $Y_1 - Y_2$ dimensions) via lip contraction. In practice, however, these movements are correlated and it would be difficult to have neutral $C_1 - C_2$ dimensions when the $H - D_1$ and $H - D_2$ dimensions are affected. Protrusion and retraction can be distinguished only indirectly from the frontal view; they are recognised much more clearly from the lateral view. In the measurements taken, $C_1 - C_2$ is affected since, from the frontal view, the protruding movement causes some horizontal expansion. The dimensions $H - D_1$ and $H - D_2$ are good indicators of lip protrusion and retraction especially if considered along with the $Z - D_1$ and $Z - D_2$ lines.

Protrusion is usually accompanied by upper lip raising and lower lip lowering, or alternatively by upper lip lowering and lower lip raising. If $H - D_1$ and $H - D_2$ are relatively more removed from neutral than $Z - D_1$ and $Z - D_2$ are (in a positive direction), then outer protrusion is probably a more distinctive feature than lip raising and lowering. Therefore, it is important to relate information from the lateral view to distinguish between the deviation of $H - D_1$ from neutral caused by spreading, and that caused by protrusion.

The term "protrusion" will therefore be restricted to movement in the anterior-posterior (that is, outward) dimension and will not include any implications as to the vertical expansion or constriction of the interlabial space. The terms open and close protrusion are used to refer to protrusion accompanied by simultaneous vertical expansion and constriction respectively. The lips may protrude outwards independently of each other, e.g. the lower lip may be retracted when the upper lip is protruded in producing one or more of the allophones of /f/ and /v/. In most cases where lip protrusion occurs, simultaneous lip raising and lowering also occur, but these parameters are usefully considered independent of protrusion. One or the other may be considered the primary parameter, when the other, though functioning, is not as important .

Retraction is a movement in the anterior-posterior dimension, in the opposite direction from that for protrusion. Retraction is, therefore, a movement of the lips inwards. Like protrusion, retraction can involve the upper lip independently of the lower lip. Upper lip retraction and lower lip retraction in fact often do operate non-simultaneously.

12.8.4. <u>Jaw movement</u> is a very important parameter, for some speakers more than for others. From the frontal view, increases in the $E_1 - E_2$ line indicate jaw lowering. With complete lip closure, it would still be possible to check for jaw movement along the $B_2 - E_2$ line. However, horizontal lip spreading or contraction may occur as obtrusive factors. From the lateral view, jaw movement can be seen more clearly. This is one parameter for which no exact measurements have been made. The angle of movement here can be tricky to detect because, whilst the distance $B_2 - E_2$ can increase, the simultaneous jaw movement backwards that normally accompanies jaw lowering, can be quite misleading.

The use of the parameters of vertical and horizontal expansion and constriction of the inter-labial space, without direct reference to any of the other parameters related to lip movement, can be very useful, not only in further distinguishing between certain speech sounds, but also in identifying speech from silence or pause.

Measurements $A_1 - A_2$ and $B_1 - B_2$ are very important because they relate to subtle movements involved in speech, possibly distinguishing the production of otherwise identical sounds (visually) like [p] [b] and [m] .

Visibility of teeth and of the tongue are at least rough indications of the stricture type of the sound being articulated. Reference is made to them in the description of visible patterns in this section.

12.9. <u>The Pilot Study</u>

My observations of my own speech and that of my informant prior to the study, indicated that the lip pattern of a particular sound was influenced by certain sounds in the contexts. Unlike other articulatory organs which seem to act mostly in anticipation of following segments in Maltese, as seen, for example in the place of articulation assimilation of nasals, voicing harmony of obstruents, and so on, the activity of the lips is dominated by the type of sounds rather than by the position of these sounds, i.e. by whether it is in the context of a sound requiring more lip activity than for that sound itself. Thus, the lips move, as it were, from the posture required for one dominant sound to the posture required by the next dominant sound. This activity is only modified by intervening vowel articulations. Thus the lip pattern for the vowel itself, for example, is determined by the nearest dominant consonant, usually the preceding one, especially when the dominant sound is a /ʃ/, /tʃ/, or /dʒ/ sound. It is often, therefore, simply a modified lip pattern of that dominant[1] sound. This is probably more so the case when a sound is prolonged.

I decided, therefore, to simply provide a context by having the dominant sound, whose influence was being investigated, juxtaposed to the sound itself that was being investigated. Thus, if /i/ were the sound being studied, and /ʃ/ the influencing sound, whose influence on /i/ was being studied, then the syllable would be /ʃi/ or /iʃ/ or /ʃiʃ/.

It also seemed that certain sounds could be classed together since no apparent differences were observed by me when these sounds were articulated in different contexts. Although, ideally, I should have made visiograms of all the possible phonemes of Maltese in all possible contexts, I decided that this was highly impracticable (considering the lists, for example, given in figure 12.9, p.275). I limited my data by classing together the sounds that I thought were interchangeable

1. A dominant sound is one that is visually recognisable in all contexts. This concept is further developed later in this chapter.

as far as lip patterns were concerned. Thus, (1) /p, b, m/ are classed together, as also are (2) /f and v/, (3) /tʃ, dʒ, ʃ, r/, (4) /t, d, n, l, ts, s, z/, (5) /k, g/, and (6) /h, ʔ/.

This classification seemed necessary if any practicable word list was to be made up.

On the basis of these observations, I carried out a preliminary investigation of the eleven monophthongs[1] in three different contexts, and of /p/ in the context of the eleven vowels as articulated by the informant A. The sounds studied are listed below:

/iʲ/	in	/ˈpiʲpa/	/haˈʃiʲʃa/	/ˈiʲdi/
/i:/	in	/bi:p/	/ˈʃi:ʃ/	/ˈi:ko:l/
/i/	in	/pipisˈtrel/	/ʃiˈni/	/ˈikel/
/e:/	in	/ˈbe:tni/	/ˈʃe:re:ʔ/	/ˈe:ri/
/e/	in	/bet:i:h/	/ˈʃedaʔ/	/eˈr:a:ta/
/a:/	in	/ba:t/	/ˈʃa:laʔ/	/ˈa:ni/
/o:/	in	/bo:t/	/ˈʃo:l/	/ˈo:tja/
/o/	in	/bot:/	/irˈʃoʃta/	/ˈot:u/
/uʷ/	in	/buʷt/	/ˈʃuʷʃa/	/ˈuʷza/
/u/	in	/buˈt:uʷna/	/irʃuˈʃta:/	/uˈza:h/

/p/	in	/ˈpiʲpa/
/p/	in	/ˈpi:na/
/p/	in	/piˈtats/
/p/	in	/ˈpe:pe:/
/p/	in	/peˈpe/
/p/	in	/ˈpa:pa/

1. The diphthongs are treated as vowel plus $\left\{\begin{matrix}/w/\\ /j/\end{matrix}\right\}$.

/p/ in /pa'pa/

/p/ in /'po:plu/

/p/ in /'pop:a/

/p/ in /'pu^{w}pa/

/p/ in /pu'pats/

The results of this study in terms of the measurements taken from the visiograms along the different parameters selected, are presented in Appendix H, in Figures H 1.1 and H 1.2. The results of the study show that:

1. There were no unique postures for the different vowels studied across contexts (see figures 12.5, 12,6).

2. There were no definable differences between the postures for the different vowels of a particular vowel set[1] in the same context, e.g. the three postures for /i/, /i:/, /i^j/ were very similar when preceded by the same consonant type (cf. Appendix H, Fig. H 1.1.); they were more similar to each other than were the postures for the same vowel in different contexts. This is less so for some vowels.

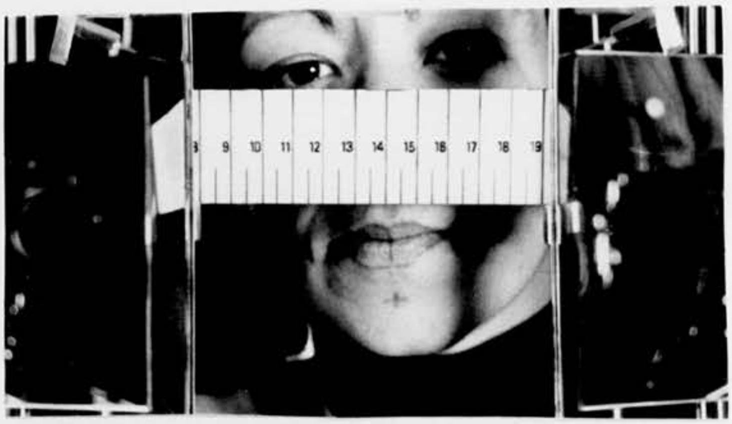
3. The closure postures (i.e. contact of upper and lower lip, eliminating all interlabial space) for /p/ followed by different members of the same vowel set were, for our purposes, identical.(cf. Appendix H, Fig H1.1).

4. The postures for /p/ across vowel sets were distinguishable and could be related to the postures for those vowels (see Fig. 12.7 and 12.8) for speaker A, much more than for speaker B. Figures 12.5 to 12.8 then, show some illustrations of the similarities and differences just discussed.

---

1. Vowel set is referred to in Chapter 8. /i/ /i:/ and /i^j/ form a vowel set, as do /e/ /e:/ and so on.

Figure 12.4



A. System used to allow measurements to be made from life-size visiograms.

B Vgm 1a. Neutral Closure for Speaker A.

C Vgm 1b. Neutral Closure for Speaker B.

Figure 12.5 Visiograms 2a to 7a : Prolonged articulation of /a/ and /a:/

Vgm 2a /a:/ in /ba:t/

Vgm 3a /a/ in /bat:/

Vgm 4a /a:/ in /a:ni/

Vgm 5a /a/ in /antiᵊk/

Vgm 6a /a:/ in /ʃa:laʔ/

Vgm 7a /a/ in /ʃat:/

Figure 12.6 Visiograms 2b to 7b. Prolonged articulation of /o:/ and /o/

Vgm 2b /o:/ in /bo:t/

Vgm 3b /o/ in /bot:/

Vgm 4b /o:/ in /o:tja/

Vgm 5b /o/ in /ot:u/

Vgm 6b /o:/ in /ʃo:l/

Vgm 7b /o/ in /irʃoʃta/

Figure 12.7 Visiograms 8a to 12a. Prolonged /p/ preceding different vowels.

Vgm 8a /p/ in /pi:na/

Vgm 9a /p/ in /pepe/

Vgm 10a /p/ in /papa/

Vgm 11a /p/ in /pop:a/

Vgm 12a /p/ in /pupats/

Figure 12.8 Visiograms 8b to 13b. Prolonged /p/ preceding different vowels.

Vgm 8b /p/ in /pitats/

Vgm 9b /p/ in /pepe/

Vgm 10b /p/ in /papa/

Vgm 11b /p/ in /pop:a/

Vgm 12b /p/ in /puʷpa/

Vgm 13b /p/ in /pupats/

The same results are valid for informant B, for the same data.

12.10. Data for the main study of prolonged articulation

On the basis of the observations in the pilot study, I decided to study the consonantal sounds selected - and listed below - in the context of only one member of each vowel set, that is, in five different vowel contexts, e.g. /pi:/, /pe:/, /pa:/, /po:/, /pu^{w}/. The consonants were selected as 'representative' of a class, unless a particular consonant was the only member of a class. These classes are:

1. ▷p◁[1] consisting of /p, b, m/;
2. ▷w◁ consisting only of /w/;
3. ▷f◁ consisting of /f, v/;
4. ▷ʃ◁ consisting of /ʃ, tʃ, dʒ/;
5. ▷r◁ consisting only of /r/;
6. ▷t◁ consisting of /t, d, n, l, ts, s, z/;
7. ▷j◁ consisting only of /j/;
8. ▷h◁ consisting only of /h/;
9. ▷ʔ◁ consisting only of /ʔ/.

The last two classes were considered to be identical, but were kept separate because of the **variability in the** articulation of /h/ (see 9.5.1, p.208). Differences between classes 4 and 5 were inconstant; no differences were observed between classes 6 and 7, nor between classes 8 and 9, but I thought it best to retain a distinction between these classes which were less constant than the differences between the first five classes. The classification could be said to be based on the posture of the lips when the consonant sound in

1. The symbol ▷ ◁ is defined in the last paragraph of this section (i.e. 12.10).

question constituted the 'take-off' (releasing) point of the syllable. The sound enclosed in the symbol ▷ ◁ , e.g. ▷ p ◁ , should be read as the class of sounds consisting of the phonemes indicated above. This will be necessary in the discussion on the lip patterns described in the main study.

12.11. The Data

The data is presented below in figure 12.9. The prolonged sound appears in phonemic transcription in the first column. The word, as written on the card for the informant, in orthographical form, appears in column two. This is then presented in phonemic transcription in the next column. A gloss of the word, with only one of the possible meanings, is given in column four.

FIGURE 12.9.

Word list with phonemic transcription and gloss for a visual study of Maltese using prolonged articulations.

Phoneme	Word	Phonemic Transcription	Gloss
Vowel/▹p◃ ___			
i	pipistrel	pip:istrel	name of bird
i^{j}	pipa	pi^{j}pa	pipe
i:	bieb	bi:p	door
e:	begħetni	be:tni	he sold me
e	bgħettni	bet:ni	you sold me
a:	bagħat	ba:t	he sent
a	bgħat	bat:	I sent
o:	bogħod	bo:t	far
o	bott	bot:	tin
u^{w}	but	bu^{w}t	pocket
u	buttuna	but:u^{w}na	button
Vowel/▹ʃ◃ ___			
i	x'ħini	ʃini	what is it
i^{j}	ħaxixa	ha:ʃi^{j}ʃa	grass (singular)
i:	xini	ʃi^{j}ni	galley
	tmexxija	tmeʃ:i^{j}ja	leadership
	x'ħiex	ʃi:ʃ	what?
	imxiet	imʃi:t	she walked
e:	x'għereq	ʃe:re:?	what drowned?
e	xedaq	ʃeda?	jaw
a:	x'għalaq	ʃa: la:?	what did he shut?
a	xatt	ʃat:	shore
o:	xogħol	ʃo:l	work
o	irxoxta	irʃoʃta	he rose (from the dead)
u^{w}	xuxa	ʃu^{w}ʃa	hair
u	irxuxtaha	irʃu·ʃta:	he resuscitated her
Vowel/ ø ___			
i	ikel	ikel	food
i^{j}	idi	i^{j}di	my hand
i:	iekol	i:kol	eat!
e:	għeri	e:ri	naked
e	errata	er:a:ta	printing error
a:	għani	a:ni	rich
a	antik	anti^{j}k	old
o:	għotja	o:tja	gift
o	ottu	ot:u	fine! (sarcastic)
u^{w}	uza	u^{w}za	use
u	uzah	uza:h	use it

Phoneme	Word	Phonemic Transcription	Gloss
▷ p◁/___V			
p	pitazz	pitats	exercise book
p	piena	pi:na	penalty
p	pipa	pi^{j}pa	pipe
p	papa	papa	father
p	papa	pa:pa:	pope
p	pepe	pepe	snob
p	Pepe	pe:pe:	name of liquor
p	poppa	pop:a	stern
p	poplu	po:plu	nation
p	pupazz	pupats	puppet
▷ k◁/___V			
k	kif	ki^{j}f	how
k	l-iskema	liske:ma	the scheme
k	qagħad	ʔa:t	he stayed
k	khaki	ka:ki	khaki
k	koka	ko:ka	cook (female)
k	kutra	ku^{w}tra	blanket
▷ t◁/___V			
t	titlu	ti^{j}tlu	title
t	tegħemha	te:ma	he tasted it
t	tagħtha	ta:ta	she gave her
t	togħma	to:ma	taste
t	tutu	tu^{w}tu	one blackberry
▷ w◁/___V			
w	twila	twi^{j}la	tall
w	wegħedni	we:dni	he promised me
w	is-swali	is:wa:li	the halls
w	kwota	kwo:ta	quota
w	ilwu	ilwu	twist
▷ ʃ◁/___V			
ʃ	x'id	ʃi^{j}t	which hand
ʃ	xegħel	ʃe:l	he switched on
ʃ	xagħar	ʃa:r	hair
ʃ	xogħli	ʃo:li	my work
ʃ	xuxa	ʃu^{w}ʃa	hair
▷ f◁/___V			
f	fidi	fi^{j}di	faith
f	fehem	fe:m	he understood
f	fama	fa:ma	renown
f	foga	fo:ga	smelly thich atmosphere
f	fur	fu^{w}r	to overflow
▷ j◁/___V			
j	jieħu	ji:hu	he takes
j	jegħleb	je:lep	he upsets (lit.)

j	jagħsar	ja:sar	he wrings
j	jogħla	jo:la	he rises
j	jum	ju^{w}m	day
▸r◂/__V			
r	ried	ri:t	he wanted
r	regħex	re:ʃ	he was contrite
r	ragħad	ra:t	she saw.
r	roża	ro:za	pink
r	ruma	ru^{w}ma	Rome
▸ħ◂/__V			
h	ħiet	hi:t	he sewed
h	ħetha	he:ta	he sewed it
h	ħares	ha:res	look!
h	ħodor	hodor	green
h	ħut	hu^{w}t	fish
▸ʔ◂/__V			
ʔ	qiegħed	ʔiet	he is ...
ʔ	qiegħedha	ʔe:da	he put her ...
ʔ	qalha	ʔa:la	he said it
ʔ	qosor	ʔosor	shortness
ʔ	qum	ʔu^{w}m	get up!
▸p◂ + C			
p	pwales	pwa:les	name of place
p	b'fatat	pfa:ta:t	with a ghost
p	b'xorti	pʃorti	with luch (good or bad)
b	bramel	bra:mel	buckets
p	btieħi	pti:hi	yards
b	bjut	bju^{w}t	pockets
p	bkejt	pkejt	I cried
p	bħali	pha:li	like me
p	ibqa'	ipʔa	stay!
▸w◂ + C			
w	tewma	tewma	clove of garlic
w	sewfu	sewfu	they 'fluffed'
w	writtha	iwrit:a	I inherited it
w	għuda	ewda	tools
w	liwja	liwja	turn, twist
w	tawk	tawk	they gave you
w	tawh	tawh	they gave him
w	sewqan	sewʔa:n	driving
w	mewġ	mewt	waves
▸f◂ + C			
f	f'posti	fposti	in my place
f	fwied	fwi:t	liver
f	f'xahar	fʃa:r	in a month
f	frak	fra:k	crumbs/bits

f	ftit	fti^{j}t	few
v	vjaġġ	vjatʃ:	journey
f	fkieren	fki:ren	tortoises
f	fħalqi	fhalʔi	in my mouth
f	fqar	fʔa:r	poor
⊳ʃ⊲ + C			
ʃ	xpakka	ʃpak:a	he split (trousers,etc.)
ʃ	xwiek	ʃwi:k	thorns
ʃ	xfar	ʃfa:r	edges
ʃ	xrief	ʃri:f	beams
ʃ	ċraret	tʃra:ret	rags
ʃ	xtajt	ʃtajt	what did you give?
ʃ	xjuħ	ʃju:h	old people
ʃ	x'kien	ʃki:n	how come? what was it/he?
ʃ	x'ħa	ʃha:	what did he take?
ʃ	x'qal	ʃʔa:l	what did he say?
⊳r⊲ + C			
r	irbit	irbi^{j}t	restrictions
r	erwieħ	erwi:h	souls
r	erfa	erfa	lift!
r	irtir	irti^{j}r	retreat
r	irjus	irju^{w}s	heads
r	irkejjen	irkej:en	corners
r	erħilu	erhi^{j}lu	leave him!
r	għerqu	e:rʔu	they drowned
⊳t⊲ + C			
t	tpatti	tpat:i	you pay back (not money)
t	tfejt	tfejt	I switched off
t	ma mittx	mamitʃ:	I didn't die
t	trab	trap	dust
d	djun	dju^{w}n	debts
t	twiebet	twi:bet	coffins
t	tkellem	tkel:em	he spoke
t	dħalt	thalt	I went in
t	dqiq	tʔi:ʔ	flour
⊳j⊲ + C			
j	tajba	tajba	good
j	tajwan	tajwa:n	Taiwan
j	dgħajfin	dajfi^{j}n	weak
j	għixien	ajʃi:n	living
j	tajru	tajru	they let fly
j	tajtu	tajtu	I gave him
j	ħdejk	hdejk	near you
j	ħdejh	hdejh	near him
j	dejqitu	dejʔitu	she annoyed him

▸k◂ + C			
g	akbar	agbar	bigger
k	kwiekeb	kwi:kep	stars
k	kfief	kfi:f	hems
k	kxaxen	kʃa:ʃen	drawers
k	krafes	kra:fes	celery (plural)
k	ktajjen	ktaj:en	chains
k	ikħal	ikhal	blue
k	ikqal	ikʔal	
▸h◂ + C			
h	ħbejtu	hbejtu	I hid it
h	ħwawar	hwa:war	spices
h	ħfirtha	hfirta	I forgave ...
h	ħġejjeġ	hdʒej:et	glass (plural)
h	ħrara	hra:ra	zeal
h	ħdana	hda:na	bosom
h	ħjar	hja:r	cucumbers
h	aħkem	ahkem	rule!
h	aħqar	ahʔar	torment!
▸ʔ◂ + C			
ʔ	aqbad	aʔbat	catch!
ʔ	aqwa	aʔwa	better
ʔ	qxur	ʔʃu^{w}r	peel (plural)
ʔ	qrar	ʔra:r	confession
ʔ	qtil	ʔti^{j}l	killing
ʔ	•aqħel	aʔhel	
C + ▸p◂			
m	tewma	tewma	garlic (clove)
p	f'posti	fposti	in my place
p	xpakka	ʃpak:a	he split (trousers, etc.)
b	irbit	irbi^{j}t	restrictions
p	tpatti	tpat:i	to pay back (not money)
b	tajba	tajba	good (feminine)
b	akbar	agbar	bigger
b	ħbejtu	hbejtu	I hid it
b	aqbad	aʔbat	catch!
C + ▸w◂			
w	pwales	pwa:les	name of place
w	fwied	fwi:t	liver
w	xwiek	ʃwi:k	thorns
w	erwieħ	erwi:h	souls
w	twiebet	twi:bet	coffins
w	tajwan	tajwa:n	Taiwan
w	kwiekeb	kwi:kep	stars
w	ħwawar	hwa:war	spices
w	aqwa	aʔwa	better

C + ▶f◀			
f	b'fatat	pfa:ta:t	with a ghost
f	sewfu	sewfu	they fluffed
f	xfar	ʃfa:r	edges
f	erfa'	erfa	lift!
f	tfejt	tfejt	I switched off
f	dghajfin	dajfi^{j}n	weak
f	kfief	kfi:f	hems
f	hfirtha	hfirta	I forgave ...
f	aqfel	a?fel	tie!
C + ▶ʃ◀			
ʃ	b'xorti	pʃorti	with luch (good/bad)
tʃ	mewg	mewtʃ	waves
ʃ	f'xahar	fʃa:r	in a month
dʒ	erga	erdʒa	repeat!
tʃ	ma mittx	mamitʃ:	he didn't die
ʃ	ghajxin	ajʃi:n	living (abstract)
ʃ	kxaxen	kʃa:ʃen	drawers
dʒ	hgejjeg	hdʒej:etʃ	glass (plural)
ʃ	qxur	ʔʃu^{w}r	peel (veg.)
C + ▶t◀			
t	btiehi	pti:hi	yards (garden)
d	ghuda	ewda	tools
t	ftit	fti^{j}t	few
t	xtajt	ʃtajt	what did you give?
t	irtir	irti^{j}r	retreat
t	tajtu	tajtu	I gave him ...
t	ktajjen	ktaj:en	chains
d	hdana	hda:na	bosom
t	qtil	ʔti^{j}l	killing
C + ▶j◀			
j	bjut	bju^{w}t	pockets
j	liwja	liwja	twist, turn
j	vjagg	vjatʃ:	journey
j	xjuh	ʃju:h	old people
j	irjus	irju^{w}s	heads
j	djun	dju^{w}n	debts
j	kjass	kjas:	noise
j	hjar	hja:r	cucumbers
j	qjar	ʔja:r	
C + ▶k◀			
k	bkejt	pkejt	I cried
k	tawk	tawk	they gave you
k	fkieren	fki:ren	tortoises
k	xkien	ʃki:n	what was it?
k	irkejjen	irkej:en	corners
k	tkellem	tkel:em	he spoke

k	ħdejk	hdejk	near you
k	aħkem	ahkem	rule!

C + ▶h◀

h	bħali	pha:li	like me
h	tawh	tawh	they gave him
h'	f'ħalqi	fhal?i	in my mouth
h	x'ħa	ʃha:	what did he take?
h	erħilu	erhiʲlu	leave him
h	dħalt	thalt	I went in
h	ħdejh	hdejh	near him
h	ikħal	ikhal	blue
h	aqħel	aʔhel	

C + ▶ʔ◀

ʔ	imqareb	imʔa:rep	naughty (sing. masc.)
ʔ	sewqan	sewʔa:n	driving
ʔ	fqar	fʔa:r	poor
ʔ	x'qal	ʃʔa:l	what did he say?
ʔ	għerqu	e:rʔu	they drowned
ʔ	dqiq	tʔi:ʔ	flour
ʔ	dejqu	dejʔu	they annoyed ... they narrowed ...
ʔ	aħqar	ahʔar	to torment

12.12. Uncontrollable Variables

I would now like to consider briefly some of the variables involved in a study of the kind undertaken here, which, for a variety of reasons, cannot be controlled.[1] Among these variables are:

(1) those within the speech material itself;

(2) those related to the speaker acting as subject, or to other speakers about whom generalizations may be made, based on the study;

(3) those factors created by the experimental or laboratory conditions themselves.

12.13.1. Factors related to speech

It is important to note that each speech act could be considered unique because it is impossible to recreate exactly the same conditions. Therefore, repetitions of the same utterance will not necessarily result in identical patterns. For this reason, the data was selected to provide enough examples, and repetition of the same examples, by the two informants, to ensure that patterns characterizing or associated with a particular sound could be distinguished.

It is the pattern and not the absolute measures that is important, of course. Both Geissler 1975, with reference to mandibular movements, and Fromkin 1964, with reference to lip positions, noted that, whereas absolute measures vary considerably for the same speaker and between speakers, the relationship or relative measures are quite stable.

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1. Such variables cannot be controlled for different reasons, for example, because the study is already extensive and it would be impracticable to extend it further.

In the study of connected speech, rate of utterance could not be controlled except insofar as the speaker maintained a reasonably consistent speed throughout the film. Even so, the data was not filmed continuously because of technical problems.

Word stress and sentence stress are not accounted for in any way. Kent and Netsell (1971) found that increased stress changed articulation in the direction of the presumed target for some speakers; for example, rounded vowels were articulated with increased lip protrusion. However, they found very few instances of altered coarticulatory patterns as a result of stress variation. They conclude, in fact, that the basic units of articulatory encoding are independent of the prosodic content of an utterance, but that

> "stress contrasts alter the temporal scheme of articulatory programming in certain aspects." (ibid.)

12.13.2. Factors related to the speaker(s)

The most obvious factor that arises out of a study using only two speakers is that of idiosyncrasy. It is possible that some patterns are idiosyncratic of one or both speakers, and may not permit generalization to other Standard Maltese speakers. It is unlikely, however, that this is the case since both speakers used for this study are considered normal by other native speakers, have no physical sense impairment and do not have deviant physical characteristics either in lip, or jaw structure, or dentition and occlusion.

12.13.3. Factors related to the Experimental conditions

Since any speech event carried out for the sole purpose of being observed or recorded is very artificial, various factors can interfere with naturalness of articulation.

To minimise interference with naturalness, no foreign object was used within the speaker's mouth, since this was considered to increase at least the speaker's awareness of his manner of production. However, the speaker was more or less immobilized by the use of the specially constructed frame. Even within this frame, certain head and neck movements, though slight, are inevitable and cannot be considered.

These relate to the possible slight movements of the head and neck - therefore involving slight upper and lower jaw displacement - which Perkell 1967 explains as: (1) being necessitated by the mandibular muscles acting to provide stability for the vocal tract activities, (2) as a passive reaction to changes in vocal tract configuration and differences in airflow velocity and pressure, as well as (3) gesticulatory movement influenced by stress placement. Fortunately, these are all forward movements, and therefore probably almost altogether are avoided by the fact that the eyebrow rest stabilizes the head quite firmly, preventing movement forward.

In most cases, jaw lowering did not occur simultaneously with the start of the articulation for the utterance but preceded it.[1] This could have been rather misleading, but synchronised pulses enabled me to relate the visual to the audio patterns. This allowed me to account for pause patterns, utterance anticipation patterns and coarticulation.

1. This was also noted by Geissler 1975.

12.14. Measurements

The resulting measurements for each visiogram appear in Appendix H, Fig. H1 to H2.The average measurements for each of the two informants are presented **together for all the parameters. The** figures show the measurements for all the segments studied, as spoken by informants A and B. Column 1 shows the phoneme studied; column 2 shows the **phonemic** transcription of the words used to contextualize the segments studied. The other columns to the right show the measurements in millimeters for each parameter considered. These are separated by thick lines; finer lines separate the data for the two informants; O refers to informant A; X refers to informant B[1].

Figure H 1.1. shows the measurements for the vowels in various contexts.

Figure H 1.2. shows the measurements for the 10 consonant classes in the context of different vowel types (e.g. ▹ p ◃ + /i/, ▹ p ◃ + /a/, etc.) for both informants. Thus, there are at least five vocalic contexts, as five vowels are considered representative visually.

Figure H 1.3. shows the measurements in mm. for the 10 representative consonants for both informants occurring as C_1 in CC clusters. The C_2 used are the other 9 representative consonants as shown in the word list used, in the left hand column. Thus, each consonant is pronounced 9 times in 9 different consonant contexts.

Figure H.1.4. shows the measurements in mm. for the 10 representative consonants for both informants.

1. A and B could have been confusing, considering the letters used for the parameters. O and X are used throughout the illustrative graphs later, for informants A and B.

The consonants are pronounced as C_2 in CC clusters. The C_1 used are the other 9 consonants, so that each consonant is pronounced 9 times in the context of different clusters.

Figure H 2 shows the averages of the measurements for the vowels. These averages are based on those of **Fig. H1.1.** The top line shows the measurements taken from the visiogram for the Neutral-closed posture for informants A and B. The measurements for each speaker again appear side by side, those for speaker A on the left, followed by those for speaker B on the right of each column for parameter, as indicated by O and X respectively at the top of the columns on the first page of the tables. The averages are taken from the measurements for the visiograms and then compared with the measurements for the 'neutral-closed' visiogram. Thus, for example, +5 means 5 mm. more than neutral for that speaker; -2 means 2 mm. less than the neutral posture measurement for that parameter, and so on. The average, in each case, is followed by the lowest (L) measurements, and then by the highest (H) measurements.

Figure H 2. shows the average measurements compared with the measurements for the neutral-closed visiogram (i.e. + or - the neutral measurements) for both informants (**p. 2-6 of Fig. H2**). The first 3 rows for each consonant refer to the measurements for the consonants in a vocalic context, the next 3 refer to the measurements for the consonant as C_1 of a CC cluster, the next 3 refer to the measurements for the consonant as C_2 of a CC cluster. The final 3 rows represent the absolute average measurements for the consonants in all three context-types, followed by the lowest and highest measurements for all contexts considered together.

I will discuss these results and present them graphically in the next section.

12.15. Presentation of results

The measurements are plotted in graph-like diagrams for immediate visual accessibility to the information. The measurements used in the graphs are the averages, for each of the two speakers, across the different occurrences of the classes of phonemes as decided in section 12.10. There are fifteen different graphs, one for each parameter used and found to be relevant. Additionally, a summary of each graph, again separate for each speaker, is added and shown along with the discussion of each graph.

Each graph shows the overall average measurement for each class of sounds - symbolized as ▷p◁ , ▷f◁ , and so on - for each of the two speakers in order to: (1) eliminate idiosyncratic or widely varying patterns, and (2) see whether any sound is distinguishable by any one (or more) parameter. The lowest and the highest values are also presented to show the variation for each sound due to phonetic context and, therefore, to relate this to the concept of dominance and stability of the visual pattern.

The plus and minus lines show the increase or decrease of the dimensions from the neutral posture measurements. The neutral posture is considered to be the speaker's rest position - different for each speaker, of course. In both cases, there is complete lip closure, so that: $A - X = 0$ mm; $X - B = 0$ mm. ($A_2 - B_1 = 0$ mm.) $Y - Y = 0$ mm.

The graphs will be discussed in the order in which they are presented, in terms of the plotted parameter values for the sounds studied.

'Visual unit' is the term used here for a posture or movement that can be identified (located) and described.

12.16. Discussion

It is remarkable that for all of the parameters considered, there is a strong correlation between the patterns used by both speakers. On occasions, the deviation from neutral for speaker A is greater than that for speaker B, but the direction and the relative measurement for the different sounds are matched very well. (cf. Appendix H, Fig. H1.1-1.4). This suggests then, that the patterns being studied are not idiosyncratic, but characteristic of the Maltese accent being studied.

A close look at the diagrams shows that there is often only a small maximum difference between two extreme sounds when measured along any one parameter. Such a parameter alone cannot be used as the correlate of a visual unit. A more visible distinction must also be present, corresponding to a difference between speech sounds for any identification to be made on visual grounds.

The deviation of the highest and the lowest value from the average value for each parameter indicated the effect of context on a sound. Very stable sounds will have very fixed values for some parameters but changing values for other parameters. In such cases, it can be said that these sounds are characterized by the parameters that do not reflect contextual changes. These aspects - the stable and the influenced parameters - will be analysed for each sound class. The horizontal lines show the deviationfor each speaker. A summary of the relationship of the sounds to each other is also shown for each graph with the discussion.

12.17.

$E_1 - E_2$ - <u>Overall frontal height</u> (figure 12.10)

This shows that for speaker A, there is decreased frontal height for ▷p , f, ʃ◁, whereas for speaker B, there is a small increase for ▷f◁ , and slightly more for ▷p◁ and ▷ʃ◁ in that order. This parameter gives us an indication of what could be happening during the production of these sounds. The most likely posture associated with decreased frontal height is that for closure - and this is shown along other parameters. Opening is not excluded because this could be counterbalanced by jaw raising, whereas the lips can form an opening which therefore produces vertical expansion. This is then reflected along the parameters: $E_1 - A_1$, $A_2 - B_1$ (or to X_L), and $B_2 - E_2$, as will be seen.

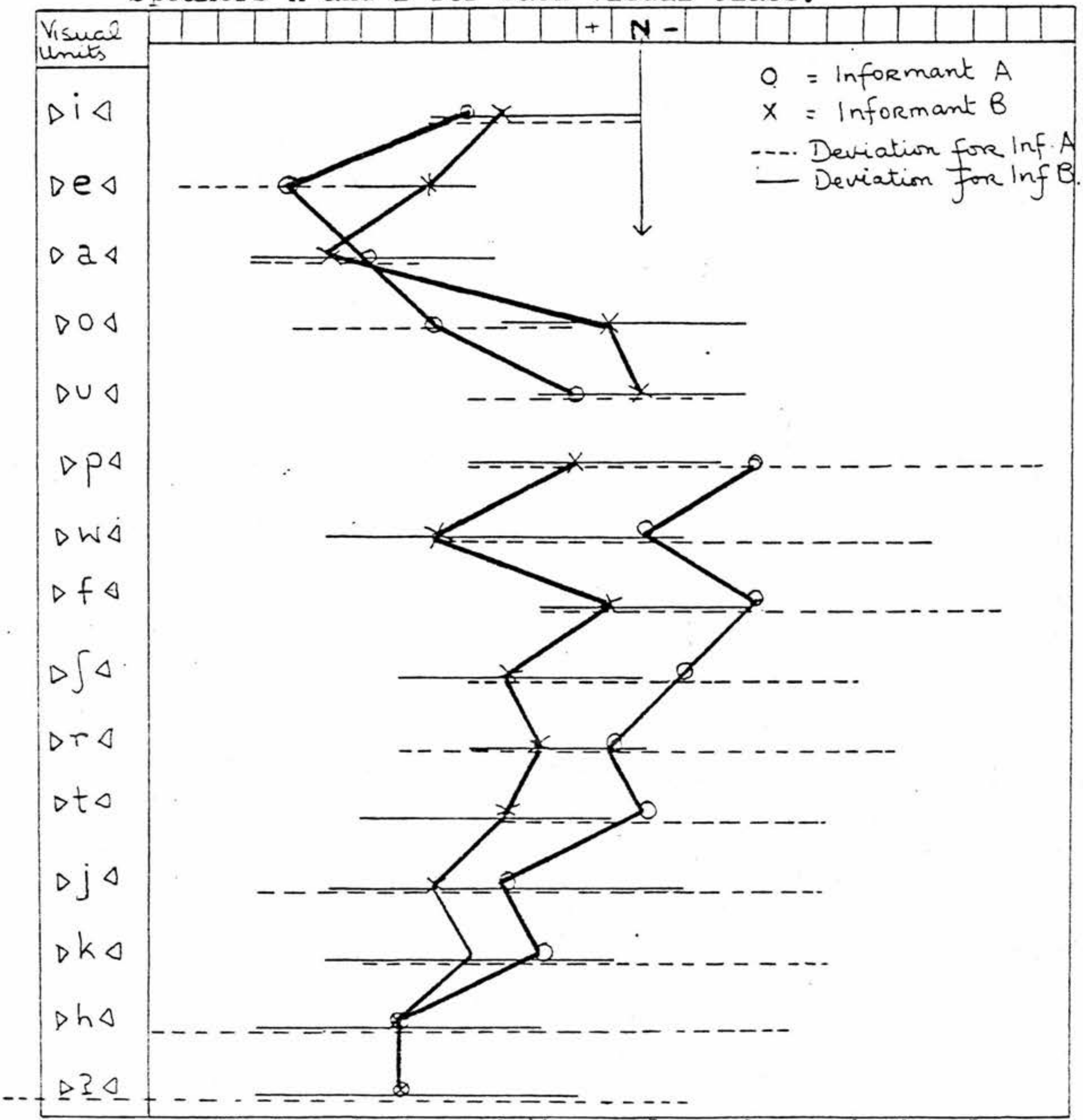
The increase in frontal height seems very gradual. At the more 'open' end of the scale are the vowels /a, a:, e, e:/ for both speakers, as well as the consonants ▷h◁ and ▷ʔ◁. It is interesting to note that ▷w◁ is at a different end of the scale for the two speakers. This shows that more than one parameter must be considered in describing visual characteristics of sounds because the same overall effects may be reached by various means. This parameter gives only a very general picture of what is happening. It is most directly related to vertical expansion and constriction of the interlabial space. Thus, we see that there is more tense upper lip lowering and lower lip raising by speaker A for the closure required for ▷p◁, and for the lower lip to upper teeth approximation in ▷f◁. This tenseness is reflected in visible creases (figures 12.7 and 12.8). However, the $E_1 - E_2$ line does not, in itself, tell us very much about the activity of the lips. It is a strong indicator of jaw movement and lower lip movement, but these have to be considered separately since the activity of the one can cancel the effect of the other, in terms of overall height.

The summary of the relationship between the sounds along this parameter shows the gradual slope from neutral to lengthened $E_1 - E_2$ for speaker B, and from a slightly decreased to a lengthened $E_1 - E_2$ for speaker A.

The clearest difference in patterning across the two speakers is the overall frontal height for ▷r, ʃ , o,(o:), a,(a:)◁.

Figure 12.10

The measurement of parameter $E_1 - E_2$: the average and the range of deviation from neutral in mm. for Speakers A and B for each visual class.



Rank-ordering of the prolonged sound visual classes from + neutral to - neutral for parameter E_1-E_2 for Speakers A and B.

A	N +									N -		
	▷e◁	▷a◁	▷h◁ ▷ʔ◁	▷o◁	▷i◁	▷j◁	▷k◁	▷u◁	▷r◁	▷w◁ ▷t◁	▷ʃ◁	▷p◁ ▷f◁
B	N +									N -		
	▷a◁	▷h◁ ▷ʔ◁	▷e◁ ▷w◁ ▷j◁	▷k◁	▷i◁ ▷ʃ◁ ▷t◁	▷r◁	▷p◁	▷o◁ ▷f◁	▷u◁			

12.18. Figures 12.11A and 12.11B

$E_1 - A_1$ is directly related to the activity of the upper lip, whereas $B_2 - E_1$ is directly related to the activity of the lower lip.

In figure 12.11A we see that ▷p◁ and ▷ʃ◁ are at extreme poles from each other. This indicates the upper lip lowering for ▷p◁ to effect a closure or firm contact with the lower lip, whereas the upper lip is raised very effectively for ▷ʃ◁. For both speakers, ▷o, (o:), u, (u^W), f◁ are also at the ▷ʃ◁ extreme of the scale, thus indicating the activity of the upper lip, which is raised for all of these.

Figure 12.11B shows ▷f◁ and ▷p◁ at the extreme end (and well differentiated from all the other sounds) from ▷ʃ◁. Since changes along $B_2 - E_2$ are effected by the lower lip, then this certainly characterizes the production of these sounds. Thus, since the line $B_2 - E_2$ increases for ▷p◁ and ▷f◁, the lower lip must be raised, whereas for ▷ʃ◁ it is significantly lowered.

Neither $E_1 - A_1$ nor $B_2 - E_2$ is related in any way to jaw movement. Thus both lips must be functioning as primary differentiators of ▷p◁, ▷f◁ and ▷ʃ◁.

The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameters E_1-A_1 and B_2-E_2 for Informants A and B.

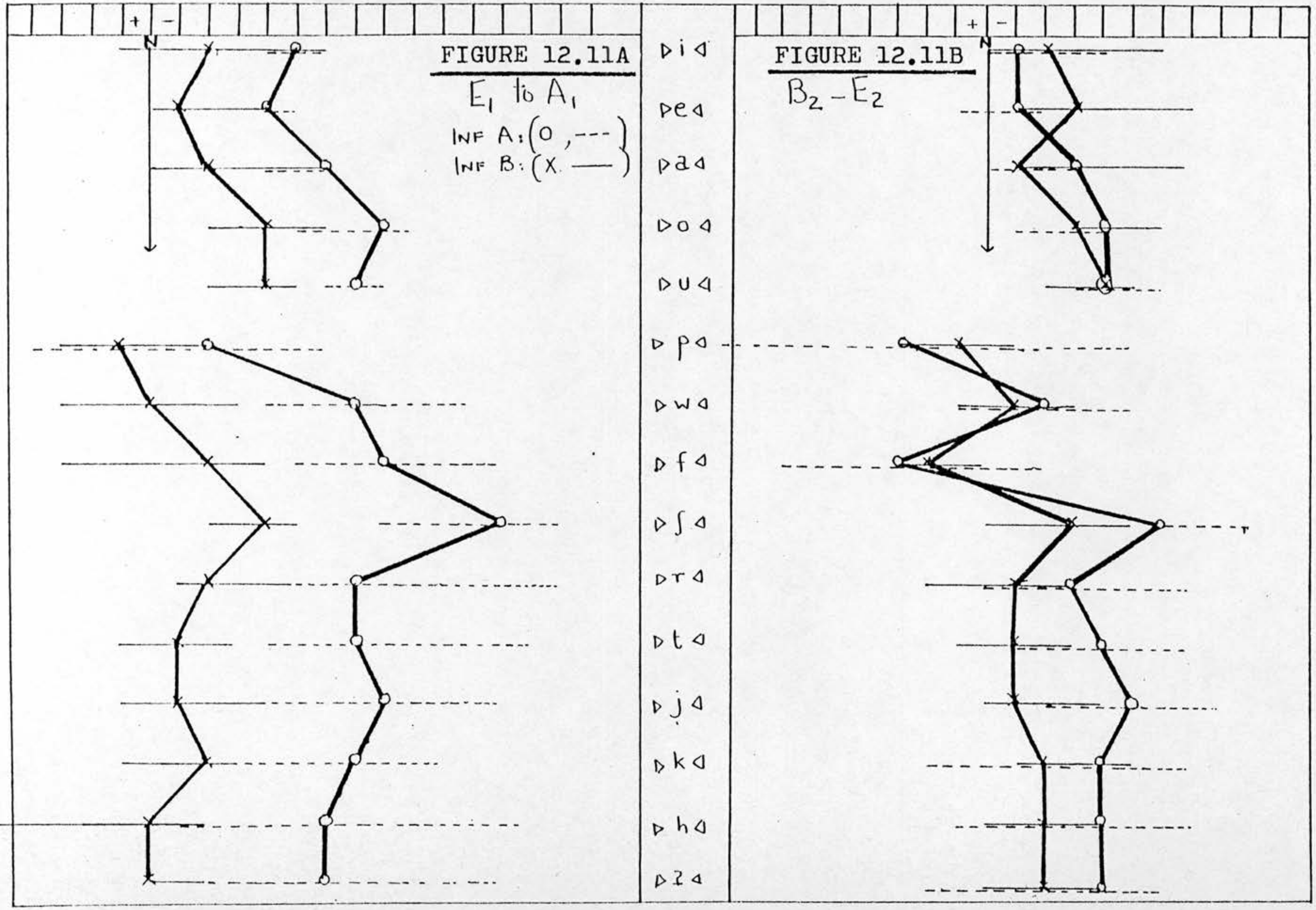
INFORMANT A

E_1-A_1	▷p◁	▷e◁	▷i◁	▷a◁ ▷h◁ ▷ʔ◁	▷u◁ ▷w◁ ▷r◁ ▷t◁ ▷k◁	▷o◁ ▷f◁ ▷j◁	▷ʃ◁
B_2-E_2	▷p◁ ▷f◁	▷i◁ ▷e◁	▷w◁	▷a◁ ▷r◁	▷o◁ ▷u◁ ▷t◁ ▷k◁ ▷h◁		

INFORMANT B

E_1-A_1	▷p◁	▷w◁ ▷h◁ ▷ʔ◁	▷e◁ ▷t◁ ▷j◁	▷i◁ ▷a◁ ▷f◁ ▷r◁ ▷k◁	▷o◁ ▷u◁ ▷ʃ◁	
B_2-E_2	▷f◁	▷p◁	▷a◁ ▷w◁ ▷r◁ ▷t◁ ▷j◁	▷i◁ ▷k◁ ▷h◁ ▷ʔ◁	▷e◁ ▷o◁ ▷ʃ◁	▷u◁

Figures 12.11A and 12.11B The measurement of parameters E_1-A_1 and B_2-E_2: the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.



12.19. Figures 12.12A, 12.12B and 12.12C

$A_1 - A_2$, $B_1 - B_2$, and $X_L - B_2$ measure the actual lip dimensions. It does, of course, reflect muscular activity of the lips, resulting in expansion or contraction of the outer lip (from the vermilion border outwards). This is related to the activity of the lips in other directions. Thus, with horizontal spreading of the lips, A - A and B - B are likely to decrease. With protrusion and simultaneous lower lip lowering, $X_L - B_2$ is bound to increase, possibly with a decrease in the "visibility" of $B_1 - B_2$.

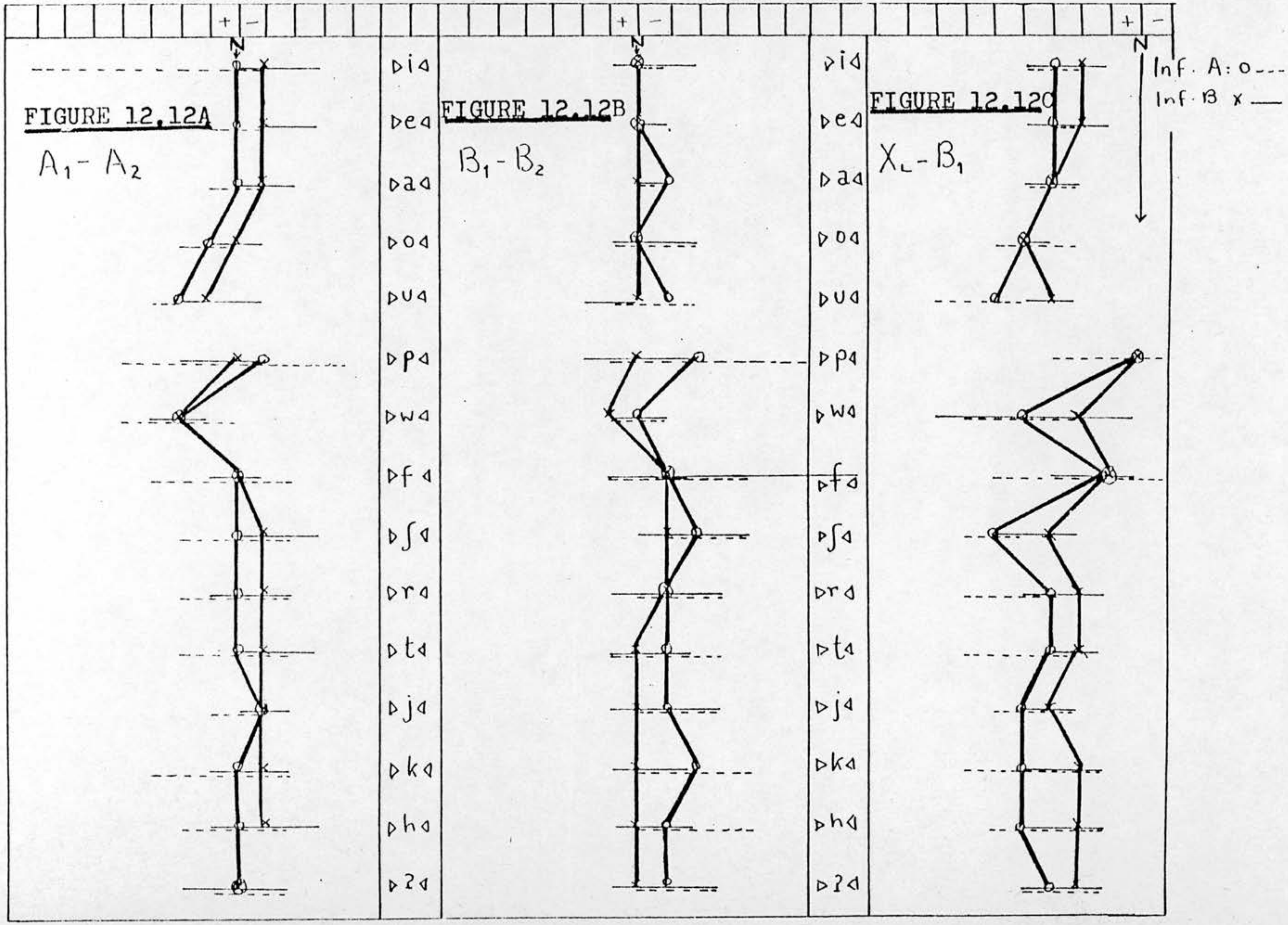
It is worth pointing out that the "invisibility" of any part of the face as a result of movement does not necessarily mean invisibility to the lip reader, who has a simultaneous view of the three-dimensional picture. Hence, it is important to consider the lateral view along with the frontal view, i.e. two or more parameters at the same time. The curve of the lower lip in relation to the chin, for example, shows that the decrease in $B_1 - B_2$ (figure 12.12B) for ▹ʃ◃ is due to the lower lip curling downwards and in towards the chin.

On the other hand, the position of the lower lip in relation to the upper lip (Fig.12.27, p.333) shows that the decrease in $B_1 - B_2$ for ▹f◃ is due to its introversion in relation to the upper teeth. For both figures 12,12A, 12.12B, there is an increase in the vertical dimension of the lips themselves for ▹w, u,(u^w)◃. This should be seen in relation to the horizontal movement which contracts the lips so that there is marked decrease in the $C_1 - C_2$ dimension. It is interesting to note in Fig. 12.12C that there is more lower inner lip visibility for ▹ʃ◃ and least for ▹f◃ and nothing for ▹p◃ . The slight visibility of the lower inner lip for ▹f◃ is caused by the upper teeth resting momentarily on the inside of the lip, whilst the lower lip curls outwards slightly from its retracted position in the anterior-posterior dimension.

The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameters A_1-A_2 , B_1-B_2 , and X_L - B_1 .

	$A_1 - A_2$				
A	▷U◁ ▷W◁	▷O◁	▷All Others◁	▷j◁	
B	▷W◁	▷U◁	▷O◁ ▷P◁ ▷f◁ ▷ʒ◁	▷All Others◁	
	$B_1 - B_2$				
A	▷i◁ ▷e◁ ▷O◁ ▷W◁	▷All Others◁	▷P◁ ▷ʃ◁ ▷k◁		
B	▷W◁	▷All Others◁	▷f◁ ▷r◁ ▷ʃ◁		
	$X_L - B_1$				
A	▷U◁ ▷ʃ◁	▷O◁ ▷W◁ ▷j◁ ▷k◁ ▷h◁	▷All Others◁	▷f◁	▷P◁
B	▷O◁	▷a◁ ▷U◁ ▷ʃ◁ ▷j◁	▷All others◁	▷f◁	▷P◁

Figures 12.12A, 12.12B and 12.12C. The measurement of parameters A_1-A_2, B_1-B_2 and X_L-B_1 : the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.



12.20.

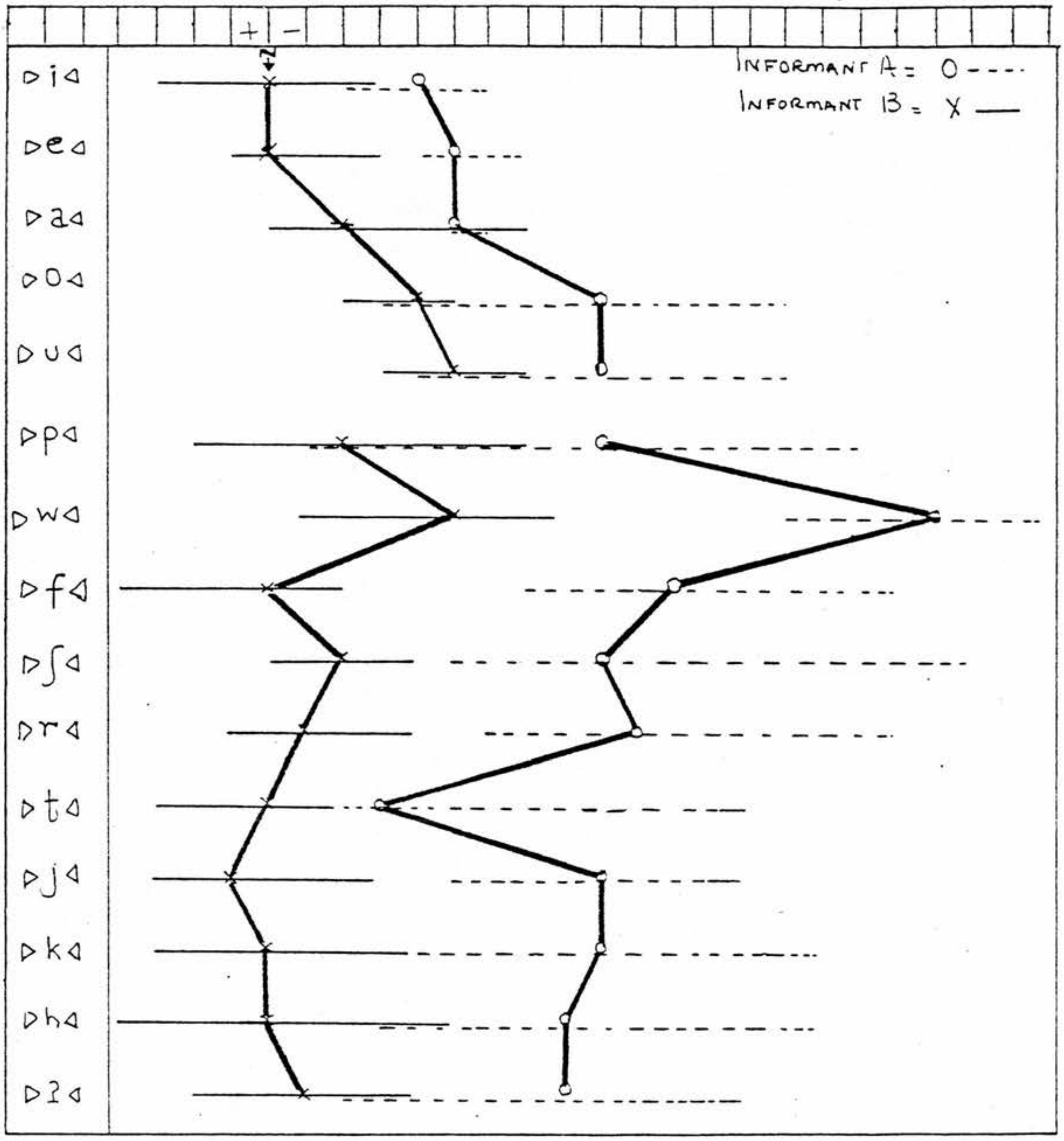
$C_1 - C_2$: Horizontal dimension of the lips measured at the corners (Fig. 12.13)

$C_1 - C_2$ relates to horizontal lip spreading, in which case there is a greater $C_1 - C_2$ line, and to horizontal lip contraction which always accompanies close protrusion in the data. It is important to note that even for the most horizontally "spread" sounds, speaker A has a shorter $C_1 - C_2$ line than he does for his neutral position. This is a clear illustration of the need to consider the measurements as relative to each other along a particular parameter. Although "neutral" seems to indicate not spread, etc., here it seems that it is the most spread position for this speaker. However, this ties in with what was said earlier about inter-speaker physiological differences.

On a relative scale, it can be seen that the ▷i, i:, i^j◁ , and, to a lesser degree ▷e, e:◁ groups are the sounds articulated with the greatest degree of horizontal lip spreading, whereas the ▷o, o:◁ and ▷u^w, u◁ and ▷w◁ classes are those articulated with a good degree of horizontal lip contraction. For speaker A, ▷f◁ and then ▷r◁ are produced with more horizontal lip contraction. Again, this must be related to another parameter from the lateral view, in this case $D_1 - D_2$. I will discuss this next. For both speakers, ▷p◁ and ▷ʃ◁ classes are also produced with significant horizontal contraction since the $C_1 - C_2$ line is relatively smaller than for the sounds produced with horizontal lip spreading.

Figure 12.13.

The measurement of parameter C_1-C_2 : the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.



The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameter C_1-C_2 for Informants A and B.

A	▷t̪◁	▷i◁	▷e◁ ▷a◁	▷h◁ ▷ʔ◁	▷p◁, ▷ʃ◁, ▷j◁, ▷k◁, ▷o◁, ▷u◁	▷r◁	▷f◁	▷w◁
B	▷j◁	▷e◁, ▷f◁, ▷t̪◁, ▷k◁, ▷h◁ ▷i◁	▷r◁ ▷ʔ◁	▷a◁ ▷p◁ ▷ʃ◁	▷o◁	▷u◁ ▷w◁		

12.21. Figure 12.14

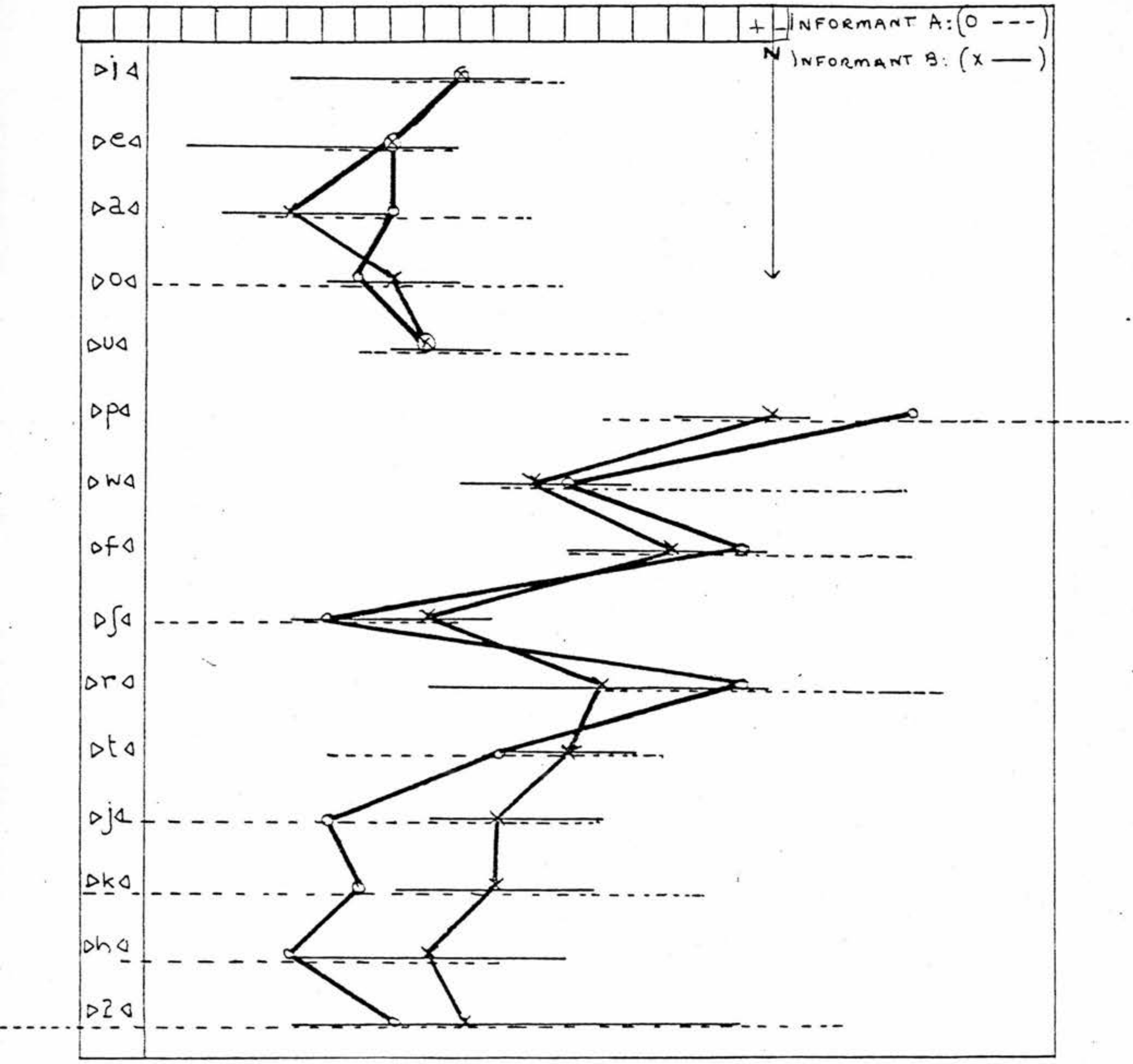
$D_1 - D_2$:

Overall lateral vertical expansion (i.e. the side view) and constriction is caused by the movement of the upper and lower lips in relation to each other. D - D is also related to upper and lower lip protrusion and retraction, seen independently.

As just mentioned, this parameter is linked to the (frontal) $C_1 - C_2$ parameter, as well as to the parameters described by the (lateral) Z - H and $H - D_1$ and $H - D_2$ lines. ▷p◁ occurs at the extreme end of the DD line, obviously due to the complete contact between the upper and lower lips for labial stops. For speaker A, the $D_1 - D_2$ line is smaller than it is for neutral, because there is visible marked tension in the articulatory closure which is not there in the rest-posture. ▷f◁ and ▷r◁ are next on the scale, also well differentiated from the other sounds. Again, this relates to the fact that there is a characteristic lower lip to upper lip relationship for both of these sounds. It seems that, at least to a small extent, the lower lip is retracted, and the upper lip protruded, such that the outer rims of the lips at the anterior end are closer together than they would be for a similar degree of opening as, for example characterises ▷w◁. ▷w◁ and ▷t◁ (in a different order for speaker A) are also differentiated by a greater degree of lateral proximity of the lips, i.e. a smaller $D_1 - D_2$ line.

Figure 12.14

The measurement of parameter D_1-D_2: the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.



The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameter D_1-D_2 for Informants A and B.

A	▷h◁	▷ʃ◁ ▷j◁	▷o◁ ▷k◁	▷e◁ ▷a◁ ▷ʔ◁	▷u◁	▷i◁	▷t◁	▷w◁	▷f◁ ▷r◁	▷p◁	
B	▷a◁	▷o◁ ▷e◁	▷h◁ ▷ʃ◁ ▷u◁	▷i◁ ▷ʔ◁	▷j◁ ▷k◁	▷w◁	▷t◁	▷r◁	▷f◁	▷p◁	

12.22. Figures 12.15 and 12.16

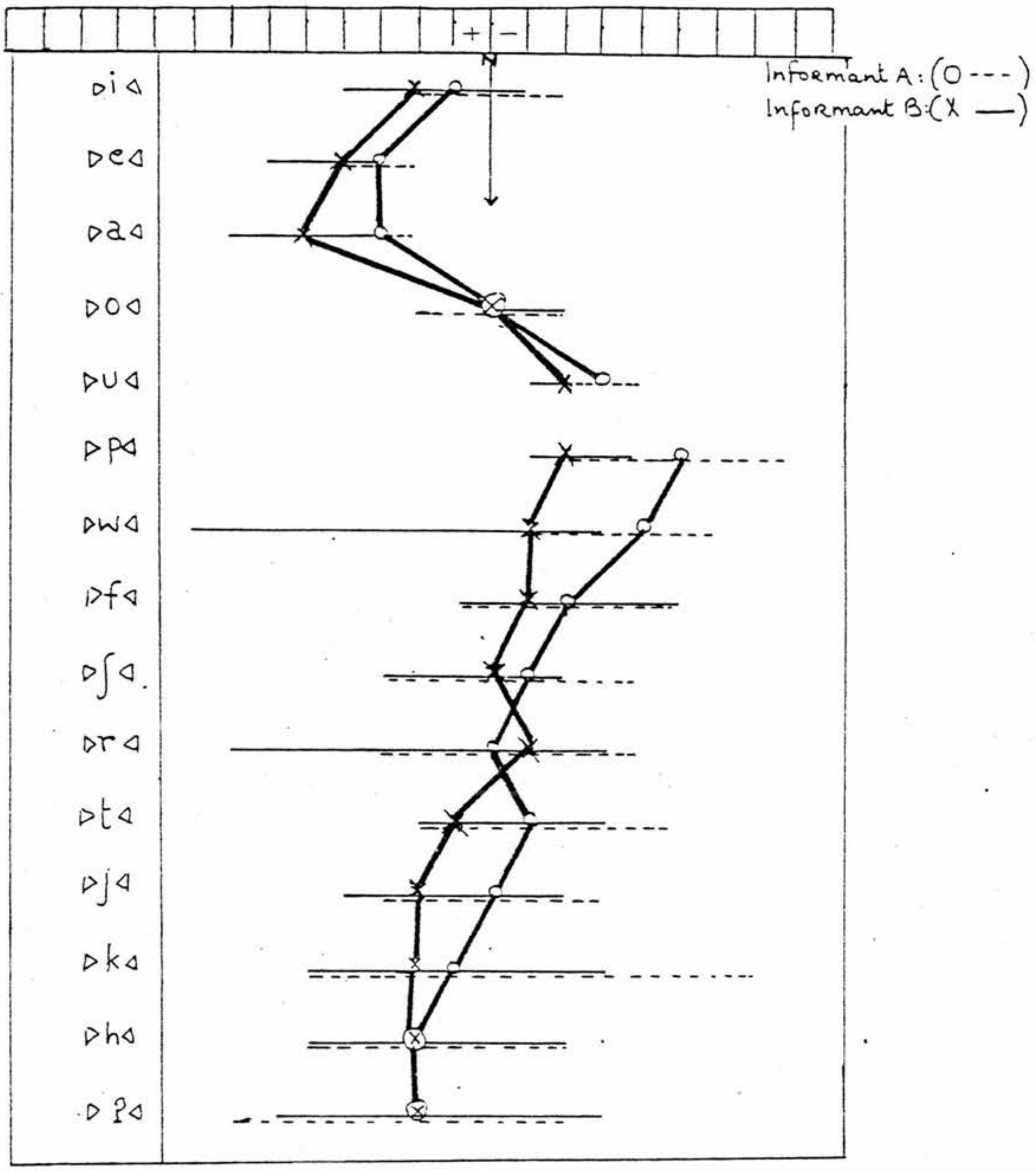
$H - D_1$ and $H - D_2$: The dimensions of lateral lip length, that is, the anterior-posterior movement of the lips outward or inward in relation to the corners of the mouth. This dimension is also related to the movement of the lips upwards or downwards, although that movement is more highly correlated with the $Z - D_1$ and $Z - D_2$ measurements.

▷t◁ and ▷j◁ are the only two sounds that do not occur in the same relationship to the other sounds for the two speakers along both these dimensions. Even then, they are placed mid-way along the scale for both speakers. This parameter is obviously a very important one, although it does not indicate what the causes of greater or lesser $H - D_1$ and $H - D_2$ lines are. To find this, we have to look at other related parameters such as the $Z - D_1$, $Z - D_2$ and $A - X$ lines. We do know, however, that there must be close proximity of the upper and lower lip for such sounds as ▷o, o:, ʃ , r, u, u^{W}, f, w, p ◁ and a considerable separation for ▷a, a:, e and e: ◁ at least.

For ▷f◁ the lower lip is retracted inwards so that, from the lateral view, the mid line of the lip is much closer to the corner of the mouth than it is for other sounds. The upper lip is closest to the corner of the mouth for ▷p◁ than for any other sound. There is an interesting relationship in the spacing out of the sounds along these two dimensions, such that ▷a, a:, e, e:◁ are distinguishable by having the greatest $H - D$ distance for both lips. This is partly due to the fact that the type of opening that occurs here involves pulling back the corners of the mouth slightly and lowering the jaw.

Figure 12.15.

The measurement of parameter H-D_1 : the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.

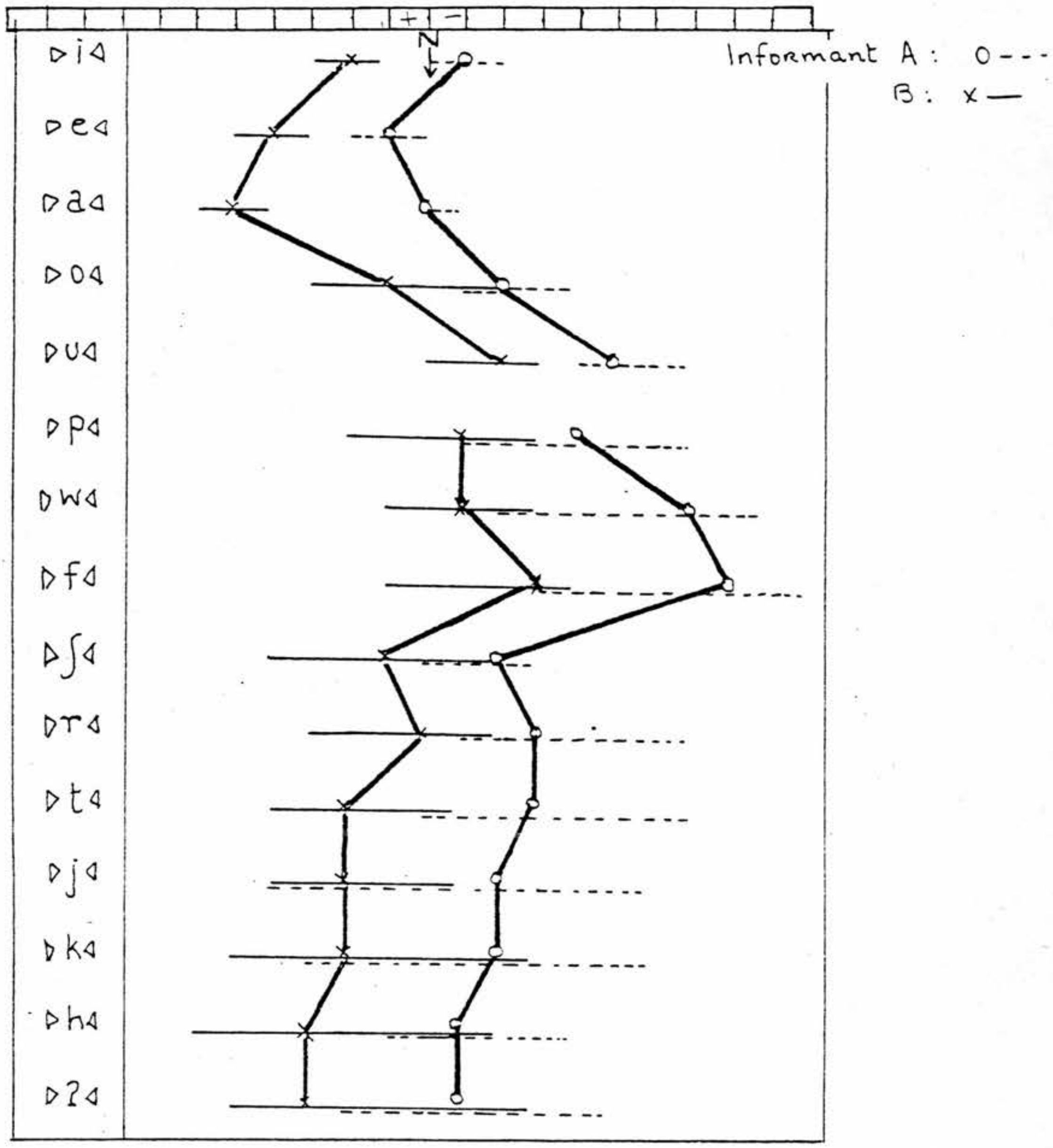


The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameter H-D_1 for Informants A and B.

INF: A	▷e◁ ▷a◁	▷h◁ ▷ʔ◁	▷i◁ ▷k◁	▷o◁ ▷r◁ ▷j◁	▷ʃ◁ ▷t◁ ▷f◁	▷u◁	▷w◁	▷p◁
INF B	▷a◁	▷e◁	▷i◁ ▷j◁, ▷k◁ ▷h◁ ▷ʔ◁	▷t◁	▷o◁ ▷ʃ◁		▷r◁ ▷w◁ ▷f◁	▷u◁ ▷p◁

Figure 12.16.

The measurement of parameter $H\text{-}D_2$: the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.



The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameter $H\text{-}D_2$ for Informants A and B.

A	▷e◁	▷a◁	▷i◁ ▷h◁ ▷ʔ◁	▷o◁ ▷ʃ◁ ▷j◁ ▷k◁	▷r◁ ▷t◁	▷p◁	▷u◁	▷w◁	▷f◁
B	▷a◁	▷e◁	▷h◁ ▷ʔ◁	▷i◁ ▷t◁▷j◁ ▷k◁	▷ʃ◁ ▷o◁	▷r◁	▷p◁ ▷w◁	▷u◁	▷f◁

12.23. Figure 12.17

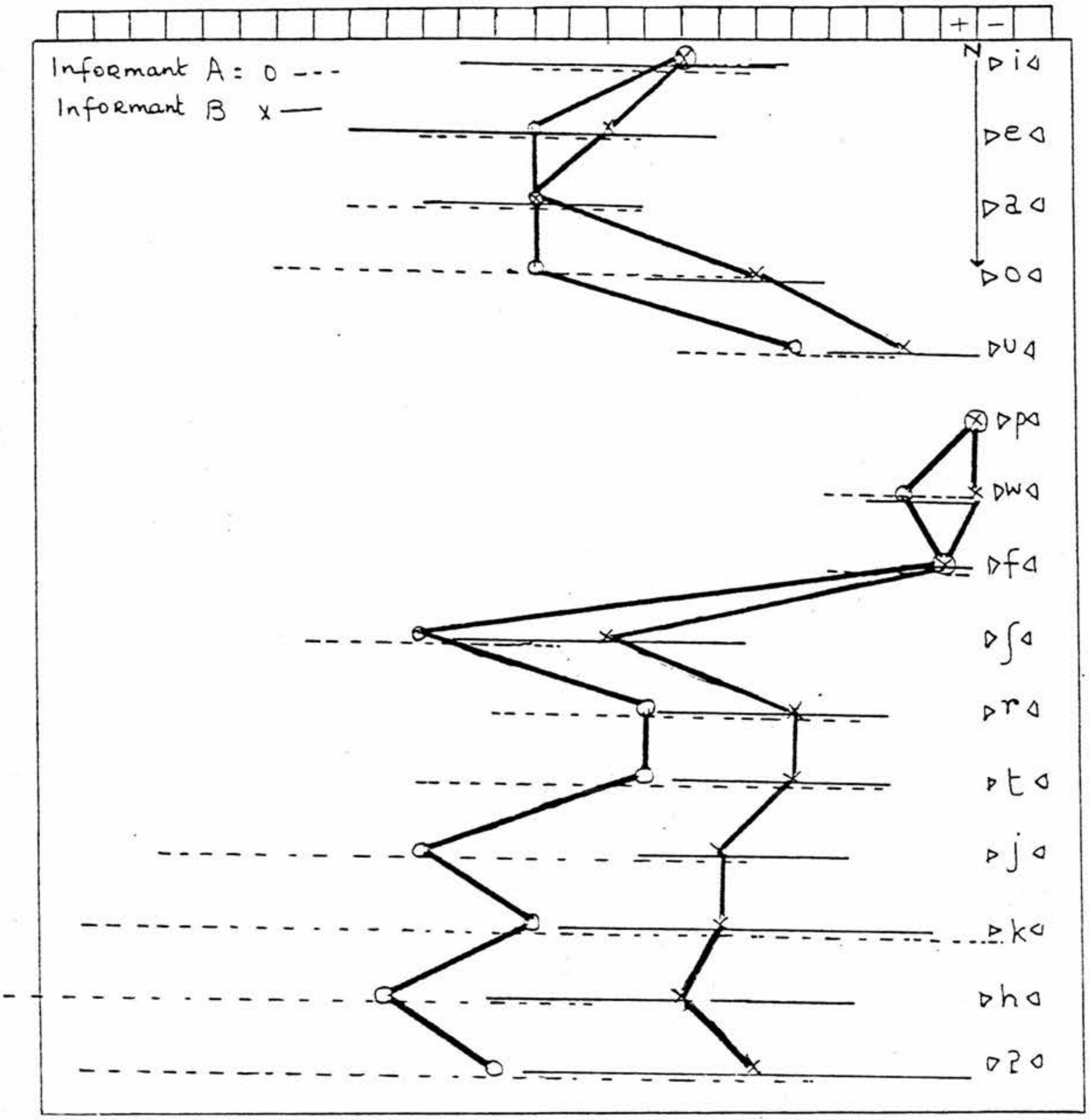
$A - X_L$: is the measurement of vertical lip separation, the vertical extent of opening or of closure of the interlabial space.

▷ p, w, f and u, u^w ◁ are again well differentiated at one end of the $A - X_L$ dimension, indicating no, or very little, separation of the lower from the upper lip. Considered along with the $X_L - B$ line, this tells us whether any inner-lip visibility (usually a result of curling the lower lip outwards and downwards) also occurs. Taken together, $A - X$ and $X - B$ show that ▷ p, f ◁ are differentiated by having less inner lip showing than do ▷ u, u^w, w ◁.

On its own, $A - X_L$ does not tell us very much about the type of interlabial space - although a large amount of vertical opening is usually accompanied by a correspondingly large amount of horizontal opening.

Figure 12.17.

The measurement of parameter A_2-X_L : the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.



The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameter A_2-X_L for Informants A and B.

A	▷h◁	▷ʃ◁ ▷j◁	▷ʔ◁	▷e◁ ▷a◁ ▷o◁ ▷k◁	▷r◁ ▷t◁	▷i◁	▷u◁	▷w◁	▷f◁	▷p◁	
B	▷a◁	▷e◁ ▷ʃ◁	▷i◁ ▷h◁	▷j◁ ▷k◁	▷o◁ ▷ʔ◁	▷r◁ ▷t◁	▷u◁	▷f◁	▷p◁ ▷w◁		

12.24. Figure 12.18

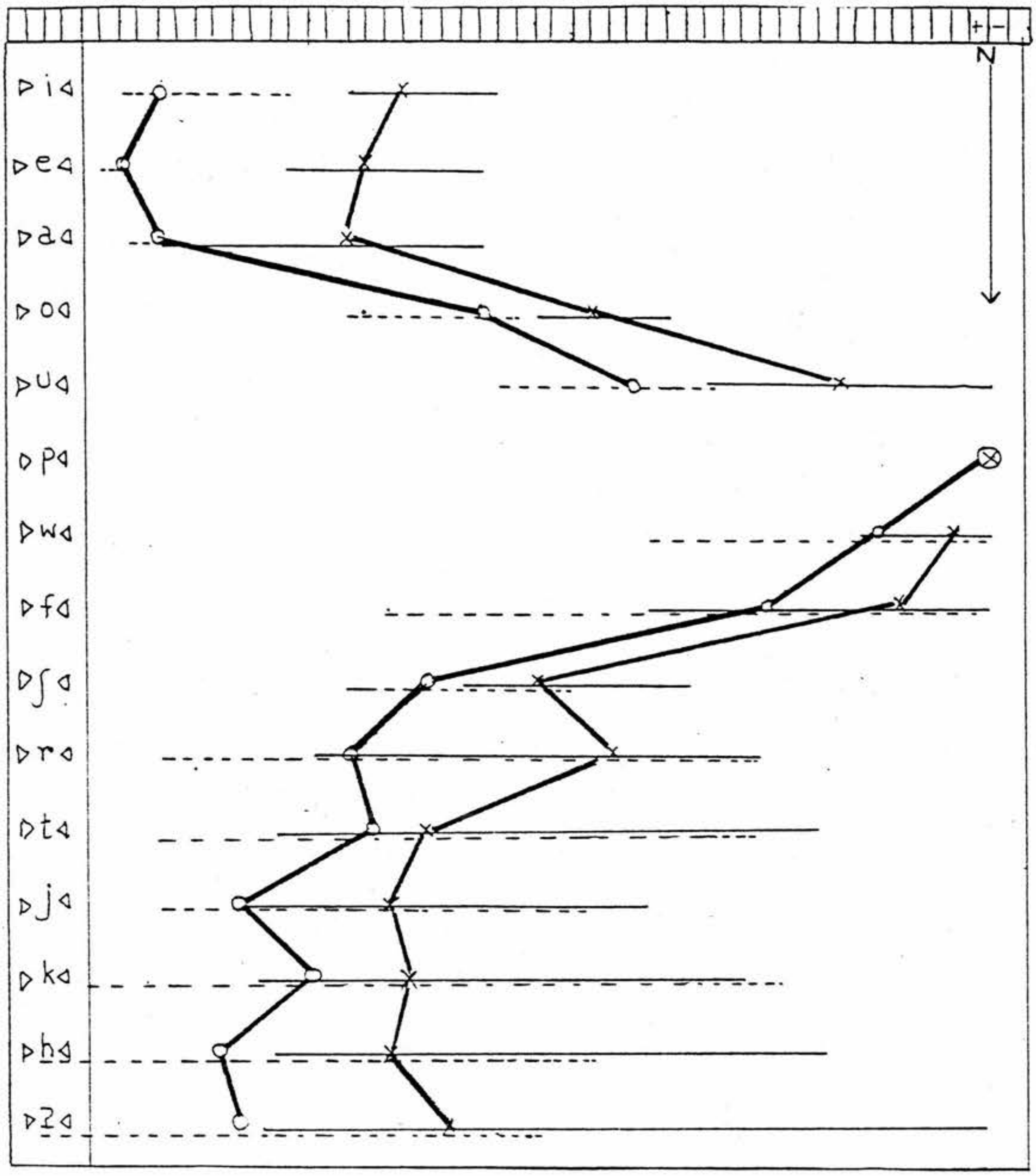
$Y_1 - Y_2$: is the dimension of horizontal expansion of the interlabial space.

This is another parameter with a high across-speaker reliability. $Y_1 - Y_2$ is the measurement of horizontal spreading of the lips from the corners simultaneous with some amount of vertical opening, i.e. separation of the lips.

▷p, f, w, u, u^w◁ are once again highly differentiated at one end of this parameter since there is very little lip separation for these sounds. ▷o, o:, ʃ◁ (and ▷r◁ for speaker B), ▷r, t◁ for speaker B are also characterized by being intermediate along the $Y_1 - Y_2$ line. The other sound types are not so easily distinguishable from each other, but certainly stand apart from the sounds with little or moderate horizontal opening. Considered along with the $A - X_L$ parameter, this tells us what overall lip-separation occurs. For sounds that have a reasonable amount of openness, teeth visibility and incisor separation provide additional distinguishable features.

Figure 12.18.

The measurement of parameter Y-Y : the average and the range of deviation from neutral in mm. for Informants A and B for each visual class.



The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameter Y-Y for Informants A and B.

A	▷e◁	▷ə◁	▷i◁	▷h◁ ▷ʔ◁	▷j◁	▷k◁	▷r◁	▷t◁	▷ʃ◁	▷o◁	▷u◁	▷f◁	▷w◁	▷p◁	
B	▷ə◁	▷e◁	▷j◁ ▷h◁	▷i◁ ▷j◁ ▷k◁	▷t◁	▷ʔ◁	▷ʃ◁	▷o◁	▷r◁	▷u◁	▷f◁	▷w◁	▷p◁		

12.25. **Figures 12.19A, 12,19B and 12.19C**

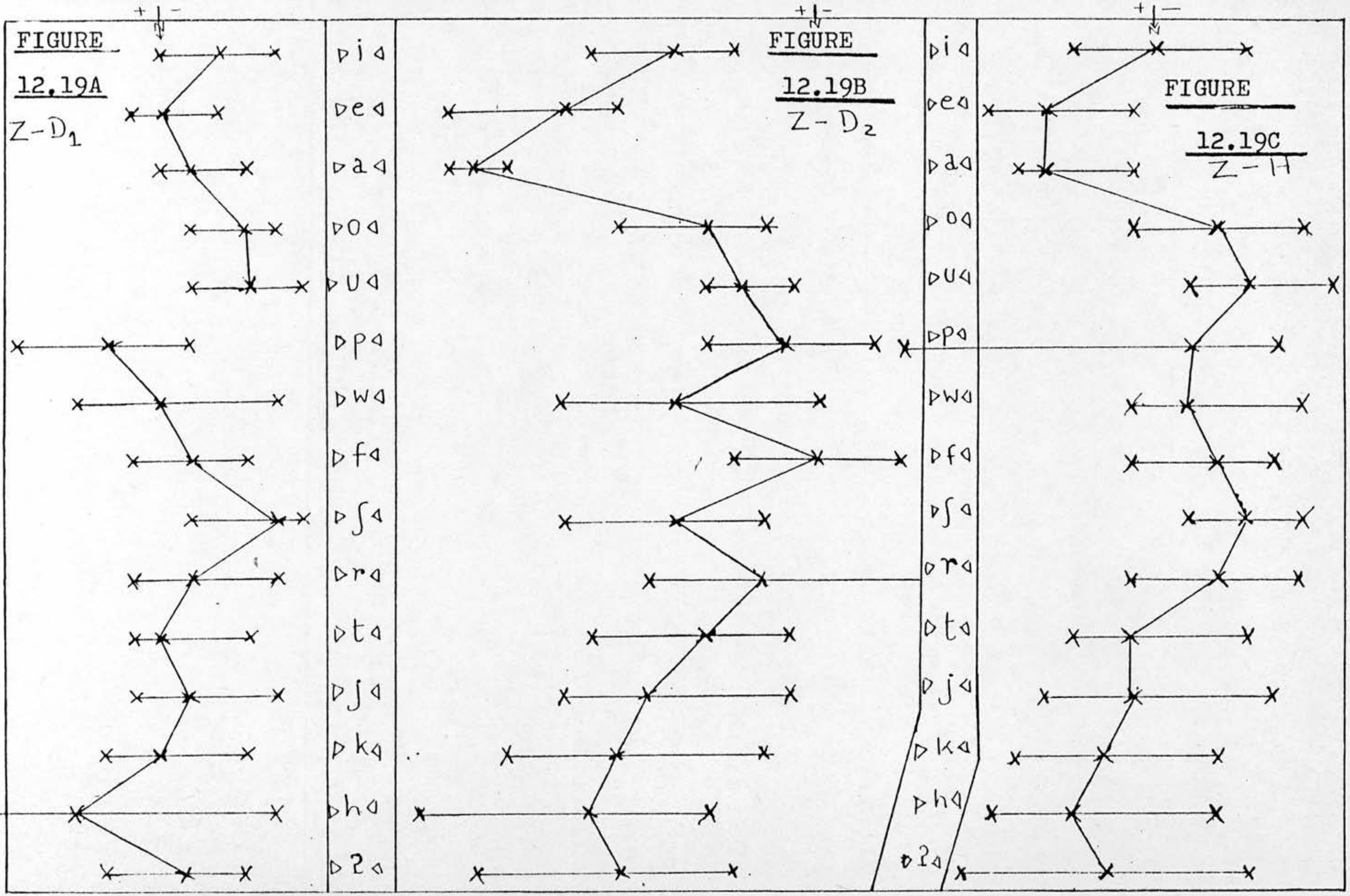
$Z - D_1$ and $Z - D_2$: are parameters related to the movement of the lips upwards and downwards as well as in the anterior-posterior direction if considered along with the $Z - H$ parameter shown in figure 12.19C which measures the movement of the corners of the lips especially in a horizontal and anterior-posterior direction.

We see then that ▷ʃ, o, o:, u, u^W ◁ are well differentiated as having the smallest $Z - D_1$ and $Z - H$ lines. The reason for this is that the upper lip is protruded outwards and upwards for these sounds, thus decreasing the $Z - D_1$ line. Since the corners of the lips also move forwards and slightly upwards, the $Z - H$ line also decreases. The $Z - D_2$ line increases because the lower lip also participates in the protruding movements outwards and either moves away and down from the lower lip or, additionally, curls down and under slightly. ▷a, a:, e, e: ◁ have larger overall openings (measured by means of the $Y_1 - Y_2$ line and the $A - X_L$ line considered together) as well as the largest $Z - D_2$ and $Z - H$ primarily because the opening is effected largely by jaw lowering so that $Z - D_1$ is not really modified.

▷h◁ is distinguishable by a larger modification along all three parameters, also reflecting greater movement of the upper lip upwards, the jaw and/or lower lip downwards and a slight spreading movement adding to the overall opening (since it also has a large $Y_1 - Y_2$ line).

▷f, r◁ and, to a lesser degree ▷p◁ also have a lesser modification of the $Z - D_2$ line and a decrease in the $Z - H$ line. Considered along with the $A - X$ line (especially for ▷f, p◁), we can relate this to a smaller overall and a small or moderate $Y - Y$ line.

Figures 12.19A, 12.19B and 12.19C. The measurement of parameters $Z\text{-}D_1$, $Z\text{-}D_2$, and Z-H: the average and the range of deviation from neutral in mm for Informant B for each visual class.



The rank-ordering of the prolonged sound visual classes from +neutral to -neutral for parameters Z-D_1, Z-D_2, and Z-H for Informant B only.

(i)	Z-D_1										
	▷h◁	▷p◁	▷e◁ ▷w◁ ▷t◁ ▷k◁	▷ə◁ ▷f◁ ▷r◁ ▷j◁ ▷ʔ◁	▷i◁	▷o◁ ▷u◁	▷ʃ◁				

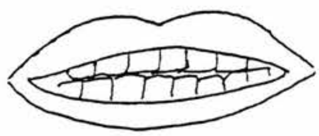
(ii)	Z-D_2										
	▷ə◁	▷e◁	▷h◁	▷k◁ ▷ʔ◁	▷j◁	▷i◁ ▷w◁ ▷ʃ◁	▷o◁ ▷t◁	▷u◁	▷r◁	▷p◁	▷f◁

(iii)	Z-H										
	▷e◁ ▷ə◁	▷h◁	▷k◁ ▷ʔ◁	▷t◁ ▷j◁	▷i◁	▷p◁ ▷w◁	▷o◁ ▷f◁ ▷r◁	▷u◁ ▷ʃ◁			

12.26. General description relating the visiograms to the measurements as shown in the tables and graphic presentation

A. Vowels

▷i, i:, iʲ◁ - These vowels are generally characterized by parted lips showing some part of both upper and lower teeth. There is some slight incisal separation for informant A's vowels in the labial and zero context, but no visible incisal separation for the vowels in the ▷ʃ◁ context, or for any of informant B's vowels. Vertical lip separation[1] increases for the ▷ʃ◁ context due to protrusion of both lips. This is much more marked for informant B than for informant A. I feel, however, that the unprotruded lips for informant A's vowels (especially for the first 4 sets) is due to the artificial situation of having to sustain the sound. Since these were also the first words on the list, the informant was not yet used to the set-up. This impression is confirmed by the fact that a ▷ʃ◁ context results in protruded lips for the vowels that he produced when the words were repeated without prolonging any of the individual sounds. The posture can be summarized visually as:

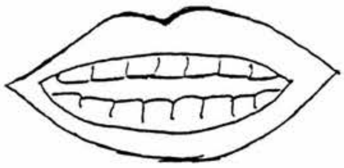


(See figure 12.21, vgm. 17a,b and figures 12.23, 12.24.)

▷e, e:◁ - There is a generally greater (than group ▷i, i:,◁ etc.) degree of lip separation and some incisal separation for these vowels; the tongue is

1. Lip separation always refers to vertical enlargement of the interlabial space.

also visible for Informant A's vowels. There is some upper lip movement downwards and inwards for informant B for the vowels in the zero and the labial contexts, as well as protrusion for the vowels in the ▷ʃ◁ context. The lower teeth are more extensively visible than for the ▷i◁ vowel set, but the tongue is not visible for informant B. There is more incisal separation for informant A than for informant B. The posture for these vowels can be summarized in visual terms as:

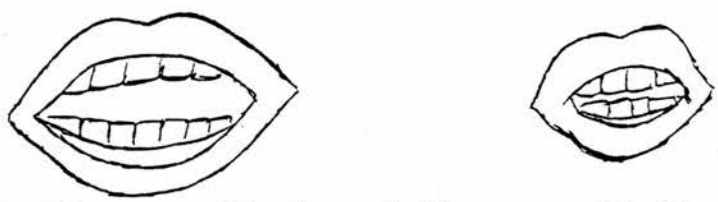


(cf. figure 12.21, vgm.18a,b and figures 12.23, 12.24.)

▷a, a:◁ - There are strong similarities between the postures for these vowels and for the ▷e◁ vowel set, except for the tongue being visibly lower down at the front for informant A.
There is little if any further obvious difference except for a slightly greater incisal separation (more for informant A than for informant B) probably due to jaw lowering and lowering of the lower lip, and resulting in greater visibility of both upper and lower teeth. Protrusion in the ▷ʃ◁ context is obvious for informant B only. The posture for the ▷a◁ vowel set can be summarized as follows in visual terms:

(cf. figure 12.21 , vgm.19a,b, and figures 12.23, 12.24.)

▷o, o:◁ - These vowels are characterized by a rounded lip shape and greater degree of lip protrusion for all contexts. For informant A only, there is a greater degree of lip separation, with greater upper and lower teeth, and sometimes tongue, visibility, with marked protrusion mostly for the zero context. For informant B there is a smaller lip separation than there is for any of the other vowels, except ▷ u ◁ and ▷ u^{w}◁. On the whole, there is a greater degree of teeth to lip depth (i.e. from outer surface of teeth to outer surface of lips), since there is more movement outwards in the anterior-posterior direction, and a resulting greater inner lip visibility for both informants. The posture for these vowels is summarized visually as follows, distinguishing between the general posture for the two informants:



(cf. figure 12.22 , vgm.20a,b and figures 12.23, 12.24.)

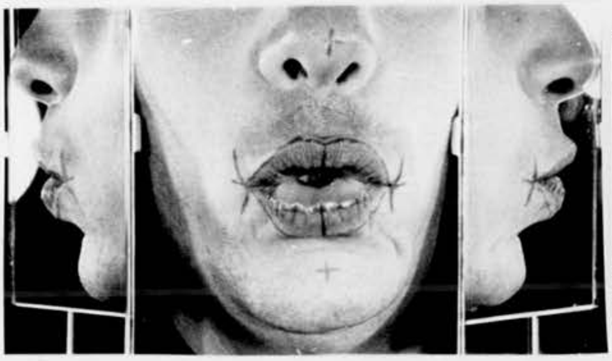
▷u, u^{W}◁ - There is a great similarity between the protrusion gesture for this vowel set and the previous one (▷o◁ and ▷o:◁) for informant B, but not so much for informant A. However, the posture for this vowel set is very similar for the two informants. There is hardly any lip separation; the teeth are not visible at all for informant B and only slightly visible for informant A. The greater degree of protrusion also results in greater inner lip visibility for informant A, and a smaller degree of horizontal lip measurement than for the other vowels, for both informants. The posture for this vowel set can be summarized visually as:

(cf. figures 12.20, vgm.14 to 16 a,b, figure 12.22, vgm. 21 a,b, and figures 12.23 and 12.24)

Figure 12.20 Visiograms 14a to 16a; 14b to 16b.
Prolonged articulation of /ʊ^{w}/

Vgm 14a /ʊ^{w}/ in /bʊ^{w}t/

Vgm 14b /ʊ^{w}/ in /bʊ^{w}t/



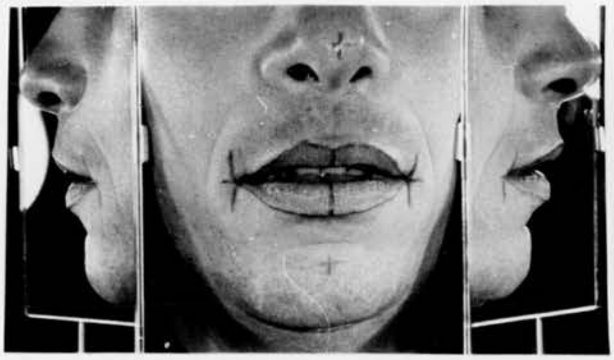
Vgm 15a /ʊ^{w}/ in /ʊ^{w}za/

Vgm 15b /ʊ^{w}/ in /ʊ^{w}za/

Vgm 16a /ʊ^{w}/ in /ʃʊ^{w}ʃa/

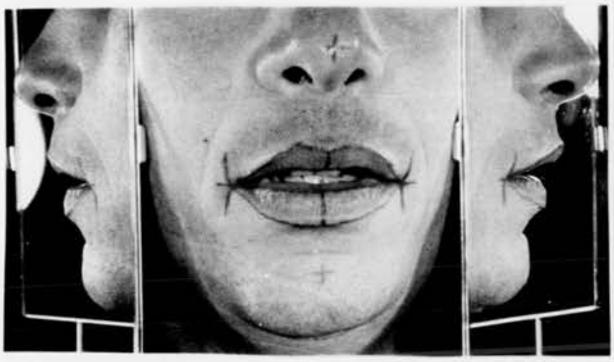
Vgm 16b /ʊ^{w}/ in /ʃʊ^{w}ʃa/

Figure 12.21 Visiograms 17a to 19a, 17b to 19b
Prolonged /t/ preceding different vowels.



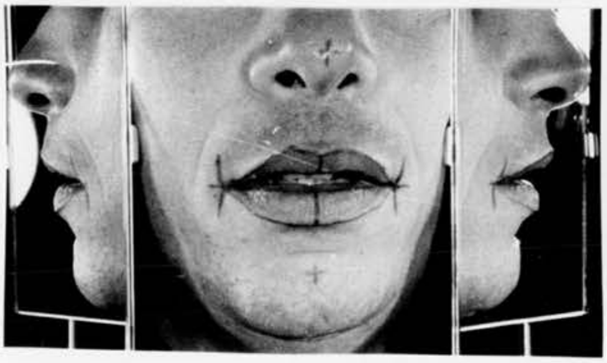
Vgm 17a /t/ in /ṯiˀtlu/

Vgm 17b /t/ in /ṯiˀtlu/



Vgm 18a /t/ in /te:ma/

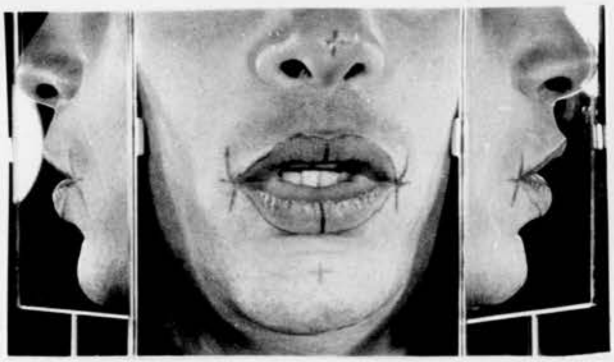
Vgm 18b /t/ in /te:ma/



Vgm. 19a /t/ in /ṯa:ta/

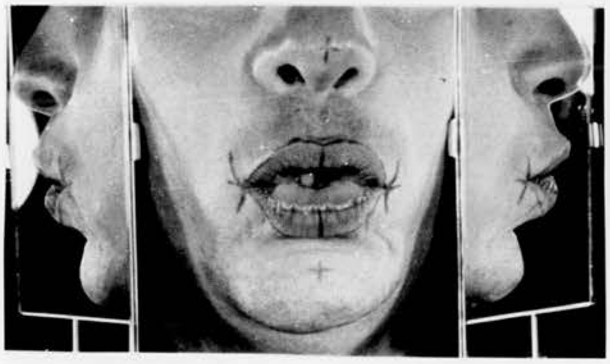
Vgm 19b /t/ in /ṯa:ta/

Figure 12.22 Visiograms 20a, 21a, 20b, 21b
Prolonged /t/ preceding different vowels



Vgm 20a /t/ in /to:ma/

Vgm 20 b /t/ in /to:ma/



Vgm 21a /t/ in /tʊʷt/

Vgm 21b /t/ in /tʊʷt/

FIGURE 12.23. Tracings of life-size visiograms of informant A
p. 1. - Vowels -

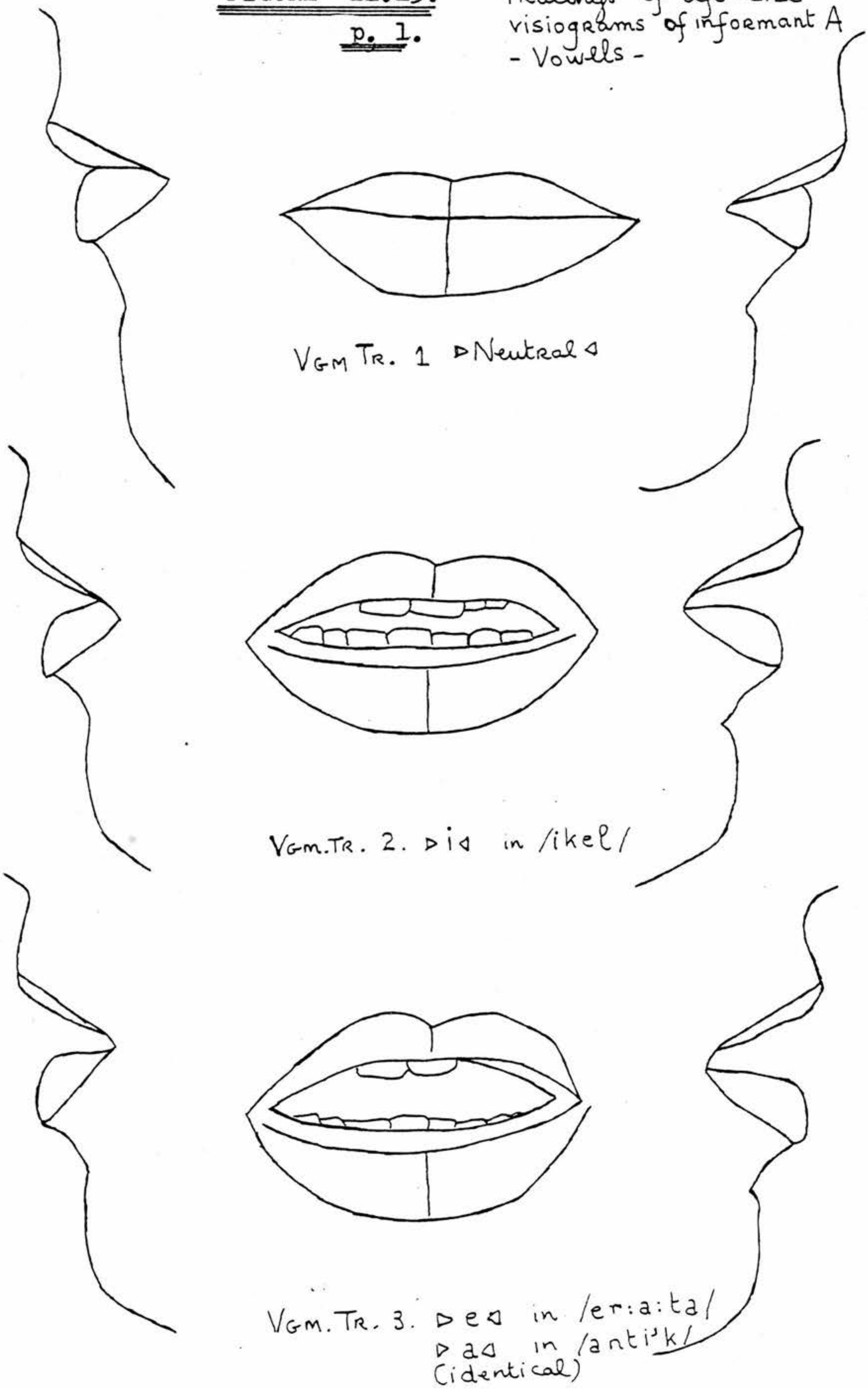
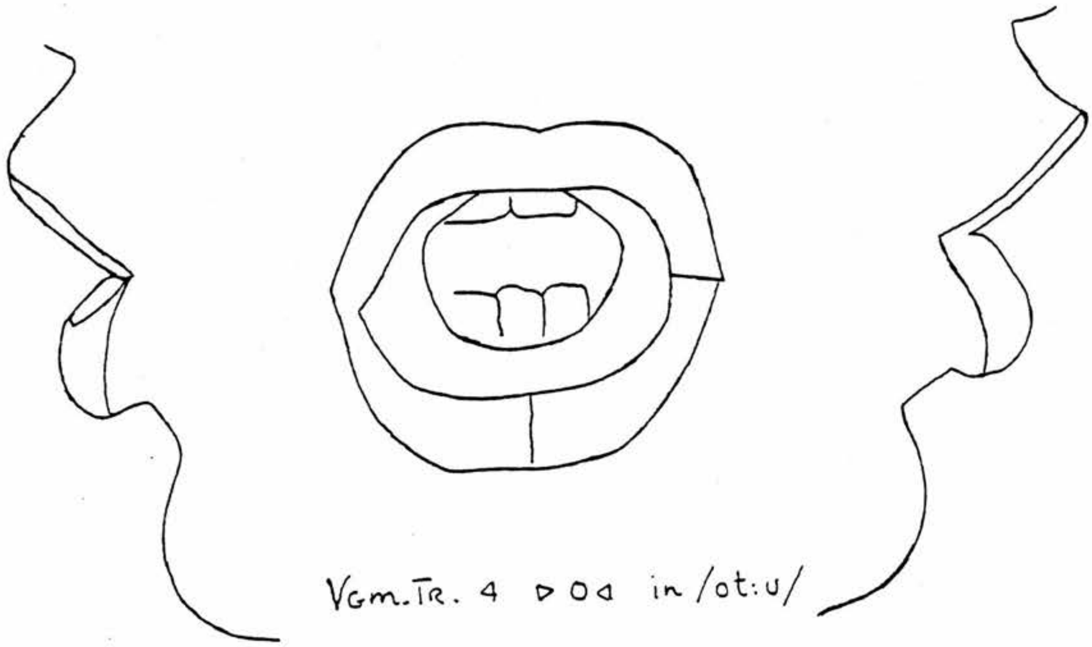
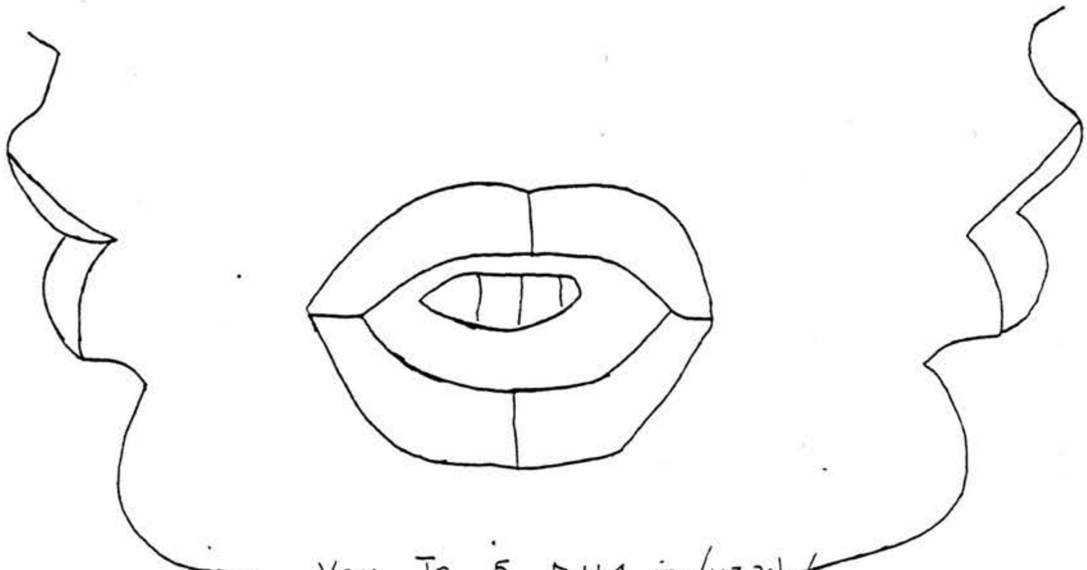


FIGURE 12.23. p. 2. (VGM. TR.-VOWELS)



VGM.TR. 4 ▷O◁ in /ot:u/



VGM. TR. 5 ▷U◁ in /uza:h/

FIGURE 12.24 p. 1.

Tracings of life-size visiograms
of Informant B
-VOWELS-

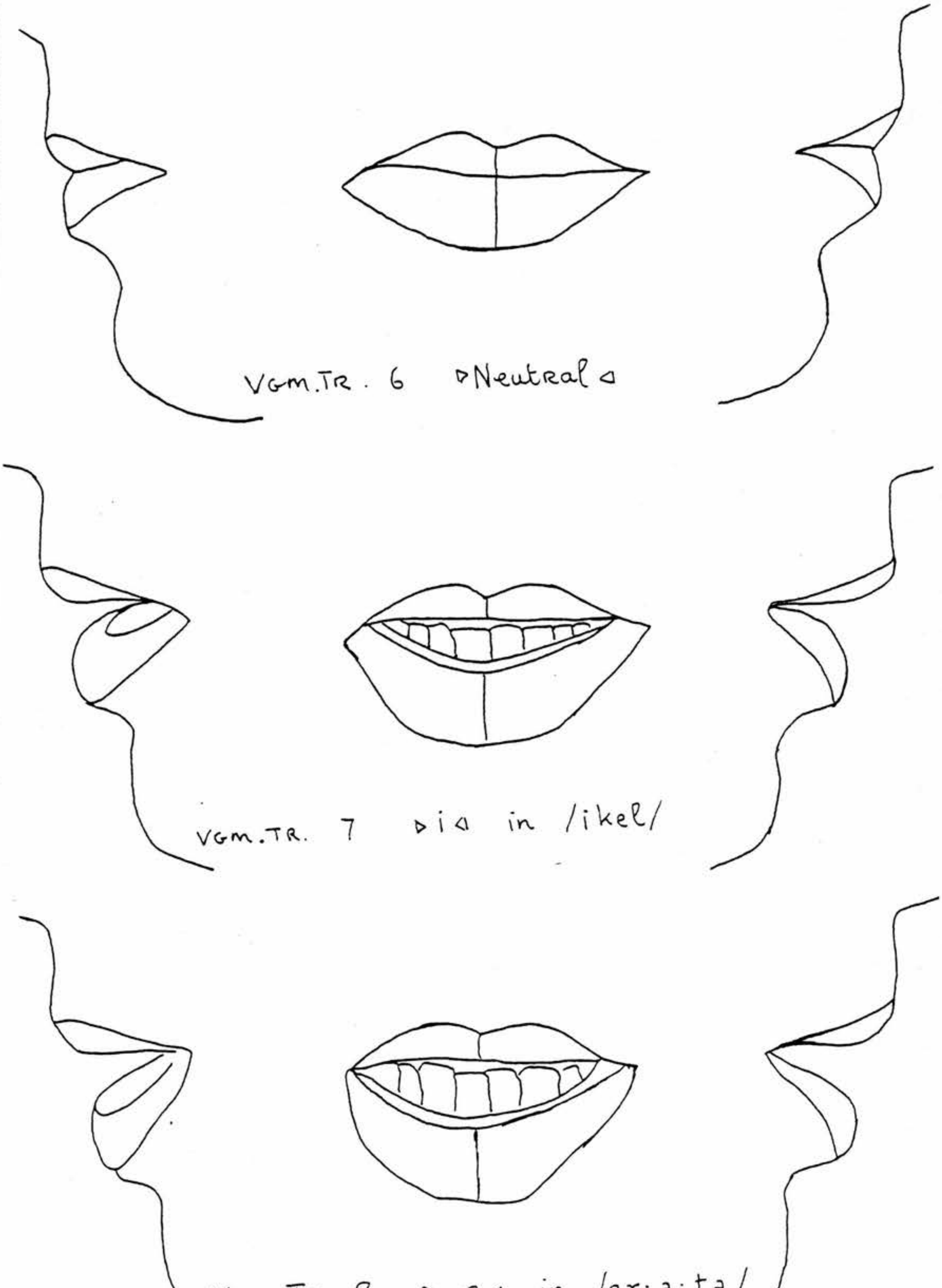
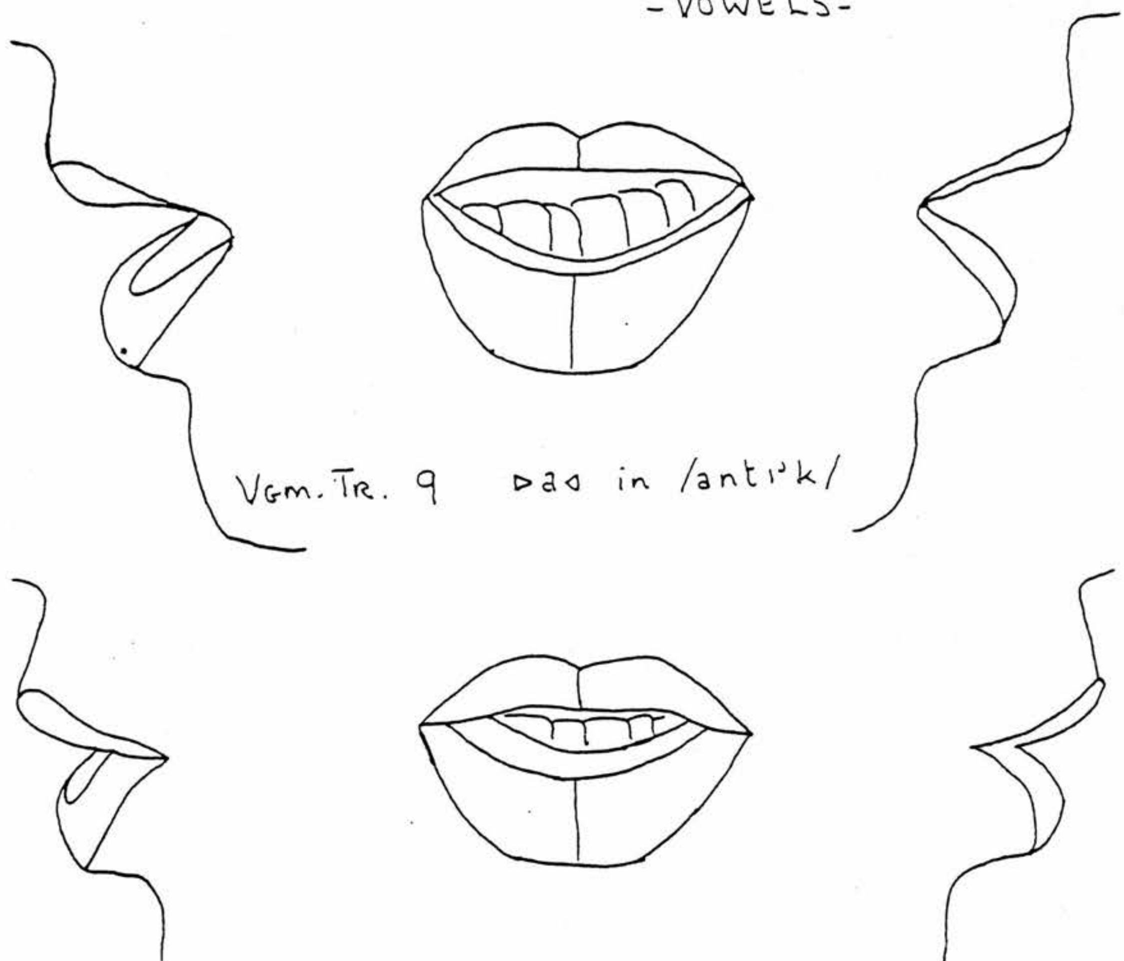


FIGURE 12.24 p. 2.

Tracings of life-size visiograms of Informant B
- VOWELS -



12.27. Informant B's vowels are related to each other on $A_2 - X$, the parameter related to vertical expansion of the interlabial space as follows (from smallest to greatest on the scale):

▷u o i e a◁

(see figure 12.17). This pattern is consistent over the following parameters, as well: $E_1 - E_2$, which measures the overall frontal height; $H - D_1$ and $H - D_2$, which measure the distance from the corner of the mouth to the outer vermilion border of the upper lip and the lower lip respectively, and is related to protrusion and the extent to which the anterior plane meets the posterior plane, if the H - D measurements are related to those measuring horizontal expansion and contraction of the lips; $A_2 - X$, which measures the distance between the upper and lower lip, i.e. the vertical separation of the lips, usually with correspondingly more teeth visibility as the separation increases; and Y - Y , which measures the horizontal extent of the inter-labial space, which must therefore be considered along with $A_2 - X$.

The pattern for informant A is almost identical, except that his vowel ▷a◁ and ▷e◁ are reversed in their relationship along these dimensions, and the vowels of the ▷o◁ set have a larger interlabial space than the ▷u◁ and ▷i◁ vowels, and a smaller overall height than the ▷a◁ and ▷e◁ vowel sets. This is explained by the difference described above: the ▷o◁ vowels are produced by informant B with a markedly greater degree of jaw lowering. Thus, there is no difference for informant A in vertical lip separation for the vowels ▷e◁, ▷a◁ and ▷o◁. For informant B, the relationship holds consistently over the three additional parameters not considered for informant A:

$Z - D_1$ ▷u o i a e◁ (with the reversal of ▷a◁ and ▷e◁)

$Z - D_2$ ▷u o i e a◁

$Z - H$ ▷u o i e a◁

The ▷a - e◁ reversal is related to a greater degree of upper lip raising and protrusion for ▷a◁. We find a relationship as that in $Z - D_1$ along $E_1 - A_1$.

The difference in lip separation between the speakers is at least partly explained by the different physical structure of their lips. This difference is reflected quite clearly in the extent to which the inner lip is visible during vowel articulation. The vowels range along $X - B_1$ (inner lip visibility) as follows:

Informant A : ▷i e a o u◁

Informant B : ▷i e u a o◁

The inner lip is visible for informant B only when some degree of outer protrusion occurs. With a minimal degree of lip separation for ▷u◁ and with lip separation without protrusion for ▷i◁ and ▷e◁, there is no inner lip exposure. However, for informant A, there is some inner lip exposure even in the neutral-closed position (see figure 12.4). The lower lip differences are also reflected in the fact that along $B_1 - B_2$ (lower lip visibility) is the same for all informant B's vowels, but differ slightly for informant A's.

The vowels are produced with the same pattern for lip spreading by both informants. Thus, the vowels are ranged as follows, along $C_1 - C_2$ (related to spreading from the corners of the lips):

▷u o a e i◁

The difference in pattern along $D_1 - D_2$ is explained by the fact that ▷o◁ is produced with more lip separation for informant A than for informant B.

Figure 12.25.

The rank-ordering of the prolonged sound vowel visual classes from -neutral to +neutral for each of the 15 parameters for Informants A and B.

	Informant A	Informant B
$E_1 - E_2$	u < i < o < a < e	u < o < i < e < a
$E_1 - A_1$	o < u < a < i < e	u = o < i = a < e
$B_2 - E_2$	u = o < a < e = i	u < o = e < i < a
$A_1 - A_2$	i = e = a < o < u	i = e = a < o < u
$B_1 - B_2$	a = u < o = e = i	No difference
$X - B_1$	i = e = a < o < u	i = e = u < a < o
$C_1 - C_2$	o = u < e = a < i	u < o < a < e = i
$D_1 - D_2$	i < u < e = a < o	i < u < o = e < a
$H - D_1$	u < o < i < e = a	u < o < i < e < a
$H - D_2$	u < o < i < a < e	u < o < i < e < a
$A_2 - X$	u < i < e = a = o	u < o < i < e < a
$Y_1 - Y_2$	u < o < i < a < e	u < o < i < e < a
$Z - D_1$	-	o = u < i < a < e
$Z - D_2$	-	u < o < i < e < a
$Z - H$	-	u < o < i < e = a

12.28.

B. Consonants

▷p◁ - The most dominant visual feature of this class of sounds is the firm upper to lower lip contact or closure for both speakers, which is related to a zero value on the $A_2 - X$ and $X - B_1$ dimensions. There is no visible jaw lowering and therefore no marked lengthening in the overall vertical dimensions, and ▷p◁ therefore figures on the low end of the vertical parameters $E_1 - E_2$, and D_1 and D_2, with a correspondingly longer $E_1 - A_1$ and $B_2 - E_2$, which are shortened from neutral by lip raising and lowering respectively in the production of other sounds. The shape of the lips in the horizontal $C_1 - C_2$ dimension, as well as in the anterior-posterior dimension, as seen in relating the $Z - H$ line with the horizontal plane varies to a noticeable extent, according to context.

The closure for this sound is recognisably different from the neutral closure for both speakers mostly because the tension is visible in the creases along the lips, as well as in the disappearance of the inner vermilion border (marked with the surgical pen) inside the closure.

This sound is therefore visually distinguishable from other sounds and from the neutral non-speech posture; moreover, other features that change according to context point to the fact that the articulation must be {▷p◁ + Vowel} or {▷p◁ + consonant} or {consonant + ▷p◁}. **(cf. Figures 12.7, 12.8, p.271, 272)**

▷w◁ - The most dominant visual characteristic of this sound is the protrusion of both lips, such that the outer rims of the lips form a circle-like shape with a very tiny interlabial space. This shape can be summarized visually as:

This shape makes ▷w◁ visually distinctive across all contexts. The interlabial space is so small, that it cannot be measured for several of the ▷w◁ visiograms of speaker B. There is a relatively greater degree of lower inner lip visibility for speaker A than for speaker B. The position of ▷w◁ on the low end of the anterior-posterior dimensions $H - D_1$ and $H - D_2$ from the lateral view, and on the low end of the horizontal dimension $C_1 - C_2$, $Y_1 - Y_2$, and the vertical dimension $A_2 - X$ characterize it very consistently. Protrusion does not necessarily lead to a larger H - D line, since the measurement from H starts at the visible corner. In this case, the corners are introverted, but the lateral view shows a visibly protruded angle of the lips in relation to the jaw:

It does not undergo obvious changes as a result of context. (**Fig. 12.27, p.333,** vgm. 22a,b.)

▷f◁ - This sound is very easily recognised from a number of features that can - but do not always - occur simultaneously in all contexts. One very stable feature is the relationship of the upper lip to the lower lip in the anterior-posterior relationship for both speakers: the upper lip is protruded forward and raised away from the upper teeth, increasing the upper teeth-to-lip depth. The lower lip is retracted so that the upper incisors come in contact with it, fairly near the vermilion border or on the inner lip. However, in some contexts, the teeth are not at all visible, especially when they rest on the inner lip since the outer lower lip is often raised upwards as it retracts backwards, thus hiding the teeth, especially if the upper lip is protruded forwards without curling upwards. The jaw is also retracted backwards. ▷f◁ is thus characterized along various parameters. The overall frontal height along $E_1 - E_2$ is near to neutral. It features on the low side on the $E_1 - A_2$ line, because of the upper lip protruding outwards and on the $X - B_1$ line since the inner **lip is usually** covered by the teeth. ▷f◁ features high on the $B_2 - E_2$ line since the lower lip is not protruded and, in some cases is pulled upwards and inwards, thus smoothing or lengthening the distance to the chin. It is on the low side of the lines $A_1 - X$ because there is only very little interlabial space visible from a frontal view; it also features low on the $Y_1 - Y_2$, $D_1 - D_2$, $H - D_1$ and $H - D_2$ lines for the same reason. However, the lips are more spread for informant B than for informant A, so that ▷f◁ lies at a diametrically opposed end of the $C_1 - C_2$ line. This does not affect the horizontal extent of the interlabial space. Visually, ▷f◁ can be summarized as follows:

frontally:  and laterally: 

(**Fig.12.27, p.333,** vgm. 23, 24 a,b.)

▷ʃ◁ - This is also a consistently easily identifiable sound across all contexts for both speakers. It is characterised by several features, usually occurring simultaneously, though some features are modified in degree in some contexts. There is a great degree of both upper and lower front teeth visibility with no (or minimal) incisal separation[1] - thus no extensive jaw lowering. Thus ▷ʃ◁ features at the high end of both the A_2 - X and the D_1 - D_2 lines which relate to the extent of lip separation, and therefore interlabial space. Since there is a good degree of protrusion of both lips with additional upper lip raising and lower lip lowering, there are other parameters on which ▷ʃ◁ also features dominantly. These are: small E_1 - A_1 and B_2 - E_2 lines, because of the upper lip raising and lower lip lowering; a greater degree of inner lip visibility, as seen in the longer X - B_1 line; a moderate Y_1 - Y_2 line indicating its being not too spread but not very contracted except insofar as it is necessary to obtain a maximal lip separation and simultaneous curling of the lips away from the teeth. Theoretically, ▷ʃ◁ should feature on the longer end of the H - D_1 and H - D_2 lines, but, because of the overall expansion of the lips away from the teeth, these lateral lines are misleading because there is a straighter horizontal plane frontally so that the points D_1 and D_2 are in fact further away from the mid line of the lips than for other sounds, i.e. the line from the corners of the mouth to the most anterior point of the lips is much less than it could be with the same degree of close protrusion. These features can be summarized visually as follows:

(Fig. 12.28, p.334, vgm. 25 a,b.)

1. i.e. They are not visibly separated.

▷r◁ - This class is certainly more influenced by the context than ▷ʃ◁ is, although these sounds could be classed together because of similar features. There seems to be a great deal of speaker variation in the degree of similarity between ▷r◁ and ▷ʃ◁. Speaker A's lip posture for ▷r◁ does not have as marked a degree of protrusion as that of speaker B, (See lateral view, in fig. 12.28, p334) except in the case of ▷r◁ preceding an ▷o◁ or ▷u◁ vowel. In fact, B's ▷r◁ lip posture is fairly recognizable across contexts. However, speaker A's ▷r◁ lip posture could easily be confused with the posture for the following vowel. It is interesting, however, that there is more lip protrusion for his articulation of ▷r◁ when the sound is not prolonged (as on the video recording of the list read without prolonging articulation of any of the sounds).

▷ɽ◁ is characterized along the same parameters as ▷ʃ◁ but not as easily identified on any of these since for informant A it never lies at the extreme end of these parameters, except for inner lip visibility ($X - B_1$) and the $H - D$ lines, where it lies fairly close to ▷ʃ◁. For informant B, however, ▷r◁ lies much closer to ▷ʃ◁ except for the dimensions $B_2 - E_2$, $D_1 - D_2$, $A_2 - X$ and $Z - D_2$. It is therefore distinguishable from ▷ʃ◁ along the parameters related to vertical lip separation and lower lip lowering. It is sometimes possible to see the underside of the tongue for speaker A during this retroflex articulation. The place of ▷r◁ along the $C_1 - C_2$ and $D_1 - D_2$ dimensions is important in distinguishing it by the features of less lip spreading and a smaller vertical lip shape (from a lateral view) from the less easily identifiable sounds described below. The identifiability of this sound depends on the context.

 (A)

 (B)

(cf. Fig.12.28, p334, vgm. 26a,b.)

The sounds ▷t j k h ʔ◁ are not easily distinguishable from each other, or from the▷i, e◁ and▷a◁ vowel sets, by any conspicuous visible feature along any particular parameter. They do not share any of the features that characterize the sounds just described - with the exception of ▷r◁. This is an important point in that these 5 sound-types are at least identifiable as a class from the previous classes of consonant sounds. The question is whether we can further subdivide this into smaller groups. The general feature of these sounds is that they are always at the higher end of the line along all the parameters. They are thus recognized as having overall more vertical and horizontal lip separation compared with the other consonants, with the exception of ▷ʃ◁. This is reflected in their place on the $Y_1 - Y_2$, $A_2 - X$ lines. They are also characterized by more horizontal lip spreading and lack of any movement in the anterior-posterior direction, unless influenced by the context. There are also some consistent differences between these sounds along various parameters. The problem arises not so much because there is no consistent difference, but because the difference occurs along the same parameters and is, therefore, one of degree and not of kind.

▷t◁ has the smallest lip and incisor separation compared to the other sounds in this group. When ▷t◁ is articulated, the lower teeth are visible for both speakers; the upper incisors are sometimes visible for informant A, but not for informant B. There is markedly greater lip and incisor separation as seen directly from the visiograms, and reflected in the A_2 - X and D_1 - D_2 lines, as follows for these sounds:

	Speaker A	Speaker B
A_2 - X	t k ʔ j h	t ʔ j k h
D_1 - D_2	t ʔ k j h	t j k ʔ h

A greater degree of lip separation for these sounds entails a greater degree of jaw lowering: there is no independent lip movement. The five sounds are ranged close to each other along most of the parameters. ▷t◁ or, alternatively ▷j◁, occupied the lower end of the range, whereas ▷ʔ◁ and ▷h◁, but especially ▷h◁ almost consistently occupy the highest end along all the parameters. ▷h◁ and ▷ʔ◁ are usually on the same point along the low to high scale and cannot be distinguished from each other in any way. ▷k◁ can be distinguished from ▷h◁ and ▷ʔ◁ and often is closer to ▷j◁ in degree of lip separation. However, there is a great deal of context-dependency for all of these sounds, and it would only be possible to distinguish two subgroups: ▷t j k◁ and ▷h ʔ.◁

Figure 12.26 shows the relationship of the consonant sounds to each other along the parameters accounted for.

These sounds cannot be distinguished visually from the vowels of the ▷i e◁ and ▷a◁ group, and they take on the visually distinctive features of the ▷o◁ and ▷u◁ type vowels. Taken in isolation, they are certainly more distinguishable from ▷e◁ and ▷a◁ than they are from ▷i◁, but they occur very close to these vowels along all the parameters considered. Their distinguishability is probably lost completely in context, i.e. to identify them, the lipreader must make use of cues other than features along these parameters, cues such as the timing of events, for example. (cf. Fig. 12.22, p316,vgm. 20 to 21, a,b, Fig.12.28, 12.29, p.334-5, vgm. 27 to 31 a,b.)

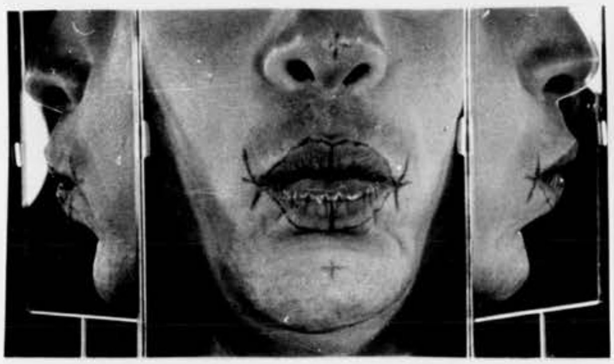
It should be noted here that a great deal of what has been described as visual characterizing features correspond to what a phonetician would describe when making an impressionistic notation of a language.

Figure 12.26.

The rank-ordering of the prolonged sound consonant visual classes from -neutral to +neutral for each of the fifteen parameters for Informants A and B.

Consonant Patterns	Informant A	Informant B
$E_1 - E_2$	f=p<ʃ<w=t<r<k<j<h=ʔ	f<p<r<ʃ=t<w=j<h=ʔ
$E_1 - A_1$	ʃ<f=j<w=r=t=k<h=ʔ<p	ʃ<f=r=k<t=j<w=h=ʔ<p
$B_2 - E_2$	ʃ<j<t=k=h=(ʔ)<r<w<f=p	ʃ<k=h=ʔ<w=r=t=j<p<f
$A_1 - A_2$	j<Rest	Rest<p=f=ʔ<w
$B_1 - B_2$	ʃ=p=k<f=r=t=j=h=ʔ<w	p<f=r=j<ʃ k=t=h=ʔ<w
$X - B_1$	p<f<ʃ=r=t=ʔ<w=j=k=h	p<f<Rest<ʃ=j
$C_1 - C_2$	w<f<r<p=ʃ=j=k<h=ʔ<t	w<p=ʃ<r=ʔ<f=t=k=h<j
$D_1 - D_2$	p<f=r<w<t<ʔ<k<j=ʃ<h	p<f<r<t<w<j=k<ʔ<h=ʃ
$H - D_1$	p<w<f<t=ʃ<r=j<k<h=ʔ	p<w=f<r<ʃ<t<j=k=h=ʔ
$H - D_2$	f<w<p<r=t<ʃ=j=k<h=ʔ	f<w=p<r<ʃ<t=j=k<h=ʔ
$A_2 - X$	p<f<w<r=t<k<ʔ<ʃ=j<h	p=w<f<r=t=ʔ<j=k<h<ʃ
$Y_1 - Y_2$	p<w<f<ʃ<t<r<k<j<h=ʔ	p<w<f<r<ʃ<ʔ<t<k<j=h
$Z - D_1$		ʃ<f=r=j=ʔ<w=t=k<p<h
$Z - D_2$		f<p<r<t<w=ʃ<k=ʔ<h
$Z - H$		ʃ<f=r<p=w<t=j<k=ʔh

Figure 12.27 Visiograms 22a to 24a, 22b to 24b
Prolonged articulation of /w/, /f/



Vgm 22a /w/ in /twiˀla/

Vgm 22b /w/ in /twiˀla/

Vgm 23a /f/ in /fwi:t/

Vgm 23b /f/ in /fwi:t/

Vgm 24a /f/ in /sewfu/

Vgm 24b /f/ in /sewfu/

Figure 12.28

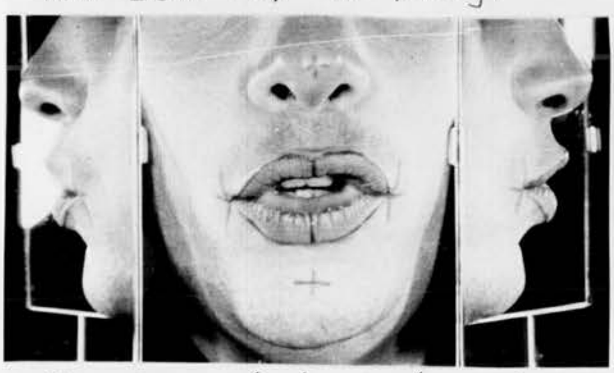
Visiograms 25a to 28a, 25b to 28b
Prolonged articulation of /ʃ/, /r/ and /j/

Vgm 25a /ʃ/ in /ʃa:r/

Vgm 25b /ʃ/ in /ʃa:r/

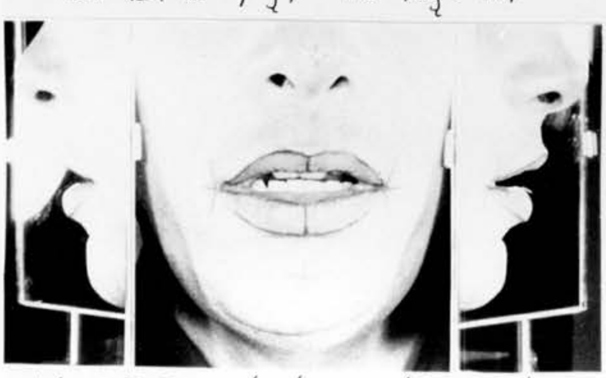
Vgm 26a /r/ in /re:ʃ/

Vgm 26b /r/ in /re:ʃ/



Vgm 27a /j/ in /djuʷn/

Vgm 27b /j/ in /djuʷn/



Vgm 28a /j/ in /ɫiwja/

Vgm 28b /j/ in /ɫiwja/

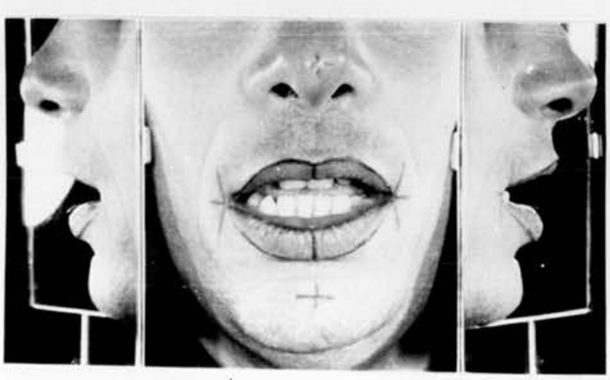
Figure 12.29 Visiograms 29a to 31a, 29b to 31b

Vgm 29a /k/ in /fki:ren/

Vgm 29b /k/ in /fki:ren/

Vgm 30a /h/ in /fhalʔi/

Vgm 30b /h/ in /fhalʔi/



Vgm 31a /ʔ/ in /tʔ̱i:ʔ/

Vgm 31b /ʔ/ in /tʔ̱i:ʔ/

FIGURE 12.30 p. 1.

Tracings of life-size visiograms of Informant A
— CONSONANTS —

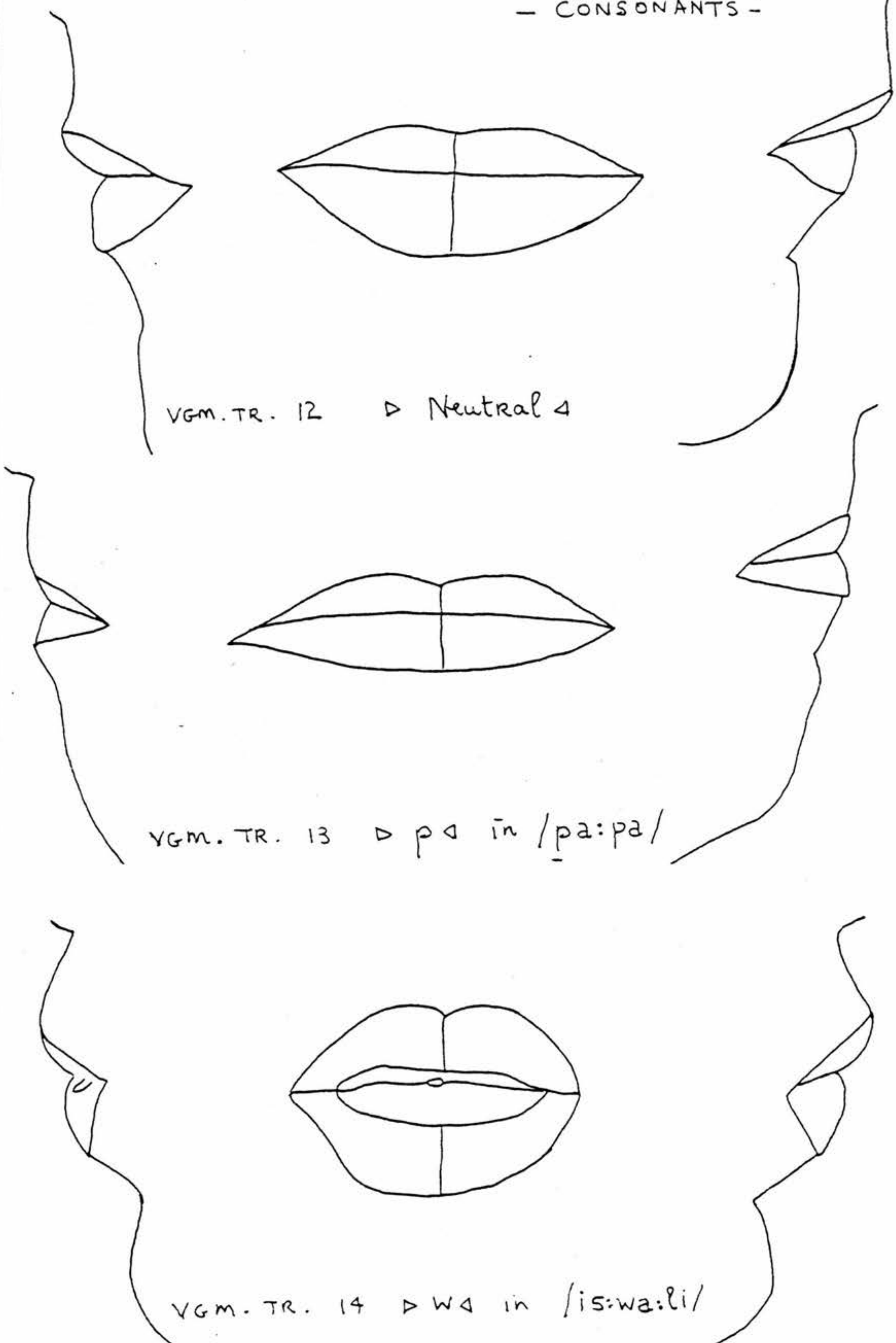


FIGURE 12.30 p. 2.

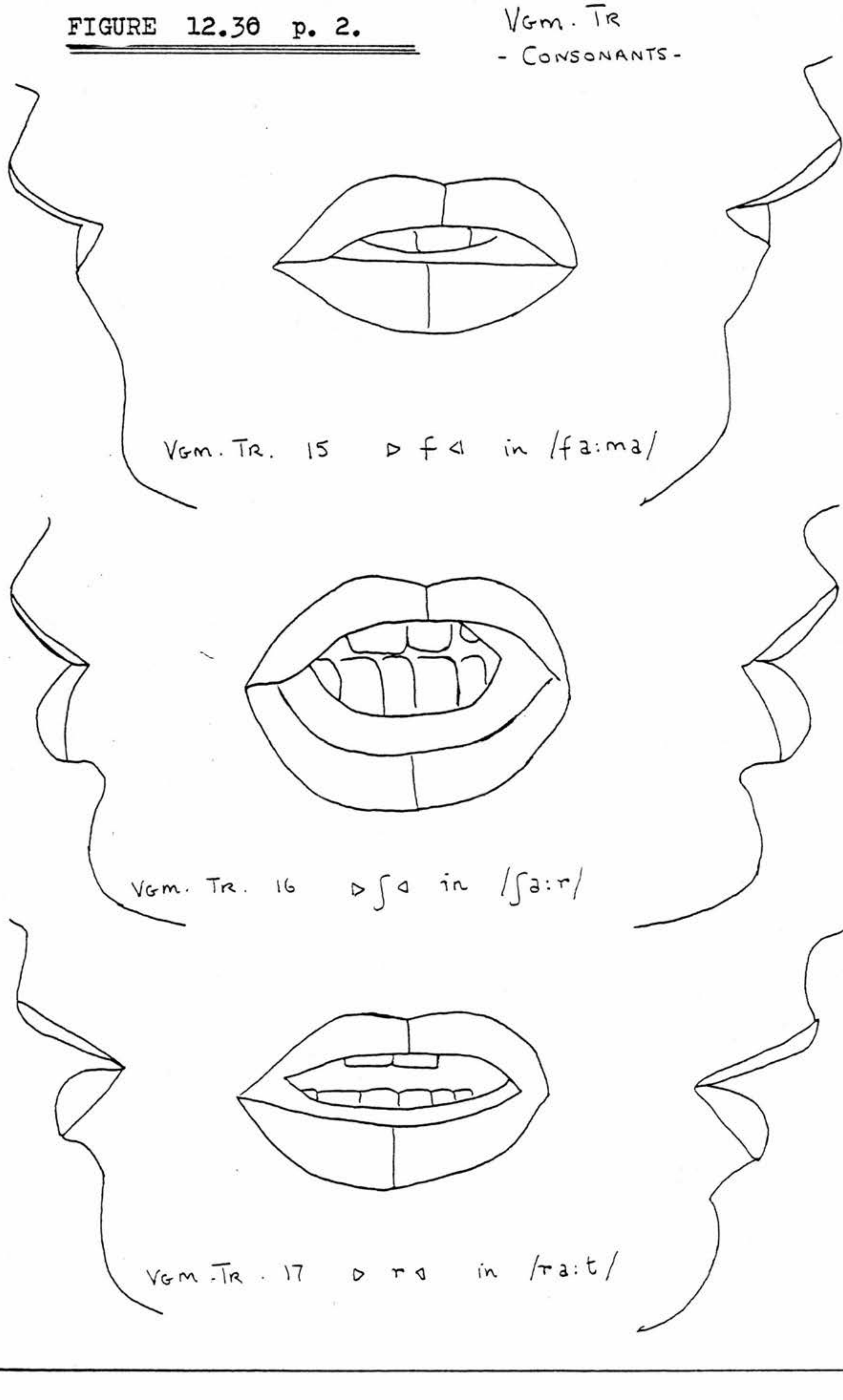


FIGURE 12.30 p 3.

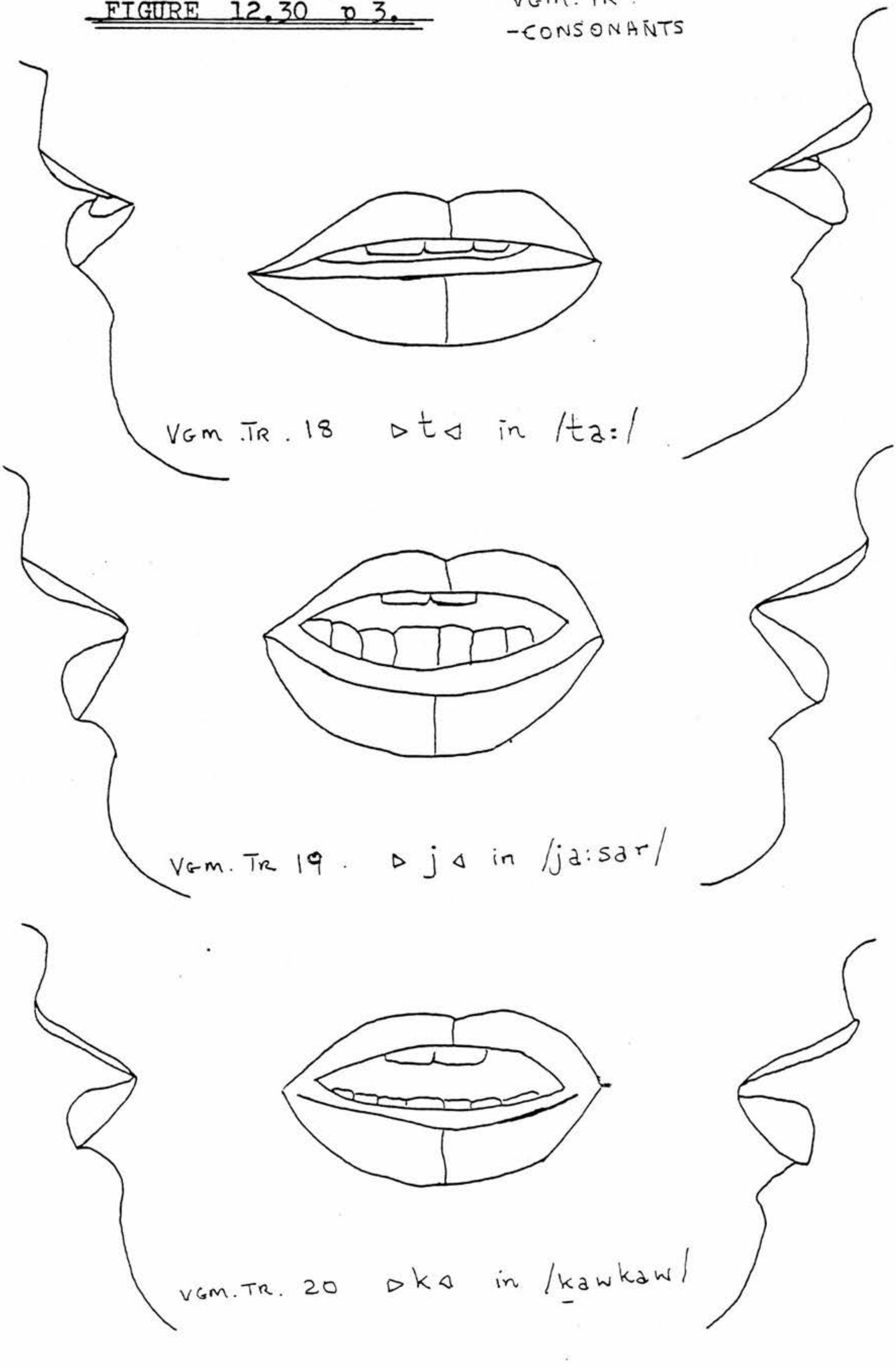
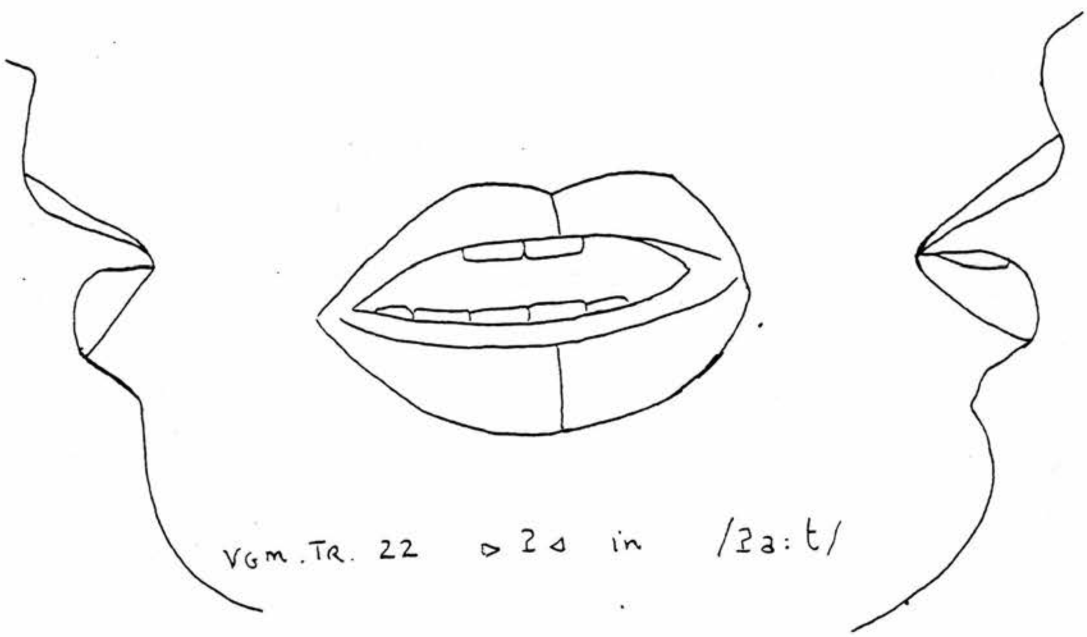


FIGURE 12.30 p. 4.

Vgm. Tr.

- CONSONANTS -

Vgm. Tr 21 ▷h◁ in /ha:res/



Vgm. Tr. 22 ▷ʔ◁ in /ʔa:t/

FIGURE 12.31
p.1.

Tracings of life-size visiograms of Informant B
- CONSONANTS -

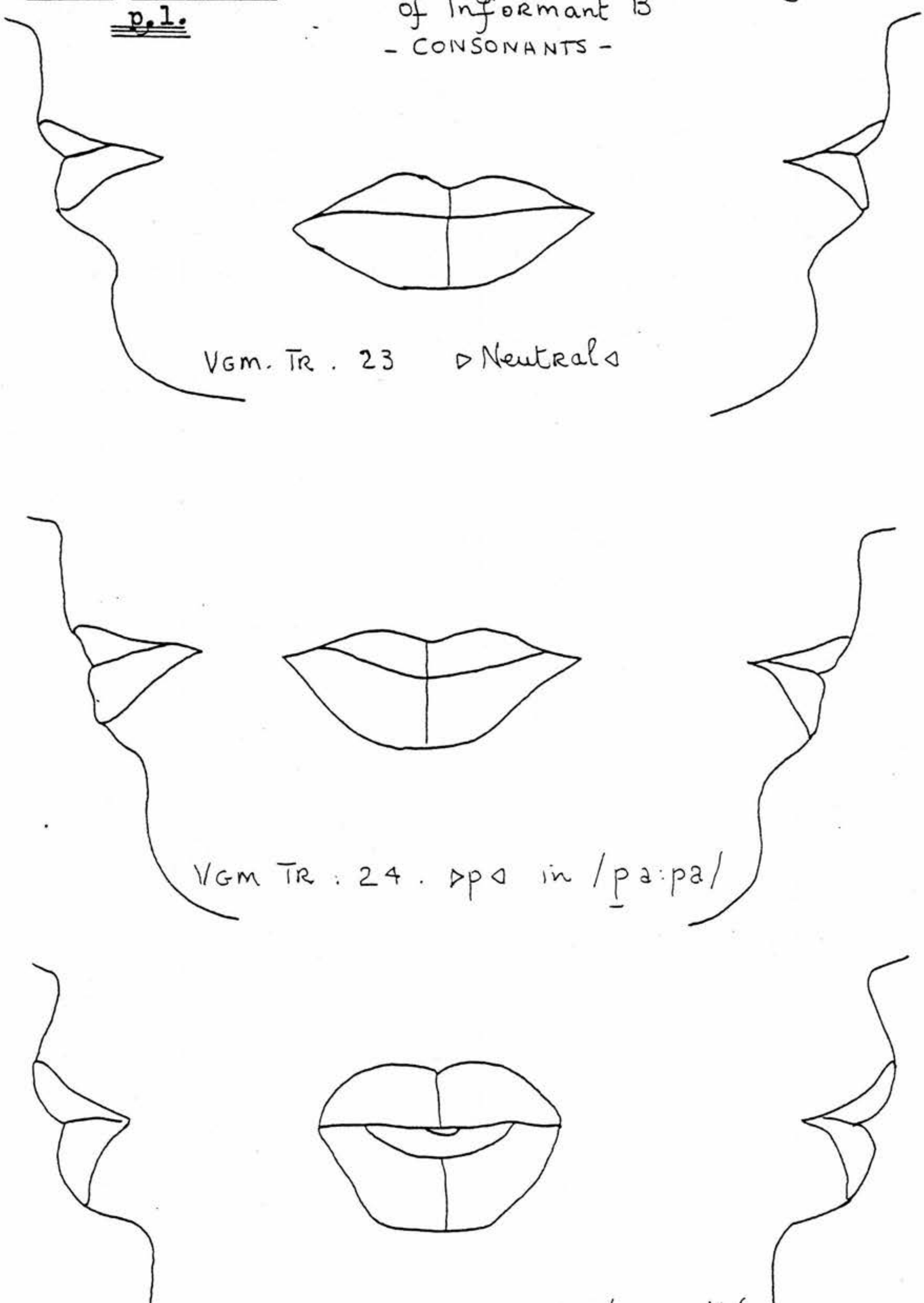


FIGURE 12.31 p.2.

VGm TR
- CONSONANTS -

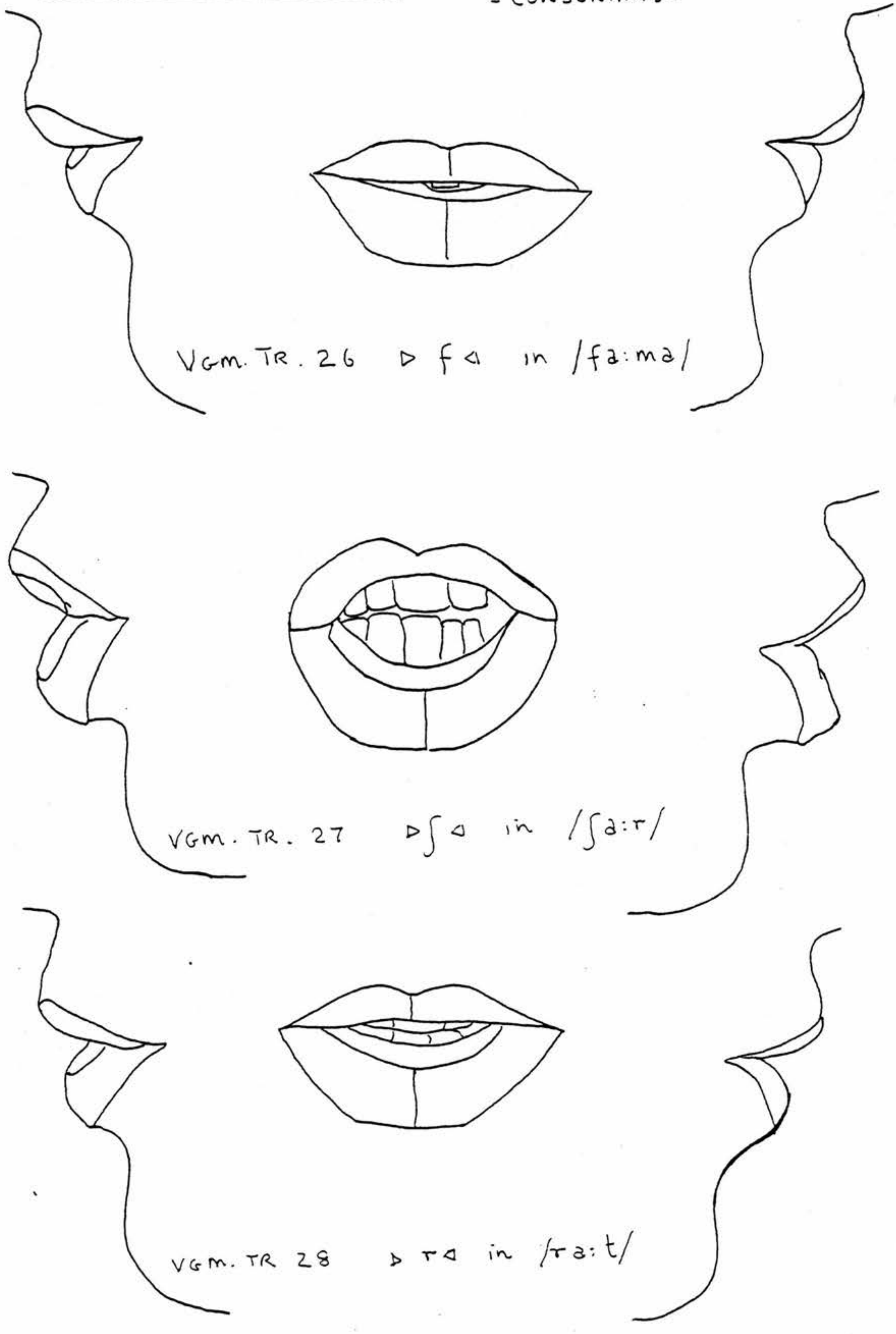


FIGURE 12.31 p.3. VGM.TR. -CONSONANTS-

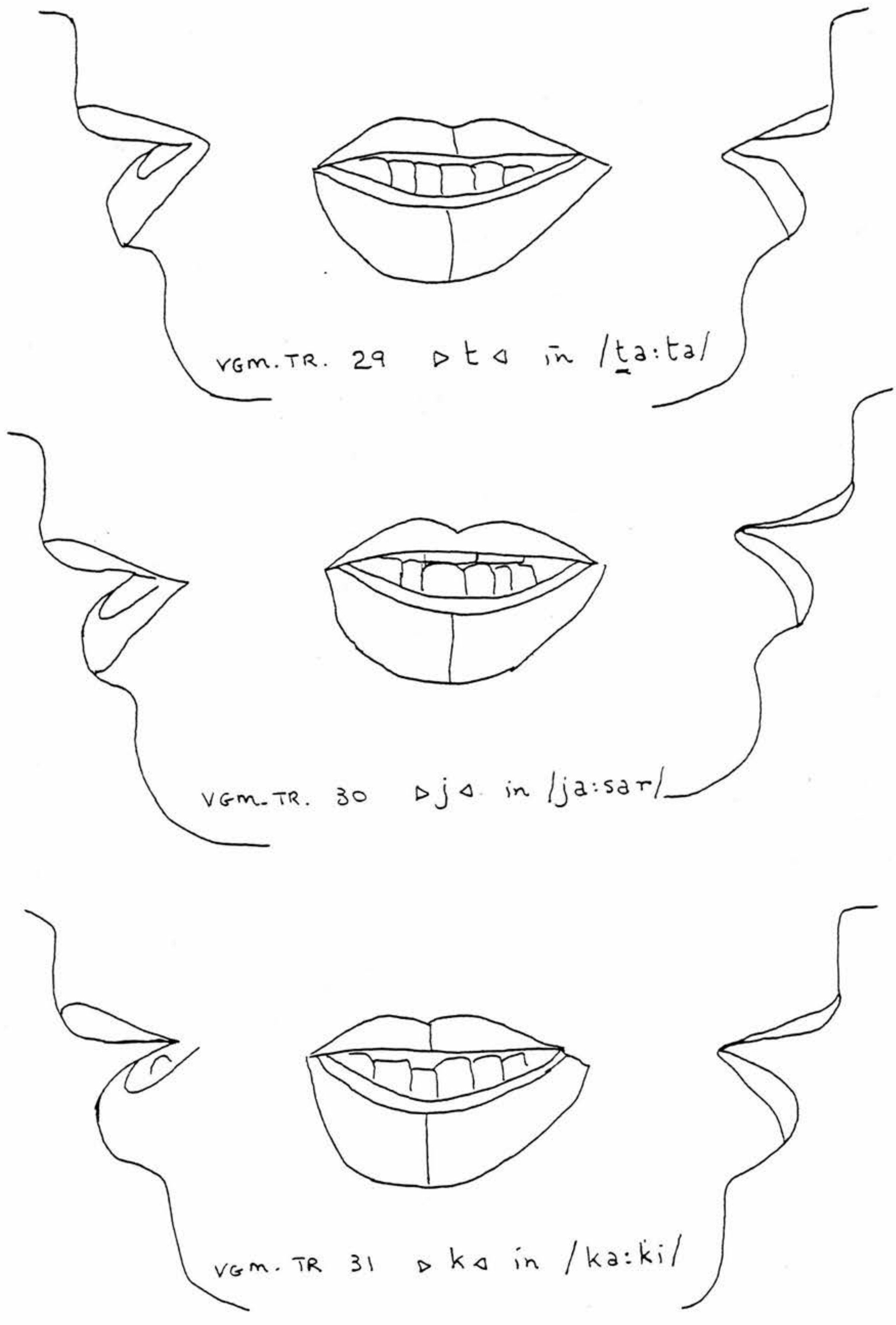
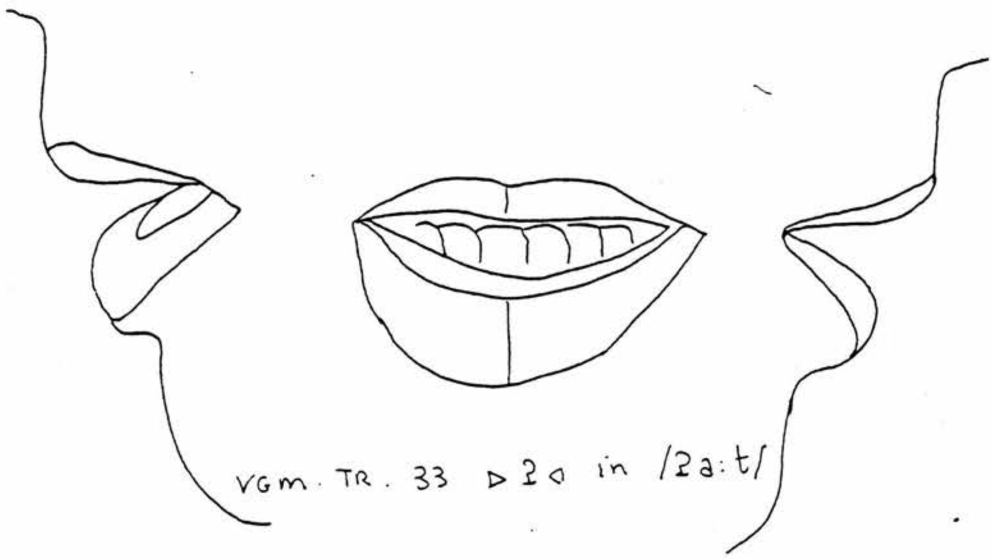


FIGURE 12.31 p.4

VGM. TR.

- CONSONANTS -

VGM. TR. 32 ▷h◁ in /ha:res/



VGM. TR. 33 ▷ʔ◁ in /ʔa:t/

12.29. The influence of the various contexts considered

A. Vowels

If we take the OVO structure as the posture for the vowels that is closest to a decontextualized vowel (acknowledging that no such phonomenon exists), we can make the following generalizations on the basis of the data presented:

(i) The most marked context is the /ʃ___ context in that it generally produces the following effects on the vowel dimensions:-

1. A decrease in the overall frontal height - the $E_1 - E_2$ line - for speaker B, even though there is generally greater vertical expansion of the inter-labial space as seen in the markedly increased $A_2 - X$ line. The effect on the overall frontal height for speaker A is not seen in the front vowels.

2. A decrease in the $E_1 - A_1$ line, which reflects a greater degree of upper lip raising, thus decreasing the distance from the outer rim of the upper lip to the nose. This does not occur very markedly for informant A, and, in fact, there is a slight increase in the $E_1 - A_1$ line for ▷o◁ for informant A, but the slight difference (decrease) is otherwise consistent.

3. There is a corresponding decrease in the $B_2 - E_2$ line, which reflects a greater degree of lower lip lowering or curling downwards, thus decreasing the distance between the outer rim of the lower lip and the chin mark for informant B and for the front vowels of informant A.

4. The difference in the $A_1 - A_2$ and the $B_1 - B_2$ line is not very consistent, but these dimensions must be considered along with the $X - B_1$ line, which reflects the amount of inner lower lip

visibility and is highly correlated to the tension in the lips themselves that result in a thickening or thinning of the lips in connection with the horizontal spreading and contraction. Informant B has consistently more (but the same for ▷o◁) inner lip visibility in the /ʃ______ context than in any other context; whereas the difference for informant A is very slight, if any, and reversed for ▷o u and u^{w}◁

5. The $A_2 - X$ line, reflecting the vertical expansion of the interlabial space increases markedly for the /ʃ____ context for all of the vowels except /u^{w}/ for informant B and for the front vowels and the back open vowel for informant A, but it decreases markedly for the ▷o o:◁ and ▷u^{w}◁ contexts. Thus, visually, the influence of the /ʃ____ context is different for the two informants.

6. There are consistent differences in the $C_1 - C_2$ line, the horizontal dimension of the lips from the corners of the mouth for both speakers, but there are also consistent differences between the two informants in this respect. Informant A's vowels in the /ʃ____ context show a consistently longer $C_1 - C_2$ line except for ▷o:◁ ; informant B's $C_1 - C_2$ line decreases for /ʃ____ except for ▷a , o , o:◁.

7. There is a corresponding decrease in the $Y_1 - Y_2$ line for informant A for the back vowels and a corresponding decrease in the $Y_1 - Y_2$ line for informant B except for ▷o:◁ and ▷u◁. This reflects the horizontal line of interlabial space, or separation of the inner corners of the mouth.

8. The only significant differences along the $H - D_1$ and $H - D_2$ dimension, which partly reflects protrusion or retraction, is a decrease, for both informants, along the $H - D_2$ line for ▷o◁.

9. Both speakers have a slightly greater lip separation viewed laterally, along $D_1 - D_2$, for the frontal and central vowels and a marked decrease in lip separation for the back vowels in the /ʃ——— context.

(ii) The influence of the labial context is not as extensive as that of ▷ʃ◁. The labial context does, however, have the following consistent effects:

1. A smaller $E_1 - E_2$ and a smaller $A_1 - X$ line, i.e. overall frontal height and vertical lip separation for speaker A, except for ▷u^W◁ The effect on the vowels for informant B is not so marked and sometimes, it consists of an increase along those dimensions.

2. The $C_1 - C_2$ line or horizontal lip separation is greater for informant A for the back vowels only.

The contextual effect on the vowels can be summarized by saying that there is a tendency to articulate the vowels with some degree of protrusion and upper lip raising and lower lip lowering when the vowel is in a /ʃ——— context, and to use the minimum lip separation required when the vowel is articulated in a labial context.

12.30

B. <u>Consonants</u>

We have seen how certain sounds, namely those in classes 1 to 5, are easily identified by certain visual characteristics due to their stability along certain parameters. However, no sound is characterised by the stability of all of the 12 (or 15) parameters at the one time. Thus, even immediately identifiable sounds such as ▷p◁ or ▷ʃ◁ are modified in some ways across contexts.

Generalizations as to contextual influence of vowels on consonants can be made much more easily than those of consonants on other consonants. Several factors have to be considered regarding inter-consonantal modifications. The articulatory characteristics of the two adjoining segments are relevant here. The relationship of the parameters involved in the production of the two consonants concerned, the importance of a specific parameter in articulating each of the two consonants, the dominance of the two sounds and their competitiveness are all relevant factors. A further important variable is the syllable structure and the specific phonetic components making up the context. The tendency of recurrent influences is stated as a tentative generalization about the modification of a sound in terms of its context.

The present study does not take all existing variables into consideration. To do this, it would be necessary to have much more controlled data comparable to minimal pairs of full length phrases and utterances. This would extend the data to impractical limits. I feel that the data selected for this study is sufficient to differentiate some of the possible visual units associated with Maltese sounds. It is not within the scope of the present study to delve further into contextual modification beyond those that contribute to the visual identifiability of a sound as well as its amalgamation into a context. Furthermore, these generalizations refer only to the data considered, i.e. they are limited to two informants although I hope that they will also be applicable to a much larger number of native speakers of Maltese.

12.31. We see, then, that of the classes of sounds considered, some are produced with very distinctive and stable lip articulation, so that they were identifiable along several parameters, others are less easily identified except negatively in the sense that they are not of the stable classes. Stable sounds are not modified in any context in such a way as to be neutralized along their characterizing features. Further, they exert an influence on other sounds which they precede or follow if these sounds are not as stable. Some stable sounds have a stronger influence than others: ▷p◁ , for example, is very stable in that it always consists of a closure, but it only modifies other sounds very slightly, if at all; ▷w◁ , on the other hand, always modifies other unstable sounds to the extent that ▷w◁ is itself recognised during the articulation of the sounds it modifies. We can talk, therefore, not only of stable and unstable sounds, but also in terms of dominant and less dominant sounds. This means that, in a competitive context, the more dominant sound has a greater influence on the sounds in the context, whereas the less dominant sounds can assimilate to the dominant sound in such a way that they are no longer visually identifiable directly.

In conclusion, a hierarchy of the Maltese phoneme-classes established in this section, depending on the stability and dominance of the visual patterns by which they are identified, can be set up as follows, from most (1), to least (8) dominant. The following should read: ▷ʃ◁ is of the stable classes, but more dominant than ▷w◁ ; ▷w◁ is also stable, but less dominant than ▷ʃ◁ , though more dominant than ▷f◁ and so on.

(1) ▷ʃ◁

(2) ▷w◁ (including ▷u◁ and ▷o◁)

(3) ▷f◁

(4) ▷p◁

(5) ▷r◁ (possibly further down)

(6) ▷a◁ , ▷e◁ , and ▷i◁

(7) ▷h◁ and ▷ʔ◁

(8) ▷t◁ , ▷j◁ , and ▷k◁ .

12.32. It is difficult to say, at this point, whether the neutral rest-position and the other postures, identified as non-sound, such as pause (often distinguishable from rest in these two informants because of some degree of lip separation) should be classified as stable or unstable. They do not enter into a relationship with other sounds so as to influence them, except insofar as they provide a free, non-competitive context. Although it has so far been possible to distinguish all of the sounds studied from the neutral rest-position, this cannot be concluded as being the case for connected speech. It seems to me, that some knowledge of the speaker's habits have to be learnt before pause-patterns become identifiable from speech-patterns. A frame of reference has to be built for each speaker in turn, depending on his or her physiological make-up, as well as speech habits. Some speakers, for example, signal the 'about-to-speak' idea in their lip patterns long before they actually say anything. Others start off quite consistently from a neutral-closed position.

The interpretation of speech through visual patterns depends on other non-linguistic visual information, which may be as crucial to communication as the linguistic part of the speech event. Since, to a great extent such information is excluded from the experimental situations discussed here, it does not form part of the data. However, I would not wish to undermine its possible importance.

12.33. It seems that there are more obvious and less obvious lip movements. It is my impression that the lipreader looks on features such as protrusion, lip curling upwards or downwards, complete closure, as positive identification clues. Different degrees of lip separation, on the other hand, though identifying a set of sounds from other sets, are not as easily recognisable. As far as the vowels are concerned, therefore, the protruded, rounded and open vowels are more distinct than the close and half-close unrounded vowels. This may be related to proprioceptive knowledge, due to the fact that in the one case, the lips are active, and, in the other, they are passive, or only led on by tongue and jaw movement. Thus, the vowels /u^w/, /u/, /o/, /o:/, /a/, /a:/ can be considered along with the stable consonant sounds, and /i/, /i:/, /i^j/, /e/, /e:/ can be considered with the unstable consonant sounds - in visual terms. The latter group is unstable because, since the lips are not necessary in the stricture required for the articulation of the sounds, they are free to anticipate or continue the movement required for the following or previous sounds, as the case may be.

This does not mean that the posture "reached" momentarily - a moment which was prolonged artificially for the purpose of this study - is always (or ever) the most crucial clue to the identification of a sound. What the lipreader sees is movements to and from these postures. This investigation, then, ends with a query: What type of movements are involved, and how do they tie in with the identifiable shapes just described? To probe into this, it was necessary to look at the movements used in connected speech. This is the question taken up in the study that follows.

Chapter 13

Visible Patterns in Connected Speech

13. Study 11 : Connected Speech

13.1. Purpose

In this section, I describe a cinematographic study of the visual patterns of connected speech. The purpose of this was to relate the patterns visible in prolonged articulation to those visible in fast connected speech. Several questions also arose out of the study of lip patterns used in producing words in isolation:

1. Are the visual units in connected speech as distinct as those that can be isolated from prolonged articulation, i.e. can the same 'postures' described as distinctive, still be recognised in connected speech?

2. Can pauses be isolated from speech?

3. In what way can movements be related to visual units? Do 'target postures' simply form part of a movement? Or do they form the nucleus or hinge of a larger organizational unit?

4. What temporal clues can be used to relate visual to auditory-sound patterns?

5. How much assimilation takes place visually?

6. In what ways can larger (or smaller) units be seen to relate to syllables, words, phrases and other units of the spoken language?

13.2. Procedure

To answer these questions, I decided to film the informants used in the previous study reading a continuous text. The film was made, using a 16 mm. Beaulieu camera running at fifty-eight frames per second[1]. The same visiograph set-up as in the previous study was used, with the cine camera placed at the same angle and **instead** of the camera used for still photography. A special pulse generator was built by Messrs. Smith, Dodds and Macrae at the Phonetics Laboratory of Edinburgh University. This pulse generator enabled the synchronisation of sound with film as it provided an accurate sound-with-vision alignment, using clicks generated at the rate of one click for every frame filmed. The visiograph was set up in the recording studio with the camera focussed through the window to the next room of the studio, so there would not be any camera noise interfering with the recording of the speech material. The speech signal and the clicks were recorded on separate channels, using the Revox tape-recorder. This recording was later analysed using the electrokymograph set-up - **for calibration - with** four simultaneous tracings for time, clicks, pitch and intensity of the speech signal. The data was later repeated through the electrokymograph mask to give an analysis of the air pressure from the mouth and nose, a time signal, as well as a laryngographic recording. This was done whilst the speaker listened through headphones to the recording made during the film. This data was then used as an additional guide to segment the speech wave form more reliably on the previous recording, although, of course, there were still differences between the two recordings.

13.3. The data

The speech material for the film consisted of a text made up of 22 Maltese sentences that are syntactically acceptable, but semantically nonsensical in that they are unlikely ever to relate to real

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1. The camera had no fixed speed-stop setting. It was intended to film at 64 frames per second.

events. The data is given below (see figure 13.1).

I decided to include all the acceptable CC clusters of the 'representative' consonants used in the previous study, and all the 'representative' consonants in the context of the five vowel types as used for the citation form study, to allow adequate comparison. The selection is shown in figure 13.2. below. Although members of the non-dominant classes were not found to be visually contrastive (e.g. ▷h◁, ▷ʔ◁, ▷t◁, ▷k◁, ▷j◁), they were retained in the connected speech material to allow more extensive investigation of their stability and identifiability.

The data was selected so that each of the consonant representatives occurred syllable-initially in the context of every other consonant representative, both preceding and following it, that is, both as C_1 and as C_2 of a releasing CC cluster, as well as followed by each vowel type (- only clusters that are permissible Maltese clusters). A few exceptions, which could not be accommodated without extending the text any further, occur as consonant sequences across syllable or word boundaries. In some cases, members other than the representative-sound were used additionally (one notable example being /l/). Figure 13.2. shows the way the data was classified. Where several examples of the same type occur, they are listed at the bottom. Repetition of some words such as ⟨il-⟩ (the), and ⟨ta⟩ (of), also ⟨-kom⟩ (morpheme meaning 'you') is inevitable.

The data was intended to be spoken by both informants in fast colloquial style for a comparative study. Informant A's unfamiliarity with the type of speech material used resulted in several hesitations, thus making the rhythm and the speech generally rather unnatural, and therefore, the data acquired using him as an informant was rejected as entirely unsuitable.

Figure 13.1a.
The textual data for the cinematographic study of the visual patterns of connected speech.

Orthography and gloss

1. L-għerq tad-dielja u l-btieħi tbierku bix-xita.

   The roots of the vine and the yards were blessed with rain.

2. Ma ftakritx kemm ċkienu u kriehu l-fkieren meta bkew għat-tħaxwix f'xahar il-ġwiez.

   She didn't remember how small and ugly the tortoises became when they cried for the rustling during the month of walnuts.

3. Xbajna u xrafna għax fil-kwota tat-trab li xtrajna mit-Tajwan kxifna frak ileqq f'wiċċna bħal kwiekeb.

   We are fed up and have become hardened because we uncovered fragments that shine in our faces like stars in the quota of dust that we bought from Taiwan.

4. Instab għerf f'għajn il-ktieb u f'qarn il-bdabad.

   Wisdom was discovered in the source of the book and the horns of the goats.

5. Il-mniegħel! xi żlieġ hawn fil-liwja tal-kfief imniżżla.

   Damn! what slime there is in the folds of the hems that have been taken down.

6. L-armla mliet il-bwiet bil-ħobż għax ma tawx kas jagħtu platt kbir lil Xmun qabel ma bagħtuh għall-mewt f'banju tal-pitrolju.

   The widow filled her pockets with bread because they did not bother to give Simon a large plate before sending him to his death in a bath of kerosene/liquid fuel.

7. Għall-erwieħ! tawk tewm twil biex terġa tħawrilhom zlazi b'xi brunġiel li tawhom meta ħxienu.

   Thank God! they gave you long garlic to make them some spicy sauces with the aubergines that they gave them when they grew fat.

8. Rwiefen ħtija tal-għawm tat-tfal biċ-ċfuf tas-suf oħxon.

Winds are to be blamed on the swimming of the children with the thick woollen bows.

9. Mur ħudkom kemm titgħarrxu żżuru l-bitħa b'fanal li writt fix-xhur tax-xitwa jekk ma turux widintkom bla ma tqumu fuq ruħkom bil-ħeġġa.

I can just imagine how tickled (lit.) you would be if you had to visit the yard with the lantern that I inherited in the Winter months if you do not uncover your ears without livening yourselves up zealously.

10. Qiskom tistħu tilwu ftit ir-regoli tal-ħabs, ma jmorrux jagħmlu għalikom.

It seems that you are too ashamed to bend the prison rules in case you should be scolded.

11. Tkellem dwar il-pjan li tawh bi kliem u qwiel lesti f'ħalqu.

He talked about the plan they gave him with prepared words and idioms.

12. Jkollu jibqa' għax xorta x'qal se jwettaq.

He will have to stay because he will still do what he said.

13. Il-bqija tal-ħjar qrasu imma jridu jieklu l-qxur għax fjakki.

The rest of the cucumbers have gone sour, but they want to eat the skin because they are hungry.

14. F'liema gwardarobba qfilt il-ħwejjeġ ħfief lwien il-fjuri meta ħriġt it-tqal li kont ħbejt.

In which wardrobe did you lock the light, flower-coloured clothes when you took out the heavy ones that you had hidden?

15. M'għandux x'jagħmel ħlief ifarrak u jxarrab x'lestejt u lqatt.

He has nothing else to do except breaking and wetting the things that I prepared and hit.

16. Qlajt kjass bil-qtil ta' dawk li ħkimt.

I raised an uproar as a result of the deaths of those I ruled.

17. Fil-qosor, qbilt li kont ħqarthom bl-irkejjen ta' rħam jaqta' l-laħam.

In short, I agreed that I had tormented them with the corners of the flesh-cutting marble.

18. X'ħin jogħlob jħalli l-ħlewwa u jqajjem il-korla.

When he slims down he leaves sweetness and awakens anger.

19. It-talb ta' Karl kollu telf għax l-imgħallem ma nħallx.

Karl's prayers are all in vain because the master did not melt.

20. Ħudhom dawk it-tjur li ħarbu ħalq ljun jbeżża x-xemx.

Take the fowl that escaped the mouth of the lion that frightens the sun.

21. Ir-romol Maltin jieklu kejl tarja fis-sajf u jdelku l-melħ bil-porga li jdewqu lit-trabi.

The Maltese widowed eat a measure of vermicelli in Summer and grease the salt with the laxative that they make the children taste.

22. Xegħelna d-dawl ikħal u rajna li għadhom mxattrin; għalhekk qegħednihom fost l-imkemmxin fuq it-tarġa.

We switched on the blue light and saw that they were still unequal/creased; so we put them with the creased ones on the step.

Figure 13.1b.

A phonemic transcription of Informant B's reading of the 22 sentences used in the cinematographic study of the visual patterns of connected speech.

The transcription was made from the film recording. Dashes indicate syllabic boundaries; no attempt is made here to preserve any unit beyond the syllable. Each sentence is numbered. === indicates a pause.

1. 'le:rʔ - tad - 'di:l - ja - ul - 'pti: - hi - 'dbi:r - ku - biʃ - 'ʃi - ta

2. ma - ftak - 'ritʃ - kem: - 'tʃ ki: - nu: - 'kri: - hul - 'fki: - re - me - ta - 'pkew - at - thaʃ - 'wi^j ʃ - 'fʃa:r - il - 'dʒ wi:s

3. 'ʃbaj - na - u - 'ʃraf - na === 'a:ʃ - fil - 'kwo: - ta - tat - 'tra:p - li - 'ʃtraj - na - mit - taj - 'wan - 'kʃif - na - 'fra:k - i - 'leʔ: - 'fwitʃ - na - phal - 'kwi: - kep

4. in - 'sta:p - 'e:rf - 'fajn - il - 'kti:p - u - 'fʔarn - il - 'bda: - bat

5. il - 'mni: - el - ʃi - 'zli:tʃ - 'awn - fil - 'liw - ja - tal - 'kfi:f - im - 'niz - la

6. 'lar - mla - 'mli:t - il - 'bwi:t - bil - 'hops - 'a:ʃ - ma - 'tawʃ - 'ka:s - 'ja: - tu - 'plat: - 'gbi^j r - lil - 'ʃmu^w n - 'ʔa - bel - ma - 'ba: - tu:h - al - mewt - 'vban - ju - tal - pit - 'rol - ju

7. al - ler - 'wi:h - tawk - 'tewm - 'twi^j l - 'bi:ʃ - 'ter - dʒa - thaw - 'ri - lom - 'tsla: - tsi - pʃi - brun - 'dʒi: l - li - 'taw - hom - me - ta - 'hʃi: - nu

8. ir - 'wi: - fen - 'hti^j - ja - ta - 'lawm - tat - 'tfal - bitʃ - 'tʃ fu^w f - tas - 'su^w f - 'oh - ʃon

9. ˈmuʷr - ˈhuʷt - kom - kem: - ti - ˈtar - ʃu - iz - ˈzuʷ - ru - il - ˈbit - ha - pfa - ˈna:l - liw - ˈrit: - fiʃ - ˈʃuʷr - taʃ - ˈʃit - wa - jek: - ma - tu - ˈruʷʃ - wi - ˈdint - kom - bla - ma - ˈtʔuʷ - mu - ˈfuʷʔ - ˈruʷh - kom - bil - ˈhedʒ - :a

10. ˈʔiʲs - kom - ˈtis - thu - ˈtil - wu - ˈftiʲt - ir - ˈre - go - li - tal - ˈhaps - maj - mor - ˈruʷʃ - ˈja:m - lu - a: - ˈliʲ - kom

11. ˈtkel - lem - ˈdwa:r - il - ˈpja:n - li - ˈtawh - bi - ˈkli:m - u - ˈʔwi:l - ˈles - ti - ˈfhal - ʔu

12. i - ˈkol - lu - ˈjip - ʔa - ˈa:ʃ - ˈʃor - ta - ˈʃʔa:l - sej - ˈwet - taʔ

13. il - ˈpʔiʲ - ja - tal - ˈhja:r - ˈʔra: - su - im - maj - ˈriʲ - du - ˈji:k - lul - ˈʔʃuʷr - ˈa:ʃ - ˈfjak-ki

14. ˈfli: - ma - gwar - da - ˈrob - ba - ˈʔfilt - il - ˈhwej - jetʃ - ˈhfi:f - il - ˈwi:n - il - ˈfjuʷ - ri - me - ta - ˈhritʃt - it - ˈtʔa: l - li - kont - ˈhbejt

15. man - ˈduʷʃ - ˈʃja: - mel - ˈhli:f - i - ˈfar - rak - uj - ˈʃar - rap - ˈʃles - tejt - ul - ˈʔat:

16. ˈʔlajt - ˈkjas: - bil - ˈʔtiʲl - ta - ˈdawk - li - ˈhkimt

17. fil - ˈʔo - sor - ˈʔbilt - li - kont - ˈhʔar - tom - blir - ˈkej - jen - tar - ˈha:m - ˈjaʔ - tal - ˈla - ham

18. ˈʃhiʲn - ˈjo: - lop - i - ˈhal - lil - ˈhlew - wa - uj - ˈʔaj - jem - il - ˈkor - la

19. it - ˈtalp - ta - ˈkarl - ˈkol - lu - ˈtelf - ˈa:ʃ - li - ˈmal - lem - man - ˈhalʃ

20. ˈhuʷ - dom - dawk - it - ˈtjuʷr - li - ˈhar - bu - ˈhalʔ - il - ˈjuʷn - i - ˈbez - zaʃ - ˈʃemʃ

21. ir - 'ro - mol - mal - 'ti^{j}n - 'ji: - klu - 'kejl - 'tar - ja - fis - 'sajf - uj - 'del - kul - 'melh - bil - 'por - ga - lij - 'dew - ʔu - lit - 'tra: - bi

22. 'ʃel - nad - 'dawl - 'ik - hal - u - 'raj - na - 'li: - 'a: - dom - im - ʃat - 'tri^j n - a - 'lek - ʔed - 'ni:- om - fost - lim - kem - 'ʃi^{j}n - fuʔ - it - 'tar - dʒa

FIGURE 13.2. Some illustrations of segment combinations selected for connected speech data

	▷i◁	▷e◁	▷a◁	▷o◁	▷u◁	▷p◁	▷w◁	▷f◁	▷ʃ◁	▷r◁	▷t◁	▷j◁	▷k◁	▷h◁	▷ʔ◁
p	1.10 biʃ 3.15 mit	6.19 bel 6.24 mewt	4.11 bat 6.9 ma	10.15 mor 21.3 mol	9.1 muʷr 9.33 mu	–	6.5 bwi:t	9.14 pfa:	7.15 pʃi 20.15 ʃemʃ	7.16 brun	1.6 pti 4.10 bda	11.5 pjan	2.13 pkew	3.25 phal	13.2 pʔiʔ
w	2.15 wiʔʃ 7.3 wi:h	12.11 wet	3.17 wan 9.22 wa	7.20 wom	10.6 wu	7.5 tewm 8.7 lawm	–	(8.13 suʷf)	6.10 lawʃ	7.10 thaw-r	6.24 mewt 22.3 dawl	(15.9 uj) 4.8 liwj	7.4 lawk 16.6 dawk	(6.22 lwh	(9.34 fuʷʔ)
f	3.6 fil 9.18 fiʃ	8.3 fen	4.4 fajn	22.20 fost	9.34 fuʔ	6.25 vban	3.23 fwitʃ	–	2.17 fʃa:r	3.20 fra:k	2.2 ftak 10.7 ftiʔt	13.16 fjak 14.15 fjuʷ	2.9 fki:	11.14 fhaj	4.8 fʔam
ʃ	1.11 ʃi 7.17 dʒi:l	20.15 ʃemʃ 22.1 ʃe:l	7.9 dʒa	8.15 ʃon 12.7 ʃor	9.7 ʃu	3.13 ʃbaj 6.17 ʃmuʷn	2.19 dʒwi:s	8.11 tʃʃuʷf	–	3.3 ʃraf	3.13 ʃtraj 14.19 hritʃ	15.3 ʃja:	2.5 tʃki:	18.1 ʃhiʔn	12.9 ʃʔa:l
r	2.3 ritʃ 7.11 ri	2.10 re 10.9 re	15.8 rak 15.11 rap	6.29 rol 14.5 rob	9.10 ru	6.1 lar-m	7.2 er-w	4.3 erf	7.8 ter-dʒ	–	4.8 fʔarn 19.4 karl	21.9 tar-j	1.8 dbi:r-k	17.13 r-ham	1.1 lerʔ
t	1.3 di:l 3.12 li	1.1 lerʔ 3.22	1.2 tad 2.1 na	7.12 lom 1.3	2.6 nuw 6.13 tu	1.8 dbi:r 19.2 talp	7.6 twiʔl 11.3 dwa:r	8.4 tfa:l	2.2 mitʃ 19.13 halʃ	3.13 ʃtraj 21.24 tra:	4.2 sta:p 5.22 li:tʃ	20.5 tjuʷ	11.1 tkel	2.15 thaʃ 7.10 thaw	9.32 tʔuʷ 14.2 tʔa:l
j	12.4 jip 13.12 ji:	9.23 jek: 14.10 jetʃ	1.4 ja 10.17 ja:m	18.2 jo	6.26 ju 20.11 juʷn	10.14 maj-m	3.16 taj-w	21.12 sajf	15.9 uj-ʃ	13.14 maj-r	16.1 ʔlajt	–	(10.19 lizk)	(18.4 rʔhzl)	18.9 uj-ʔaj
k	13.17 ki	2.4 kem 3.27 kep	6.11 kas 19.4 karl	9.3 kom 10.10 go	1.9 ku	6.15 gbiʔr	3.7 kwo: 3.25 kwi:	5.11 kfi:f	3.18 kʃif	2.7 kri:	4.6 kti:p 11.9 kli:m	16.2 kjas	–	2.2.4 ik-hal	22.15 lek-ʔed
h	1.7 hi	9.38 hedʒ	9.13 ha 10.13 haps	6.7 hops	2.8 hul 9.2 huʷt	14.24 hbejt	14.9 hwej	14.11 hfi:f	7.23 hʃi:	14.19 hritʃ	8.4 htiʔ 15.5 hli:f	13.5 hja:r	16.8 hkimt	–	17.7 hʔar
ʔ	10.1 ʔi's	22.7 ʔed	6.18 ʔa 12.15 ʔa	17.2 ʔo	11.15 ʔu	17.4 ʔbilt	11.11 ʔwi:l	14.7 ʔfilt	13.14 ʔʃuʷr	13.6 ʔra:	16.1 ʔlajt 16.4 ʔtiʔl				–
i	3.21 i					5.12 im				8.1 ir	2.18 il 4.1 in		22.4 ik		
e										4.3 erf					
a			10.19 a:				5.6 awm		3.5 aʃ		2.14 at 6.23 al:				
o						2.2.19 om								8.14 oh	
u					4.7 u						5.14 ul	15.9 uj			

The numbers refer to Sentence and Syllable number in Figure 14.1 b.

13.4. The data analysis technique

The analysis presented here is based on a frame-by-frame analysis of the two films made of speaker B. Film 1 contains sentences 1 to 16; film 2 contains sentences 16 to 22. Every fifth frame was numbered by hand, using a divider, since the electronic counter used during the filming did not show up on the film. The electrokymographic tracings of the sound recording were also analysed. The clicks and time traces were numbered and calculated, and the speech signal was segmented. The second recording made (see 13.2. above) was found to be very useful when the information from the speech wave form and the pitch and intensity traces were not sufficiently clear in indicating a change in sound type. Of course, some segmentation problems still had to be solved arbitrarily. Since no information about what the other speech organs were doing at the same time could be obtained from cinefluorography or dynamic palatography, it is not possible to talk about the synchronisation of other articulators except insofar as this can be inferred from the other data.

A preliminary analysis of the film was run at 16 fps (approx. ¼ of the speed) to determine whether further categories were needed in order to describe adequately the visual characteristics of connected speech. It was decided that the categories and terminology used for the prolonged speech data would be sufficient, except that the reference was now to movements and not postures.

After a preliminary run through of the film at 16 f.p.s., the data was analysed frame-by-frame. A description of the visual movements was recorded with reference to the frame number of the frame in which they appeared, indicating the start and end of a movement, of obvious, recognisable 'postures' and their 'approach'. The segmented audio trace was then fitted in (aligned with the frame number indicated by the click number) to allow reference to be made to the auditory data correlated with the movements. Tracings were made of some 'postures' considered as target stages or reference points for the movements to enable comparison.

Thereafter, the film was again run at 16 frames per second for 2 main reasons:

1. to check that the description noted down from the frame-by-frame analysis was observable in the moving image;

2. to see whether there was any sort of observable rhythm visible in the speech movements that could be related to an organizational unit in the data, i.e. a unit higher than the individual speech sound.

13.5. Presentation of results

The rest of this chapter is divided as follows: (1) a comparison is made between the parameters used for the prolonged articulation data and the connected speech data; (2) the patterns of 'postures' identifiable in connected speech are described; (3) the patterns of movements in the connected speech data are discussed. This is the major section as it presents the film data analysis; (4) the timing of events and the hierarchy of organizing units within connected speech is discussed. The chapter is concluded with a discussion on the possible interpretation of visual patterns in normal everyday speech.

13.6. The relevance to continuous speech of the parameters used for the description of prolonged sounds

I would like to suggest some modifications to the concepts put forward in the discussion of the prolonged speech data in order to account for the different type of data we are dealing with here. In the present data we have to account for movements. Movement can perhaps be thought of, for convenience, as constituting a series of postures held only momentarily. This definition can only be convenient if we account for postures within the dimension of time. Moreover, it has to be seen whether the identifiable postures of prolonged speech are just as identifiable and whether they are still recognisable along the same parameters.

First of all, I would like to reconsider the 'neutral-closed' posture introduced in the last chapter. This concept is still useful here because the 'neutral-closed' posture marks some of the long pauses between sentences. Moreover, it is still distinguished from other sounds requiring firm lip contact by the same features given in the description of prolonged speech, namely, the absence of lip-surface deformation, which is required for the labial oral and nasal stop postures, which also have closed lips. However, it is not easy to recognise a labial sound which initiates an utterance, and therefore occurs at the end of a pause period, since the same tissue deformation could simply be a "waiting to speak" signal. This is resolvable within the time dimension, as will be seen below.

We now have to add another concept, that of the 'neutral-open' posture, that also marks non-speech. This posture is particularly common in the shorter pauses between utterances or parts of utterances, and the beginnings and ends of longer pauses. For informant B, whose connected speech data forms the bulk of this study, there are quite definite distributional criteria for these two neutral non-speech postures, or "pause-markers", depending on the length and purpose of the pause. A very long pause between sentences is often marked by a period of neutral closure; shorter pauses, where only the absolutely minimal time is taken for pause, and therefore, the whole non-speech period is still anticipating speech, are characterized by a neutral-open posture. Both pause-postures are recognisable by their absence of movement for most of their duration. There is a hardly noticeable movement towards a more open state than is necessary for the first speech sound just before each reinitiation of the speech act.

Both these pause-postures are important in that they mark what is speech from what is not speech. However, visual movements in connected speech cannot be measured as the deviation 'neutral' or 'pause' postures: movements can only be seen in relation to the most recent posture reached. This is one crucial difference between the analysis of connected speech and the analysis of prolonged speech data. Since no posture is actually prolonged, we have to abandon the term in the sense used previously. We have to modify it to refer to a stage in a movement, or, more accurately, a stage or turning point between two movements. It is a stage, nonetheless, that is identifiable, and therefore very important in its own right.

The same terminological framework used to describe the postures in the prolonged speech data is applicable to the present study because we are still concerned with movements in three dimensions. We see:

(a) lower and upper lip raising and lowering;

(b) jaw raising and lowering;

(c) jaw retraction and protrusion;

(d) upper and lower lip protrusion and retraction;

(e) upper and lower lip spreading and contraction, as well as movements of the corners of the mouth forwards or backwards.

The movements of connected speech, then, are describable in the same way, via the same parameters, with the important difference that they occur in a continuum of movements where one movement flows into the next. Each description refers to a dynamic process such that what was previously recognised as protrusion because of the deviation of the lips from neutral in an anterior direction, can only be called a protruding movement if the previous stage reached was less protruded and a movement of the lips in the anterior direction can actually be identified. Thus, a protruding movement, the initiation of which can be identified at /l/ of /ilwu/ in the speech signal, is coextensive in time with three sounds, [l] , [w] [u] . The number of phonemic units accompanied by the same visual movement, can only be resolved if the timing of events allows. Lip retraction in the posterior direction, for example, usually follows lip protrusion if a sound like /a/ follows a sound like /u/ or /ʃ/ , and so on, even though /a/ in isolation cannot be thought of as a sound produced with lip retraction.

We see, therefore, that the identification of some sounds can take place by immediately recognising some visible features (see below 13.7.), whereas other sounds are signalled as movements away from an identifiable sound. This is, in fact, an advantage because we can now recognise certain phenomena in the speech continuum which were not, in themselves, recognisable, with reference to the neutral-closed posture. Postures, or target positions, can be considered as reference points, throwing light on the identification of preceding and following movements or the movements to- and-from themselves - since they can be considered as a changing stage in the direction of the two movements. We have the additional time factor as a cue, of course. The 'postures' are constantly changing and can be traced in terms of timing and duration. Thus, the duration of the lip contact for [p] may be much shorter in a cluster when it is followed by an unidentifiable consonant as C_2 and this may be important in identifying the unit. Timing is considered below.

One important aspect of connected speech that has been implied throughout is the fact that sounds accommodate each other, so that, for example, the degree of close protrusion for [u] may well be increased if it is followed by another syllable with an element articulated with some protrusion such as [tʃ], for example. On the other hand, protrusion for [u] may be decreased if it is in the context of an element requiring lip spreading, such as [i:], or retraction with the lower lip for [f], and so on. Several more complex accommodation phenomena can be seen. This is the 'struggle of survival' of dominant and non-dominant sounds. The identifiability of a non-dominant sound can be highlighted if it is sandwiched between two dominant sounds in the same syllable, for example [i:] in [kfi:f]. The short opening required between the first and the second [f] could only possibly be interpreted as a close vowel sound, and certainly not [a], [a:], [e:] or [e]. since these require a greater degree of jaw opening.

It is, in some ways, easier to identify movements, and interpret them than it is to recognize postures in isolation. This is because the three dimensional moving image is easier to relate to a continuum of sound than is a static image. Small movements are also easier to detect than small deviations from the neutral posture: movements are visible; the neutral posture must be recalled. The slight movements of the jaw and the corners of the mouth are extremely informative, and can only be detected through the actual movement. This is important especially in the interpretation of the visual units organized in time, as opposed to the identification of certain postures reached. Vowel movements indicating the presence of a syllable, are often very slight movements of the jaw. On the other hand, the movements are often very fast and cannot be interpreted on their own.

13.7. Recognisable 'posture' stages

An analysis of the film shows that the more marked visual patterns are immediately recognisable and can be reliably related to the dominant segments characterized by these patterns. These segments are:

1. Those requiring complete contact between upper and lower lip, i.e. firm closure of the interlabial space [p, b, m] . They are additionally recognisable by a quite quick movement of the lips from a position in which the lips are often well apart, to a firm closure.

2. Those segments requiring marked protrusion of the lips with a good degree of upper lip lowering and lower lip raising, such that the lips are round-shaped and a very small interlabial space is visible. These are [w,][u] and [o] . They are distinguishable from each other by the greater (for [w] and [u] , and lesser for [o]) degree of tight closure and, therefore, amount of interlabial space. These are additionally recognised by the definite movement outwards of the corners of the mouth from the side view, as the lips contract horizontally and approach each other vertically.

3. Those segments requiring retraction and often raising of the lower lip with some protrusion of the

upper lip, so that two upper front teeth are often visible, resting on the inside of the lower lip. These are [f] and [v] . They are additionally recognised by the movement of the lips in a contrasting relationship to each other on the anterior-posterior dimension.

4. Those segments requiring a good degree of protrusion, as well as upper lip raising and lower lip lowering, allowing a good amount of teeth visibility, usually without any jaw movement (at least not throughout, and not a necessary part of the articulation in all contexts) or corresponding incisal separation. These features mark the sounds [ʃ] , [tʃ] and [dʒ] ; these sounds are also additionally recognised by the quick movement of the lips in opposite directions vertically, and without any horizontal contraction that is not required by the vertical movement.

The above can be considered as the most immediately recognisable 'events' in the speech continuum. They are always there when one of the segments characterized by them occurs. Just as important is the fact that these events never occur unless one of the associated segments is there. Thus,[ɻ], [ɾ] cannot be put into the same category because its characterizing features are only left intact in favourable non-competitive contexts. This does not, however, mean that the visible events are simply coextensive with only that segment in time. They often take place over a duration that covers more than just the single segment which they characterize. The only possible exception in the present data, is when the utterance-initial segment requires complete closure, which was already there in the pause stage. This ambiguity could occur because surface deformation, that usually accompanies speech (in contrast to pause patterns) often characterizes a 'speech anticipation' gesture overlaid on the pause pattern. However, it is usually the case that a period of static lip separation precedes all utterances except those starting with a class 1 (▷p◁) shape. In this case, a neutral-rest pattern is followed by a 'surface deformation' on a neutral-closed stage of much longer duration than any occurrence of either of [p], [b] or [m] in any context. So, this occurrence must be interpreted as the anticipation of a class 1 sound followed by the sound itself, but difficult to segment from it visually.

It would be very difficult to base the interpretation of speech from visual patterns on four identifiable patterns linked to eleven contrastive sounds. The recognition of these sounds themselves, in fact, involves more than that because each sound is articulated along with a preceding and/or following sound. There is usually, therefore, what I would like to call a "syllabic gesture", which forms the reference point for identification of larger units of speech rather than the individual sound itself. The syllabic gesture involves some type of opening or closing movement from either a recognisable or a vague pattern to another, a movement that can be used to trace the vowel type of each succeeding syllable. The recognisability of the movement depends very much on the similarity or difference between the sequential syllables, primarily therefore, on the type of vowels following each other, since jaw movement usually reflects tongue height for vowels. When syllables contain identical or very similar nuclei (vowels), one movement actually glides over both syllables. Other articulatory organs, primarily the tongue, may be very active at the time, but there are no associated simultaneous visible movements differentiating between them. This merits more detailed discussion with close reference to the data.

13.8. Visible movements

13.8.1. It is difficult to talk of the visible movements of the lips and jaw without reference to the identifiable 'postures' already described as characteristic of certain sound types. In fact, I will be talking of movements as movements to and away from such postures in the case of the dominant sound-types because the more closely I investigate the visible patterns of speech, the more it seems that these posture-types form some of the targets of the movements involved. However, the movements cover a much more complex sequence of non-visible articulatory events than do the posture stages themselves. It is usually possible to identify movements that cover units very close to the syllable in structure. (These are listed as 1, 2, and 3 below.) These movements seem to pattern around a vocalic target, that is, generally, the most open phase of the jaw required for each syllable. I will be dealing here with these movements covering at least the more important part of the syllable, the vowel plus one or more dominant or non-dominant sounds. To do this, I have categorized types of movements that I have been able to identify in the data, as follows:

1. (i) Vowel + Dominant consonant;
   (ii) Dominant consonant + Vowel;

2. (i) Vowel + Non-dominant consonant;
   (ii) Non-dominant consonant + Vowel;

3. (i) Dominant consonant + Dominant consonant + Vowel;
   (ii) Vowel + Dominant consonant + Dominant consonant.

This categorization accounts for all types of (C)(C)V(C)(C) syllables, as well as syllables with an initial CCC cluster, since these simply have an additional dominant or non-dominant consonant.

There are two main reasons for this categorization. The first relates to the identifiability of the four dominant sound-types from the nearest vowel. The overall patterns for ▷p◁ ▷f◁ are easily recognisable from the visual patterns for the vowels; ▷w◁ is identical to ▷u◁ , of course, but does not create any ambiguity since the consonantal versus vocalic status of this sound is related to distributional criteria. The second reason is that it is possible to distinguish between the relationship of a dominant consonant movement to a single consonant from the relationship of a movement to a CV structure, or indeed to any other structure, via the duration of the movement. The movement for a dominant consonant usually includes as an identifiable part of it a vocalic target, as will be seen below. Further, this categorization allows the identification of dominant from non-dominant syllables, i.e. syllables with at least one uniquely identifiable element from others with no easily recognisable components. I use the term 'uniquely identifiable' because it should still be possible to interpret some types of syllables from the visual patterns that do not bear a one-to-one correspondence with a single sound type.

The more complex syllables, in terms of movements involved, are the more easily recognised ones, because separate movements involve different turning-points and, therefore, more information as to the vowel type and the different degrees of openness required for the various components.

Movements are therefore associated with units of sound far larger than the dominant or non-dominant sound to which they relate directly. They can encompass one consonant in a syllable, e.g. contact of upper lip with lower lip in 2.1[1] [m] ; a CV structure that also constitutes a whole syllable, as in the protrusion and upper lip lowering and lower lip raising in 1.9 for [ku] ; part of one plus another whole syllable, in the case of retraction and upper lip raising and lower lip lowering in 1.6 and 1.7 in [ti: hi] ; a CC structure that forms part of a syllable can be covered by one movement uniquely associated with one of the consonants of the cluster, as, for example with the ▷f◁ type movement in 5.11 for [kf] ; whereas, the VC that forms the rest of the same syllable is covered by the two movements of opening from ▷f◁ posture, and back to an ▷f◁ posture for [i:f] , also in 5.11. The same movement can continue for a duration of two syllables in the case of unstressed syllables containing no dominant element, as for example 8.5 and 8.6 [ja - ta] .

13.8.2. In the section that follows, I will be using symbols to summarize the verbal description. These are as follows:

{ }	-	encloses a number of elements only one of which is involved at any one time;
~~	-	refers to lip protrusion;
———	-	refers to lip spreading;
-------	-	refers to neutral posture;

1. The numbers refer to 13.1b, e.g. 2.1 means sentence 2, syllable 1.

.... - refers to the position/movement of the lips as is required for the segment in question (enclosed in brackets);

//////, \\\\\ - refers to raising or lowering of the jaw or lips(as specified) respectively.

 - is superimposed over one or more segments to show that the movement takes place during the duration of all of the segments.

13.9. <u>Movements involving ▷p◁</u>

It has already been shown that the never changing feature of this ▷p◁ class of sounds is the firm contact of the upper and lower lip in what can be called a lip-closure posture. This 'posture' is held in the data investigated for an average duration of 4 frames, corresponding to approximately 7 centiseconds. The very fast movement to closure of the lips probably makes the closure easier to perceive. Closure can occur within two frames (approximately 3.5 centiseconds) even when the previous opening is very great. It seems that the closure is more difficult to perceive (relatively) when it occurs after a sound requiring very close approximation of the lips, as, for example for ▷f◁ . The movement following closure, i.e. the separation of the lips towards another target is much slower than is the movement to closure of the lips.

Simultaneous with the vertical movement of the lips towards each other, are other movements related to the context in which ▷p◁ sounds occur. If movements in the horizontal and/or anterior-posterior direction are required for sounds preceding the stop, the following things can happen during the closure stage of the complex movement.

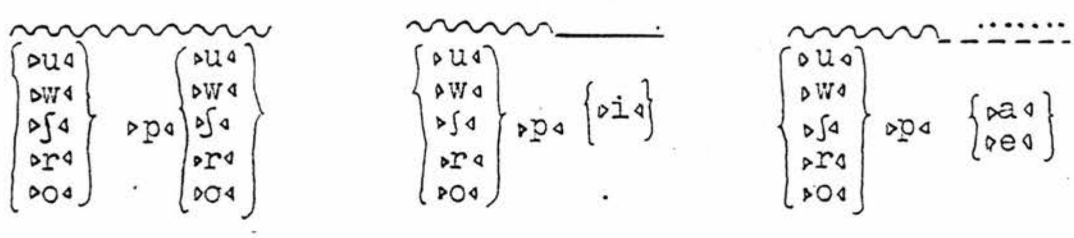
1. In the case of a preceding sound requiring protrusion:-

(i) the lips can continue protruded throughout the closure stage if the following sound also requires protrusion;

(ii) the lips can gradually retract and spread if the following sound requires spreading;

(iii) the lips can retract to a neutral-type posture if the following sound requires lip separation but no significant degree of movement in a horizontal or anterior-posterior direction.

(i) (ii) (iii)



In the case of (ii) and (iii) the movements can be considered the same if the elements preceding are replaced by those following ▷p◁ , and vice versa, but with a reversal in the direction of the movement. Sometimes, the effect of the preceding or following sounds requiring protrusion, can result in horizontal contraction of the lips during the ▷p◁ closure, with little or no movement in the anterior-posterior direction.

2. In the context of a preceding dominant sound requiring retraction, namely, lower lip retraction in relation to the upper lip (which usually is protruded) for the sounds [f] and [v] , then the following movements can take place during the closure stage:-

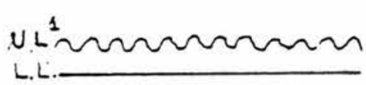
(i) upper lip protrusion and lower lip retraction in an ▷f◁ - type posture (see figure 12.27, p.333) can be maintained throughout the closure, and even during the release of a vowel or consonant requiring protrusion;

(ii) in the same context as (i), protrusion may occur for both lips during the second half of the closure stage;

(iii) a more relaxed contact would replace the ▷f◁ -type posture of the closed lips in any context other than that specified in (i);

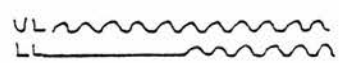
(iv) the upper lip may retract and spread in anticipation of the spreading movement required for the following sound, whilst the lower lip maintains its retracted spread ▷f◁ -type posture.

(i)



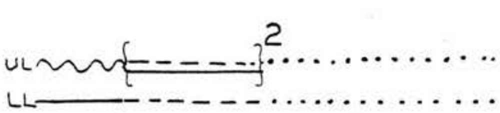
{▷f◁, ▷v◁} ▷p◁ {▷o◁, ▷u◁, ▷w◁, ▷ʃ◁, ▷r◁}

(ii)



{▷f◁, ▷v◁} ▷p◁ {▷o◁, ▷u◁, ▷w◁, ▷ʃ◁, ▷r◁}

(iii)



{▷f, ▷v◁} ▷p◁ {any context except one requiring protrusion}

(iv)

{▷f◁, ▷v◁} ▷p◁ {▷i◁}

---

1. UL = Upper lip; LL = Lower lip.
2. { } means that either movement is possible: --- or —.

13.10. Movements involving ▷w / u◁

The characterizing movement for this class of sound - both lips moving forward in the anterior-posterior direction and contraction horizontally, thus increasing the protrusion effect - usually lasts for much longer than the sound itself. This is a movement that precedes the sound and continues over several sounds when these are not dominant sounds. In fact, protrusion can last over 20 frames (approximately 34.5 centiseconds), that is, over four sounds when these are not specified articulatorily for lip movements. The ▷w / u◁ context affects all sounds preceding and following ▷w / u◁ because both lips contract horizontally and protrude (anteriorly) even in the articulation of some dominant sounds, although this does not happen with the ▷a◁ context. The effect of ▷w / u◁ can occur as far as 5 preceding sounds away, e.g. in 10.3 and 10.4 [tisthu] , or 2 preceding syllables away, as in 13.9 to 13.11 [maj - ri^j - du] , it can continue over a whole phrase if this is interspersed with ▷w◁ or ▷u◁ type sounds, e.g. in 9.5 to 9.11 [ti - tar - u - iz - zu^w - ru - il] , though there are word boundaries that could cause deprotrusion[1], or allow the effects of the context to die away. Thus usually we have:

(i) {any C or V except ▷a◁ and, sometimes ▷i◁} ▷w / u◁ {any C or V except ▷a◁ and, sometimes ▷i◁}

but,

(ii) {▷a◁ / ▷i◁} ▷w / u◁ {▷a◁ / ▷i◁}

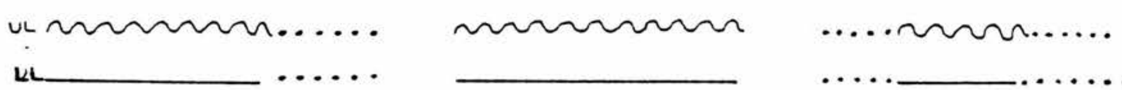
1. Deprotrusion is the reverse movement of protrusion, i.e. the lips retract to a point closer to the teeth.

It is interesting to note that in the $/\left\{\begin{matrix} \triangleright i \triangleleft \\ \triangleright a \triangleleft \end{matrix}\right\}$ ____ or $/$ ____ $\left\{\begin{matrix} \triangleright i \triangleleft \\ \triangleright a \triangleleft \end{matrix}\right\}$ there is sometimes a marked retraction and a compensatory horizontal contraction, so that there is identifiable surface deformation and general lip tension in the articulation of ▷w / u◁ .

13.11. Movements involving ▷f◁

The characterising movement for ▷f◁ sounds - protrusion of the upper lip and retraction of the lower lip in the anterior-posterior direction - is a very dominant one, and is also of a duration longer than that of the sound itself, lasting usually over 7 frames (approximately 12 centiseconds). The ▷f◁ characterising features can affect and can be affected by even dominant sounds, without affecting the identifiability of either. The lip movements required to produce ▷f◁ , usually start during the movement for the preceding vowel, or after the next vowel sound has been reached - in terms of lip separation, or the most open stage required for the vowel. This happens for all vowels. The lower lip is immediately retracted in the movement towards the upper lip. Thus, the transitions from the vowel to ▷f◁ should be characterised acoustically by this definite lip movement. All consonants, however, are affected by the upper to lower lip relationship during their actual articulation, so that, even during a dominant ▷ʃ◁ shape, where protrusion of both lips always occurs, the lower lip is still retracted at least slightly in relation to the upper lip, such that it is quite clear that a ▷f◁ type sound is to follow. When an ▷f◁ sound precedes a ▷ʃ◁ or ▷w◁ sound, there is always a sliding movement of the lower lip upwards towards the articulatory movement required for that following sound; but the lower to upper lip retraction is lost quite quickly. However, when the preceding or following sounds are members of the non-dominant sounds, the ▷f◁ shape dominates the lip movements during the articulation of any preceding or following non-dominant sound, such that, except for the unusually long duration, the visual unit would be considered as corresponding to a [f] or [v] . The movement, as can be seen below, is basically one of upper lip protrusion and lower lip retraction, in terms relative to one another (i.e. the lips):

(i) (ii) (iii)



(i) {▷p◁, ▷ʃ◁, ▷w◁, ▷u◁, ▷o◁, ▷i◁} ▷f◁ {▷p◁, ▷ʃ◁, ▷w◁, ▷u◁, ▷o◁, ▷i◁}

(ii) {▷t◁, ▷j◁, ▷k◁, ▷h◁, ▷ʔ◁} ▷f◁ {▷t◁, ▷j◁, ▷k◁, ▷h◁, ▷ʔ◁}

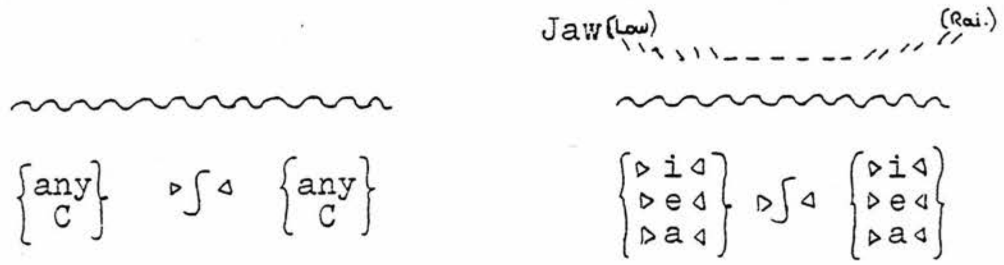
(iii) {▷a◁} ▷f◁ {▷a◁}

13.12. Movements involving ▷ʃ◁

The characterising movement for ▷ʃ◁ is that of upper lip raising, lower lip lowering and simultaneous protrusion of both lips with as little horizontal contraction as possible, resulting in a very large interlabial space all round. These movements usually precede the articulation of the sound itself, and are often maintained well after the end of the production of the sound. These movements operate in very much the same way as those of the other dominant sounds, particularly ▷w◁ , where contextual influence is concerned.

The average duration of the movement is 10.5 frames, approximately 18 centiseconds - the longest of the dominant movements. When the dominant sound ▷f◁ precedes ▷ʃ◁ there is no intermingling between movements, as indicated above.

It is not possible to say how much of the protrusion and horizontal contraction for [w, u, o] is influenced by ▷ʃ◁ ; when ▷ʃ◁ follows these sounds there is a movement of the upper lip upwards and of the lower lip downwards, as well as a curling over of the lips upwards and inwards. Thus, it is still possible to distinguish between the occurrences of the 2 types of sounds. When ▷ʃ◁ precedes dominant sounds, it is slightly influenced by ▷f◁ (see above, under ▷f◁ movements). It is distinguishable from ▷w◁ but it is difficult to say whether it increases the degree of protrusion; it influences ▷p◁ in that there is a marked horizontal contraction before the lips are in contact for ▷p◁ and this horizontal contraction is maintained during the closure stage of the movement. When ▷ʃ◁ precedes the vowels ▷i e a◁ , it sometimes dominates over the lip movement in such a way that the same degree of protrusion and upper lip raising and lower lip lowering are maintained throughout the vowel sound. At other times, lip movement co-occurs except that the articulation of vowel sounds are visually distinguishable because there is a definite jaw lowering, like a sudden jerk downwards, during the vowel articulation. When ▷ʃ◁ follows these vowels, the same even happens in reverse. That is, when the vowel is being articulated, there is upper lip raising, lower lip lowering, as well as protrusion, but the interlabial space is larger than that for ▷ʃ◁ . The vowel articulation is followed by a smart raising of the jaw for the articulation of ▷ʃ◁ . This is probably due to the coordination of mandibular movements with tongue height. The contextual influence of ▷ʃ◁ on the vowel can be summarized as:

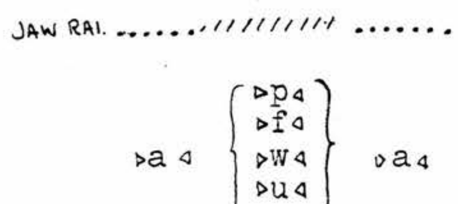


13.13. Syllabic movements : movements involving vowels

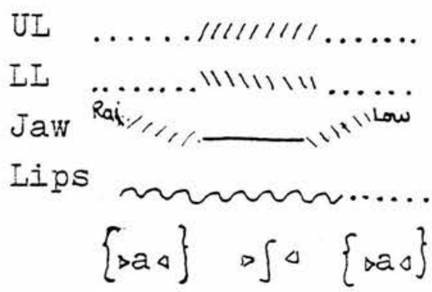
Note: ▷o◁ and ▷u◁ are considered with the dominant sound-classes.

I have already considered the movements required from or to the various dominant sounds. These can be summarized as follows:

(i)



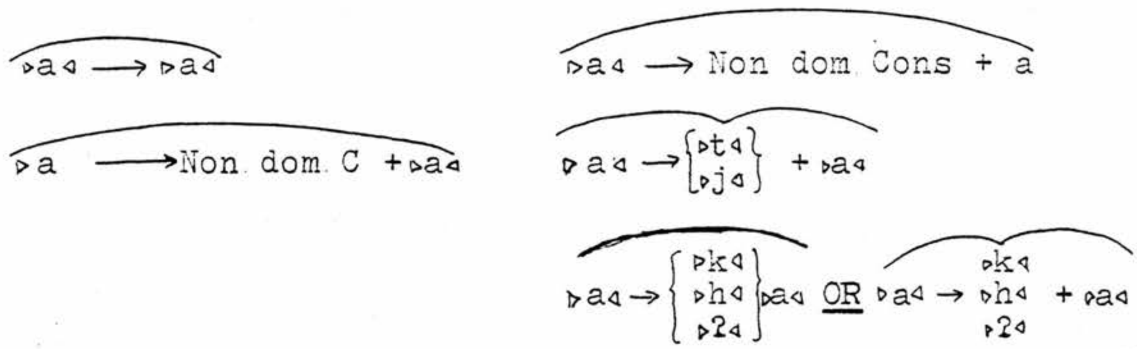
(ii)



I will now consider the movements involving other vowels.

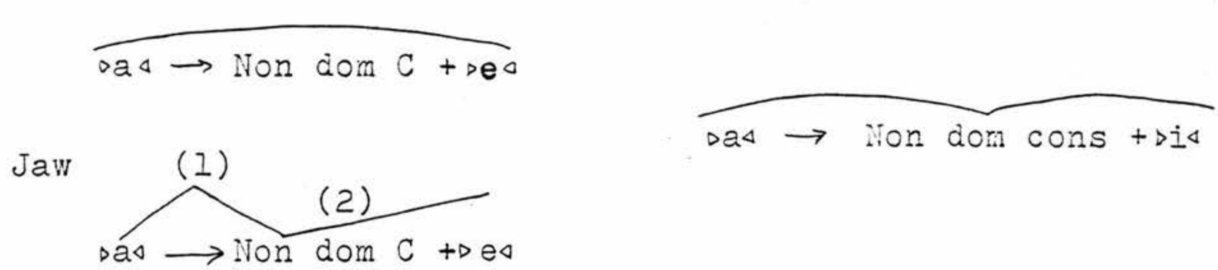
The movement of ▷a◁ to and from another ▷a◁ is often a continuation of the same movement or a retention of the posture reached, such that all visible changes in the direction of the movement take place after the second ▷a◁ syllable and will depend on either the next dominant consonant, if it is a related consonant, or on the type of vowel involved. It will therefore be considered as a type i, ii or iv or v. However, there is often a slight visible jaw movement in the case of the second syllable containing an ▷a◁ vowel, and a preceding non-dominant consonant, such that there is a slight jaw raising movement corresponding to the tongue approximation to the palate when the non-dominant consonant is a front-of-velar consonant. Thus, if ⌒ indicates one continuous movement, (iiia) can be expanded as (iiib):

(iiia) (iiib)



The movement from ▷i◁ involves lip separation and jaw lowering for ▷a◁ jaw raising and lip spreading with a corresponding approximation of the lips (upper lip lowering and lower lip raising) for ▷i◁ , whether or not it is released by a non-dominant consonant. However, when only the minimum lip separation is effected for the ▷a◁ syllable, there is not usually any separate movement for the ▷i◁ syllable:

(iv) (v)



<u>Movements involving ▷i◁ and ▷e◁</u> syllables operate similarly. There is sometimes only one movement covering sequential ▷i◁ and ▷e◁ syllables,

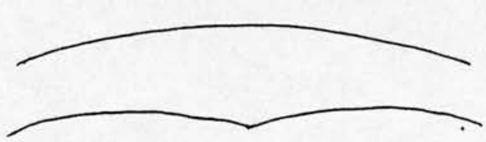
whereas there is rarely only one movement covering a sequence of ▷i◁ and ▷e◁ , or ▷e◁ and ▷e◁ syllables. The 'choice' of a single or two separate movements is usually made depending on:

1) whether the second syllable is stressed or not. When it is stressed, it usually involves a separate movement, although sometimes the first syllable accommodates to the opening required for the second syllable, if that is stressed, i.e. it depends if there is a foot boundary;

2) if the words belong to separate phrases, that is, whether there is a potential pause boundary between the two syllables. In the case of a phrase boundary, the two syllables require separate movements. When one movement covers both syllables, the movement is always of obviously longer duration and, therefore, timing can resolve the interpretation. 'Interpretation', for the moment, is defined as relating the movement with a sound unit, i.e. recognising a sound from its visual pattern.

(i)

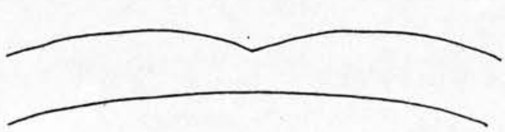
(a) (b)



▷i◁ ⟶ (Non dom C) + ▷i◁

(ii)

(a) (b)

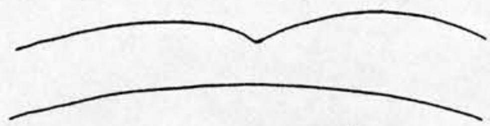


▷i◁ ⟶ (Non-dom C) + ▷e◁

(iii)

(a)

(b)



▷i◁ (Non dom C) +▷a◁

I can see no connection between stress and jaw movement.

13.14. Units in the visual medium

13.14.1. The findings of the present study lead to the postulation of three hierarchical units for the description of the visual characteristics of connected Maltese speech. The minimal unit is that related to the 'posture' because it is essentially the identification of a culmination of a movement from which further movements proceed in a different direction. The visual posture is used in producing a segment in a specific context. This is not the same as a sound in isolation because the implications regarding the movement inside which the posture is organized, differs depending on the context. Thus, /a:ʃ/, /ʃa:/, /ʃi:/, and so on, are all different and these differences have important implications in the interpretation of visual patterns. This is discussed earlier under 'Syllabic Movements'. Some postures are distinctive in that they are uniquely related to a small set of sounds, and therefore directly informative, because we can say that those sounds are visible, but others are not, and therefore are much more ambiguous in that they are relatable to many sounds.

Postures are units that must be posited in the description of the way sounds are seen to be produced; they need not be useful as units in the analysis of perception as they stand. It has already been said that postures are not coextensive with phones in time or size; they are not the visual counterparts of phones. Rather, they are the visually distinguishable features relatable to sounds produced in sequence. Most postures may be related to one specific sound, but may also distinguish, to some extent, the context of that sound.

13.14.2. The minimal unit in terms of which lip patterns have been described has been called the viseme by Fisher 1968. The viseme has been defined as an independently identifiable visual posture occurring during the production of speech, a 'visual phoneme'. However, since no visual posture is ever coextensive with a single phone in continuous speech, the definition is not very accurate. The essential characteristics that can be attributed to a visual posture are that it is visible, fairly stable and therefore describable. "Viseme" seems to be the only coined term for the minimal visual unit. I have decided, however, not to adopt the term because of the misleading association that the word 'viseme' has with 'phoneme'. Instead, 'visual posture' will be used here since no other suitable terms come to mind.

We can say then, that some sounds are identifiable by highly distinctive visual postures; others are produced with visual patterns that are not very distinctive because they occur during several different possible sound sequences. In connected speech, distinctive visual postures usually override the less recognisable ones so that the lips and external mouth area and the jaw are already moving towards the posture required for the next visually distinctive sound. Visual postures are, therefore, not coextensive with phones as to time of onset or duration; they are not, strictly speaking, the visual counterparts of phonemes, but the visual identifiable features relatable to sounds in sequence. Some visual postures may correspond closely to a specific phoneme, but also provide a cue to the identity of the preceding or following sound, whether or not the posture for that sound is distinctive.

13.14.3. The next unit in the organization of visual patterns is the movement. This is a visually identifiable unit during connected speech. It is usually coextensive with one vowel and/or a preceding or following dominant consonant. That is, it is coextensive with a whole or a part of a syllable. A movement is essentially a movement between the articulation of one sound and another even if it does not include any immediately recognisable feature associated with either one or the other of those sounds.

The movement is a 'vetoing unit' and must be considered with its durational or timing features. In connected speech, a 'posture' is only identifiable as the turning point of a movement.

The distinguishable visual postures are reference points in the speech continuum. They are relevant in that they mark time, and therefore mark the presence of linguistic units. They are patterned in terms of movements. They are movement-hinges since the lips must be described in terms of the movement from one sound target to the next. It is difficult to describe postures without referring to the sounds which they primarily characterize. This is because the visual aspect of speech production is not as primary or essential an aspect of speech as the auditory-acoustic aspect. The visual-oral correspondence holds because it is the utterance shape that is being referred to and the utterance is a structure of sounds. The visual patterning can, therefore, be considered as one further step in the decoding process, but there is no direct, intentional visual encoding of speech, except when the lips are primary or secondary articulators. This means that there is no need at all to make articulation visible. Some speakers make very little use of lip and jaw movements in their natural speech. It is impossible to interpret the speech of these people from the visual patterns.

There are, of course, inter-speaker variations as to the number and types of visual postures. Since only two subjects are used in this study, it is not possible to come to conclusions with far-reaching generalizations. Further research will have to be done to investigate the application of this study to a wide number of Maltese speakers.

13.14.4. The movements that have been described are themselves organized within larger units. To delimit and define these larger units, it is necessary to determine the unit boundary and characteristics of these larger units, which, in turn, relate to the rhythmic pattern of the language.

Unfortunately, the set-up for the present experimental study does not allow me more than speculation as to the higher rhythmic units which are used in the organization of the lower linguistic units. To ensure consistent measuring and reliable comparison, it was necessary to use the visiograph set-up described in the previous chapter. This does not allow free movement of the head: in fact, one of the primary purposes of the visiograph was to prevent such movement. Thus, head movement related to stressed syllables, if it takes place in Maltese as it is said to do in English (cf. Brown, 1977) cannot be seen in my data.

The only unit that may be delimited with at least partial reference to the data, is the pause-bounded unit, that is, a unit that is separated from the preceding or following unit by a pause, or an identifiable duration of "non-speech". Thus, each of the 22 sentences could be delimited from the others by an identifiable pause[1]-period, although I (the speaker) read the entire text as connected speech. Moreover, there are three additional identifiable pauses: in sentence 3 between syllables 4 and 5, in sentence 9 between syllables 21 and 22, and in sentence 13 between syllables 7 and 8. These pauses do not interfere with the natural rhythm of the utterances. They cannot be interpreted as hesitations, false starts or stops, change in motor command, and so on. Therefore, they are not misleading as far as visual - or other - interpretation of the speech act is concerned. The experimental set-up, particularly the awareness that no one was being addressed by the speaker, is probably responsible for the scarcity of these natural pauses for breath.

What I am suggesting here, therefore, is that in real speech events, it may be possible to identify two rhythmic units for the perception of visual speech: (1) one unit delimited by such actions as head movement during the articulation of stressed syllables, and (2) the other delimited by pauses (or a sequence of at least two silent stresses in terms of Abercrombie's analysis - cf. Abercrombie 1964) probably directly related to a larger linguistic unit than the foot. This final unit will probably be more useful in lip-reading since it will consist of a large enough sense-unit (in the semantic meaning of 'sense') for a 'closure' (for interpretation) to be made by the lipreader before going on to the next unit. This larger unit is important because sometimes a reinterpretation of the smaller units will have to be made in the light of the information

1. In referring to the data, a pause is also identified as silence in the kymograms.

obtained over all the constituent parts of this larger unit. The use of such a unit, higher up in the organizational hierarchy of visual patterns, has important implications for the ways in which speech can be slowed down optimally for purposes of easier visual interpretation without causing rhythmic distortion. This statement should be considered in the light of the fact that unnatural segmental and syllable timing results in unintelligibility.

Interesting speculation can be made on the synchronisation of facial expression and gesture with larger visual units. However, since the present data does not provide any information at all in this respect, I can only consider the possibility of it happening.

13.14.5. The question of unit size in lip-reading is a very important one. Ideally, the units necessary in terms of short term memory should be delimited. This would include what the lipreader must 'take in' before he or she can close the sense-unit, that is, before making an interpretation of the visual patterns into semantic meaning. The role of memory is outside the objectives of the present study.

The discussion regarding the first two visual-phonetic units attempted was based on the findings of my studies. I could only make tentative remarks on a third unit since this is directly related to the unit that lipreaders use in interpreting speech. This may vary depending on the linguistic ability of the lipreader, as well as on other extralinguistic factors.

13.15. Postscript

13.15.1. Rhythm in Maltese

The study of rhythm in Maltese is outside the scope of this thesis since rhythm is itself a vast field with extensive implications regarding the organization of units further up than the syllable in the linguistic hierarchy. No study has yet been made of Maltese rhythm. However, the following description is based entirely on my own impressions of what Maltese sounds like to me as a native speaker and phonetician. Everything stated here regarding rhythm must therefore be considered as a hypothesis based on aural impressions.

Maltese spoken utterances in a colloquial style, as well as in an ordinary reading style, seem to be organised around small units in which the stressed syllable plays the dominant role. The stressed syllable is given rhythmic prominence in Maltese. If it had to be classified as either stress-timed or syllable-timed, I would not hesitate to say that it is stress-timed. It would then be immediately implied that the rhythmic "feet" (units consisting of the stressed syllable and all further unstressed syllables up to, but not including, the next stressed syllable) are impressionistically, at least, isochronous. This would immediately place Maltese in the same class as languages like English in terms of its rhythmic basis - an inevitable consequence since English is one of the most extensively studied stress-timed languages. Furthermore, isochrony entails a great deal of modification of the unstressed syllables usually in the form of vowel reduction, both durational and qualitative. In English, this is made possible by the weakening of unstressed vowels. Maltese, however, cannot be classed with English in the way it organizes its rhythmic units around the dominant stressed syllable. Maltese does not tolerate the extensive weakening that takes place in English, where many unstressed vowels become centralized. There is much more isochrony at the syllabic level (regardless of stress) than there is in English, but, possibly, other things happen that probably do not happen in languages such as French which are clearly syllable-timed.

I believe that the native speaker's expectations and what he actually hears are both relevant considerations in his perception of rhythm. Unfortunately, the way stressed syllables are made prominent and the way unstressed syllables are adjusted cannot be dealt with here.

13.15.2. Timing

The timing of articulatory events in speech is crucial in the study of both speech production and speech perception.

> "A spoken word is itself an unfolding event, and to describe it one must consider how it develops in time." (Nickerson et al. 1974 p.2)

Several studies have been made on normal and fast reading speeds and on optimum rates for the perception and understanding of the spoken medium via the auditory channel.

In production, the timing of speech events is important for basic intelligibility. It seems that if the overall rhythm of speech is maintained, the physical speech event can undergo a great deal of distortion and still be intelligible. Speech that is too slow, containing more and longer pauses, and that shows no grouping beyond the segmental, i.e. phoneme sequencing, is very difficult to understand and even to listen to.

It is considered unnatural and the speaker is said to have abnormal speech.

Not a great deal is known about the organization of speech events into correct or optimum timing patterns. Investigations of degrees of intelligibility (e.g. Hood 1966) suggest that temporal fluency relies on the timing relationships at the segmental, but especially at the syllabic level, with a good rhythmic pattern in which stressed and unstressed syllables are well differentiated in stress-timed languages. Timing is important in that several cues about other phonetic features such as voicing, or even stricture type, are very closely tied up with, or are, in fact, derived from the modification of segment duration in particular contexts. Several of these modifications are language specific, but there are probably many widespread similarities in segment-timing relationships. Modification of the duration of unstressed syllables and of stressed syllables in relation to each other is vital to building up a rhythmic pattern in stress-timed languages. Analyses of the speech of hearing-impaired speakers show that they are often unable to adopt appropriate timing patterns in their spontaneous speech and their reading, thus failing to provide the listener with informative cues from even the segmental level of production. One reason for this is that they devote too much effort in attempting to enunciate phoneme-sequences without any attention to the overall effect.

> "Apparently, the effects of context are not simply the results of undershoot in items in a sequence of individual invariant articulatory targets when the commands to produce these targets occur in rapid succession. There appears to be a reorganization of the motor commands for a given segment depending on the context and on the timing constraints. It is as though the speaker has a variety of ways of producing the gesture for a given speech sound, and in a given situation he selects a particular one of these. These observations indicate the difficulties that face

a deaf child when he is learning to produce speech with the proper temporal characteristics." (Nickerson et al 1974, p.12)

Timing has been an important consideration in this study. Some attention has been given to segmental timing, i.e. the duration of vowels and of consonants in different phonetic contexts (chapter 6 and chapter 10). The timing of lip patterns and of jaw movements is also studied here. The particular questions asked here in relation to visual patterns are:-

1. How long does a visual 'posture' last?

2. How long does the movement approaching the visual posture go on for, and, further, when does it become clear to the lipreader that a particular posture is being approached?

3. How long does it take for a posture to die away and when is it clear that a different movement is being made?

The answer to these questions provides most of the necessary information regarding the dominance or weakness of the visual patterns corresponding to sounds in relation to each other - since most speech sound types are examined in all possible combinations.

The timing of events - the approach, arrival and dying away stages of the visual patterns - are also crucial in establishing a unit or a hierarchy of units (i.e. in finding out how units are organized at different levels). The answer is not a simple one. It was seen, in the section on studies of coarticulation that the data is not always self-evident. My own observations and studies have led me towards the view that some visible patterns point to a unit larger than a single consonant phoneme or a single vowel phoneme. Very often, a visible pattern relates to both at once.

It may be concluded, therefore, that a visible pattern relates most directly to the syllable, or at least to the syllabic nucleus. The anticipatory effect of vowels on preceding consonants is such that at the arrival stage of a posture, the next movement can also be assessed to some extent, in some cases more than in others, as is described in sections 13.9 to 13.13. I have posited a visible unit, a posture, and would now like to show how it is relatable to what could be a syllable, but is often more than a single syllable, and sometimes a part of 2 syllables. The identifiable 'posture' as a visual unit is related to the following possible sequences of phones in speech:

V C : when the following consonant has some effect on the preceding vowel, but is usually not very dominant, e.g. /iʲt/ /as:/

C V : when the vowel pattern can be seen during the articulation of a stable consonant, e.g. /pa/ /ʃi/

C C V : as with C V, but with one consonant being unstable and therefore not being represented visibly, e.g. /dʒdiʲ/ /pta:/

C C C V : as with C C V but with two unstable consonants not being visibly represented, e.g. /ʃtra/

V : when the vowel is either represented by two visual units, one during the vowel tongue-articulation for the vowel itself, and the other anticipated in the consonant, or when the consonant articulation is incompatible with the vowel articulation, or so dominant as to prevent coarticulation, e.g. /pu/ /fo/

C : as with V when the consonant is very dominant, e.g. /ʃ/ .

In other words, this visual unit is truly related to either (1) a single vowel, (2) a single consonant, (3) a CV sequence, or (4) a VC sequence or a CCV or CCCV sequence. In this case, however (i.e. (4)), the sequence would hardly qualify as distinct from a V or CV sequence, except insofar as duration is used to disambiguate between possible sequences.

13.15.3. Limitations

The fact that the lips are not crucial to the production of intelligible speech does not enter into consideration here. Ventriloquists cannot be lipread, neither can speakers who make very slight lip and jaw movement. Most speakers do use their lips during natural speech and the lip movements which they make in speaking a particular language are patterned quite consistently. This will, therefore, be considered as the norm.

Ballard and Bond (1960) conclude from their study that oro-facial behaviour for acceptable speech can vary significantly in any community, due to physiological differences and community patterns. Certainly there is great variation among speakers. At one extreme, a few speakers in fact can be said to have two basic lip positions: (1) for /p/ /b/ /m/ - lip contact; (2) lip separation for all other sounds. Problems arise when the speaker has asymmetrical speech (where use is made of one side of the mouth more than the other, and therefore, one side of the lips moves much more noticeably), when the speaker has very thin or very thick lips in comparison with the speakers that the lipreader has been used to. A different visual frame of reference must be set up to retune to such visual postures as lip spreading, lip protruding, and so on.

Arguments about ideal speaking conditions for lipreading lead nowhere. Lipreading cannot take place efficiently in conditions of poor lighting and other physical factors (such as a moustache). Even in the best conditions, it is only partial data for decoding speech. It must take place in a situation where a great deal of guesswork can be done. The narration of a fatal accident by a giggly speaker would never be correctly interpreted by even the most expert lipreader. A good knowledge of the language, the speaker's physical make-up and his speech habits, and a clear idea of the situational context goes a long way towards successful interpretation of lip patterns. Speech is several times removed, in the course of the coding process, from what can be loosely termed as 'that which is to be communicated'. Various complex factors are involved in the decoding journey, amongst these being: what is assumed by the speaker, what is expected by the listener, and what is understood but not expressed verbally, and so on.

A P P E N D I C E S

APPENDIX A

Appendix A.

Use of Available Methods for the Description of Vowels

It is surprising to find that the Cardinal Vowel system is the only internationally communicable system for referring to vowels without having to actually reproduce them. Even then, phoneticians' decisions as to where vowels should be placed on the Cardinal vowel chart vary quite widely, depending on where the phoneticians were trained. Ladefoged (1959) shows that this system can only be used after rigorous training within the Jones-tradition. The further removed phoneticians are in the apostleship-line from Jones, the more widely do their decisions seem to vary. However, Laver (1965) shows that it is possible to use the system quite accurately and efficiently when the sounds investigated are heard repeatedly and reexamined over a period of time by phoneticians trained in the auditory values of the Cardinal Vowels.

Part III is an attempt to clarify articulatory and acoustic details regarding the Maltese vowels. The Cardinal Vowel system uses auditorily defined reference points that leave ambiguities regarding important aspects of vowel production and perception. The auditory description needs to be supplemented by other forms of description including that of duration and lip position.

The vowels, like all other speech sounds, are not events that continue unchanged over a period of time. They are, in fact, also the results of movements from preceding sounds to following sounds. However, it does appear that their characterizing quality - the sound 'heard' by the native speaker - is achieved during the point in time when the tongue is positioned in a particular relationship to the palate (and accompanied by a specific lip position) rather than by the movement preceding or following this 'state' (Delattre 1964). This perceived stability, though very transitory (as short as 2 or 3 centiseconds according to Delattre 1959, Lehiste and Peterson 1961) seems sufficient to allow the listener to identify a vowel.

In spite of the relative instability of the formants during vowel production, we can still talk about the perceived 'steady state' of vowels in reference to acoustic terms. The term 'peak' is used here to refer to the climax of a movement, for example, most spread or most rounded with reference to lip movement, most close or most open with reference to tongue approximation towards the palate and so on, during the production of a vowel. It has been shown that although it is difficult to identify such a short duration of 2 or 3 centiseconds in the spectrographic pattern, as equivalent to a steady state in a vowel of longer duration, the peak (or near-target) can be defined as the point when a change is noticeable in the direction of the formants.

> "...usually somewhere within the syllable nucleus ...a noticeable change in the slope of the moving formants" (Lehiste and Peterson, 1961, p. 272).

The description in chapter 7 assumes such a vowel peak or target. It does not refer to where the tongue came from or which direction it is headed for. However, reference to such direction of movement is made in the description of the articulatory function of the lips, where the concept of element-dominance is also introduced. A discussion of the influence of phonetic context is also included with the study of consonants in chapter 9.

Descriptive Parameters for the articulatory and acoustic description of vowels, and general discussion

Vowels have been studied extensively in innumerable places with reference to very different languages. In most cases, articulatory studies have been concerned with describing vowels by means of three parameters:-

1. The height of the tongue in relation to the palate, i.e. the degree of raising of the body of the tongue;

2. The place of the highest part of the tongue in relation to the palate, i.e. the position of the tongue with reference to the front-to-back dimension of the vocal tract;

3. The position of the lips.

The reason for this is that during the production of vowels air is allowed to leave the vocal tract relatively unobstructed and hence no characterising stricture is formed by the articulators (as occurs in producing some consonants). Vowels are:

> "voice (voiced breath) modified by some definite configuration of the supraglottal passages, but without audible friction". (Sweet 1906)

In spite of the physical differences between speakers' vocal tracts the vowels produced can still be considered the 'same' in auditory terms. This means that some compensation in the total configuration is made by the individual speaker in accordance with such movements as tongue raising in relation to a very deep versus a very shallow palate. Since the resulting similarity is an auditory one, the three parameters on which the Cardinal vowel system is based can only be auditory. Naturally, these auditory parameters are closely related to articulatory ones and are in fact defined as such. Hence, training within the Cardinal vowel system can be regarded as an individual's ability to relate an auditory reference point to an articulatory one. A vowel is placed at a certain distance from a CV on the basis of how the listener interprets it proprioceptively in relation to the articulatory difference it entails from that CV insofar as the listener is concerned. This means that the listener recognises a vowel with reference to a CV only if he can relate both directly to his own articulation. So, the CV chart is an auditory representation of articulatory facts. However, the two-dimensional graphic representation and the spatial relationship between the points of reference can be and often are misleading since the points on the CV chart do not hold a one-to-one relationship with articulatory points of reference. Partly due to the schematization of the vowel area into a simple diagram, the spatial distance between the vowels on the chart ignores such dimensions as lip position, jaw position, pharyngeal constriction, air pressure and, most important of all, the shape of the tongue. One common criticism is that the back and the front vowels are placed on equidistant points on the chart but the place of articulation difference is not the same for these two sets. On the other hand, identification of one vowel with reference to a set of vowels seems to be the usual method by which a listener identifies the vowels of each speaker he meets (Ladefoged 1967). This point is discussed further in the chapter on Vowel Perception.

Ladefoged 1959 introduces a three-dimensional diagram to represent the third parameter, lip rounding, which is not included in the traditional quadrilateral. Yet he summarises his view:

> "These dimensions are not the most appropriate parameters with which to specify vowel quality" (ibid. p.103)

because of the relevance of:

> "a third auditory dimension for which there is yet no convenient name nor adequate data concerning its data" (ibid.p.103)

and,

> "this feature of vowel quality is not easy to assess in auditory terms alone" (ibid. p.102)

Catford 1977 discusses the possibility of describing and classifying vowels in a way that parallels the traditional consonant classification system by location and stricture. He calls the vowels "approximants" (Catford

1977, p. 164) and represents the vowel space as a segment of a circle which he calls a "polar co-ordinate" vowel diagram, thus integrating vowels into his general classification scheme. The scheme reflects the aerodynamic aspect of the vowels. However:

> "though obviously more 'rational' than the traditional system, it is much more difficult to use in practice. It seems easier to slide the tongue as a whole vertically or horizontally, rather than along the radii of the polar co-ordinate system; assessment of the relationship of vowels to CV is thus easier using the traditional figure.
>
> In the second place, the traditional quadrilateral is more appropriate than the polar co-ordinate system for the display of various types of vowel systems that match up with the quadrilateral much better" (ibid. p. 184)

> "There appear to be two reasons for these anomalies, an acoustic one and a physiological one. If we plot the Cardinal Vowels on an acoustic formant chart, showing the values of F_1 reading downwards on the vertical axis and the values of F_2 reading right to left on the horizontal axis, we get an arrangement not very dissimilar from the shape of the Cardinal Vowel chart, as in figure 55. It is clear from this chart that, in terms of values of F_1 and F_2, i , a and u are, acoustically,[1] the most extreme or most differentiated vowels, and the CV chart displays this feature more clearly than the polar co-ordinate chart.
>
> The physiological (and psychological) fact is... that judgements about the articulatory postures of vowels are chiefly based on proprioceptive information from the intrinsic and extrinsic muscles of the tongue. Now, to a large extent, the muscles involved in the production of close vowel positions are the same - whether these vowels are front or back - namely, the geniohyoid and the posterior fibres of the genioglossus, which bunch the tongue up by pulling the hyoid bone and the tongue-root forwards; the longitudinals, which aid in tongue-bunching; and the stylo-glossus, which helps in raising the tongue. Likewise, the muscles that retract the tongue are to a considerable extent the same (to a greater or lesser degree - the glossopharyngeus and hyoglossus) whether these vowels are close or open. It is not surprising, therefore, that both close vowels (as opposed to open vowels),

> and back vowels (as opposed to front vowels) 'feel' like natural classes, whereas the series i-i-u-o- - , which certainly forms a 'natural' class of peripheral 'narrow approximant' vowels, does not in fact 'feel' proprioceptively like a natural class."
> (ibid. ;.186)

The main differences between these two approaches is a matter of selection forced by the two-dimensionality of both the Jones and Catford diagrams. Jones chooses to place the CV on a scale directly related to auditory differences; Catford chooses to relate the vowels to each other on a stricture and location basis. Ladefoged shows how the third dimension could be represented but does not, to my knowledge, make use of it in his own studies. The usefulness of either system can only be judged by its practicality in the description of human vowels which are always spoken in a specific context and do not necessarily retain that quality that is most distinctive when they are spoken in isolation.

It seems that, theoretically, a total representation of vowels that includes all the relevant parameters is ideal because such a scheme will show the resulting quality of the vowel. In practice, it remains important to be able to isolate each parameter for the sake of comparison in referring to the physiological aspect of vowel production.

APPENDIX B

Appendix B

Data for the Study of Vowel Duration

The words listed below make up the data for the study of vowel duration reported in chapter 6. They are classified to enable easy reference from the text. The duration values in milliseconds are listed immediately after the phonemically-transcribed words. The values for informant 1 appear first and those for informant 2 follow. (Thus, bi^{j}k 220, 290, 220 under "/i^j/ Monosyllables" should be read: /i^j/ in the monosyllabic word /bi^{j}k/ was 220 ms. and 290 ms. in two repetitions of the word, as read by informant 1, and 220 ms. as read once by informant 2.)

/i^j/

Monosyllables

(19; 17)

bi^{j}k	220,290;220.
ki^{j}f	290,240,150; 220.
fi^{j}k	300,200;170.
ʔmi^{j}s	270;225.
ti^{j}p	160,280,165; 200.
hi^{j}t	160;215.
bi^{j}t	-;210,230.
di^{j}k	170;180.
fi^{j}ŋ	140;230.
qsi^{j}m	240;275.
ki^{j}t	280,155;190, 225.
si^{j}t	-;230.
dʒi^{j}p	-;200.
fti^{j}t	-;210.
i^{j}t	-;245.

Multisyllabic - Stressed

(73;50)

it:ˈi^{j}ni	-;110.
ˈpi^{j}ter	-;120.
ˈbi^{j}du	-;85.
ˈbi^{j}na	-;175,120.
ˈʔi^{j}ma	-;160.
ˈli^{j}ma	-;180.
ˈpi^{j}ŋa	160;200.
iˈri^{j}dni	-;190.
ˈhi^{j}tha	-;170.
ˈʃi^{j}ni	-;185.
ˈbi^{j}da	-;180.
taˈbi^{j}p	260,150;205.
taˈbi^{j}ba	170,160;160.
ˈpi^{j}pa	170,170,110; 150,180.
ˈpi^{j}ka	180,170,140, 110,160,120, 105;140.
ˈbi^{j}gi	240,210;145, 175.
ˈti^{j}gra	200,180,160; 140.
ˈfi^{j}kom	160,150;105.
ˈfi^{j}ni	-;210.
ˈi^{j}sa	-;140.
ˈi^{j}dek	130;160,65.
timˈʃi^{j}ʃ	-;175.
titˈwi^{j}ʃ	-;220.
nikoti^{j}na	180,140; 85.
ˈfi^{j}kom	-;115.
hamˈji^{j}ŋ	-;130.
ketʃ:i^{j}ni	-;80.
ˈbi^{j}kom	190,180;165.
bok:i^{j}n	220,200,130; 220.
ˈti^{j}na	160,180,120; 195,115.
ˈkni^{j}sja	100;140.
ˈktʃi^{j}na	125;195.
parˈti^{j}t	135;200.
tkiddˈni^{j}ʃ	145;190.
irbi^{j}t	220,180,175; 220.
mentˈni^{j}ʃ	80,190;185.
ˈti^{j}tlu	180;165.
inˈti^{j}k	280,165;180.
gowlˈki^{j}per	140,120; 100.
karˈotsi^{j}n	230;65.
diˈki^{j}t	270,190;170.
ˈni^{j}na	170,160; -.
ˈtʃi^{j}na	170,200; -.
ˈfi^{j}na	190; -.
ˈki^{j}na	180; -.
*irˈki^{j}k	200,140;140.
ˈi^{j}di	190,160; -.
ˈi^{j}du	160,180,160, 60; -.
diˈki^{j}da	140,70,170, 160; -.
*irˈpi^{j}t	185; -.
*pok:i^{j}n	155,155; -.

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Monosyllables (44;15)

zi:t	-;235.
kti:p	210;245.
pi:t	210;245.
mi:t	190,200;210.
ki:n	170,180,140,240, 220;265.
pi:k	-;265.
tʔi:ʔ	150;265.
bi:p	230,180;295.
ski:t	290,160;250.
ksi:h	230;260.
tni:t	-;240.
fi:ʔ	-;280.
fi:h	-;260.
smi:n	-;240.
hi:t	160;220.

Multisyllabic Stressed

(75;45.)

ˈpi:tru	200,200,145; 185.
maˈdi:ʃ	260,200;200.
ˈpi:di	260,220;215.
ˈbi:du	260,220;200, 220.
ˈdi:ta	240,230,210; 220.
ˈfi:tel	250,200,190; 185.
ˈsi:fer	220,220;65.
tuˈf:i:ha	150;170.
duˈb:i:na	230,155;205, 190.
ˈpi:gi	200,220,250,170; 220,240.
o:tɨ:n	140;240,310.
kef:i:na	140;220.
ˈʔi:ma	-;230.
ˈzi:da	-;220.
ˈpi:na	-;295.
ˈmi:ʃi	-;195.
ˈni:ʃef	-;205.
it:i:ni	-;240.

'dʒi:ta	-;205.
'wi:sa	-;210.
'ri:dna	-;195.
'hi:ta	-;215.
'ʃi:ni	-;260.
'bi:da	-;160.
'si:ket	-;185.
'pti:hi	170;195.
ru'm:i:na	160;240.
'bni:sa	145;190.
ketʃi:ni	220,200;195, 190,210,265.
'iksi:h	230,170;170.
il'ksi:h	230,180;190.
iti:h	310,110;235.
it:i:h	300;220.
meʃ:i:h	190,160;230.
'ski:ken	230,200;195.
kit:i:ba	230,210;155.
kiti'bi:la	-;230.
at:i:h	-;180.
'bi:dja	240,210; -.
tuf:i:h	220,160; -.
dub:i:n	280,220; -.
*'pi:ki	75; -.
*tu'p:i:na	160; -.
*'ti:ta	160; -.
'ti:kol	240,220,180, 155; -.
'ki:ku	220,140; -.
kit:i:p	270,170,270, 190; -.
'ki:fer	220,220; -.
'hzi:na	260,240; -.
nidʒ:i:let	240,180; -.
'i:bes	220,160; -.
'i:kol	240,180; -.

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<u>Monosyllabic</u> (20;9)

fe:m	180,250,240,310; 280.
de:p	320,310,240;265.
te:m	240;260,255,250.
be:t	330,270;260.
de:n	-;300.
se:m	-;220,185.
*pe:k	215,180,300; -.
*ke:p	205,340; -.
*ke:k	170,270; -.
te:mt	160; -.
te:	290; -.
metʃ	220; -.

<u>Multisyllabic Stressed</u>

(26;15)

'be:ta	-;250,230.
'de:ni	-;220,250.
'de:ba	-;195.
'be:da	-;225.
'be:dni	280,300;240.
'be:tni	140,220,230;195.
'tʃe:da	290;230,210.
'e:ni	-;270.
'te:tnu	220,220;165.
'de:ʃa	280,250;240.
'fe:ma	260,240;260.
'de:ra	-;265.

/a:/

<u>Monosyllables (16;16)</u>

ʔa:t	-;160,225.
ʔa:m	-;210,245.
sa:m	-;210.
da:m	-;235.
ka:s	200;205.
a:m	-;265.
a:f	-;265.
ta:m	-;235,200.
a:t	-;260.
ba:t	230;215.
ra:t	-;160.
spa:k	210,180,310; 230.
tʃa:ʔ	200;245.

<u>Multisyllabic Stressed</u>

(60;47)

'imka:tar	215,280;135, 200.
'ta:ni	-;200.
'ma:na	200;235,230.
at:en'ta:t	-;190.
im'ta:ten	215,280;215.
mate'fa:ʃ	-;210.
'na:fek	220;185.
tisku'za:h	-;155.
mak:i'narju	-;205.
mate'ma:tika	-;145.
sit:a:ʃ	-;230.
nutʃ:a:li	-;220.
tik:unten'ta:h	-;215.
pu'za:ti	-;220.
atʃa:n	270;215.
tak:wis'ta:	-;245.
itʃ:as:a:	-;220.
inkaʃ:a:t	-;200.
'da:ra	-;240.
'a:ksa	180,190,260;175.
'ma:k:es	140;145.
kap'ta:n	-;220.
'ta:tom	-;235.
'a:ti	-;220.
tim'pa:na	-;205.
vul'ka:n	-;200.
inkaʃ:a:t	-;200.
'ka:na	-;265.
'a:na	-;295.
'ha:mi	-;280.
'ha:li	-;245.
'ha:mja	-;200.
ʃur'ba:n	-;245.
'a:dam	-;230.
'a:ni	-;250.
'a:da	-;240.
'a:dma	-;210.
'a:ʃwa	-;230.
'dja:ra	-;300.
'ʔa:lu	-;265.
'ba:la	-;260.
'fa:ru	-;245.
'ta:ti	-;225.
'ra:tom	-;195.
'ma:kom	240,180;220.
'pa:tʃi	180; -.
'pa:ga	220,270,240; -.
'pa:pra	175,120,220; -.
kan'ta:ta	200,200; -.
ir'ta:b	200,225,300; -.
ins'ta:p	200; -.
tu'z:a:na	180; -.
'a:tu	215; -.
im'ha:tra	190; -.
it:a:ma	250,220,200; -.
'da:ta	240; -.
'kma:mar	155; -.
'tna:bar	175; -.
tmin'ta:	200; -.
'pa:tri	200,170,220; -.
timpi'ka:ʃ	220,200; -.
*'pa:ka	175,175; -.
'ka:ki	180,270; -.
'a:ma	260; -.
'fa:ma	100,200; -.
'a:ndi	200; -.
'a:dʒ:el	220,200; -.
'a:tsa	250,200,210, 150; -.
'da:mu	240,180; -.
'ta:tu	240,180; -.

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<u>Monosyllables</u> (20;11)

no:m	220;215.
sko:p	290,210,190; 215.
ko:k	280,300,240, 165;175.
to:n	230;200.
ko:s	195;220.
bo:t	200,310,280, 240;270.
mo:t	190;250.
lo:p	-;255.
mo:s	-;275.
so:t	-;285.
flo:k	-;135.

<u>Multisyllabic Stressed</u>

(27;36)

'o:du	-;180.
'o:lə	-;160.
'sko:la	-;235.
'ko:la	-;235.
'ro:ta	-;220.
'o:la	-;240.
'so:da	-;220.
'o:tja	200,200;225.
'po:plu	220,210,200, 150;220.
'sko:mdu	140,200;185.
'no:li	200;235.
ir'to:t	-;245.
'to:kis	-;195.
'do:da	320,270;220.
'to:ga	320,230;220.

ˈto:ma	280,240;235.
ˈko:ka	260,215;210.
ˈsto:na	320,240;185, 280.
ˈo:pra	180;210.
iˈs:o:gra	190;210.
toˈp:o:ni	190;260.
kusˈto:dju	-;215.
ˈo:mja	-;235.
ˈmo:li	-;240.
ˈko:ma	-;200.
ˈo:du	-;280.
ˈo:d:a	-;195.
ˈo:nja	-;220.
ˈro:da	-;240.
ˈmo:la	-;235.
ˈdo:mna	-;200,195.
tiˈs:o:gra	-;170.
fatʃ:o:l	-;210.
toˈp:o:ni	-;245.

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<u>Monosyllables</u> (23;19)

tu^{w}t	230,300,300, 220,280,270, 180,180;230.
bu^{w}t	-;215.
du^{w}t	280;235.
tsku^{w}k	240,155;175.
mu^{w}t	270,210;195.
ku^{w}s	230;220.
bu^{w}s	230,180;225.
tu^{w}k	155;220.
dnu^{w}p	140;170.
bu^{w}t	280,320,250, 215; -.
*pu^{w}t	200; -.

<u>Multisyllabic Stressed</u> (65;50)

ˈnu^{w}na	220;200,225.
gusˈtu^{w}s	280,240,230; 220,250.
ˈpu^{w}pa	160,115;160.
lamˈpu^{w}ka	140,180,110, 130;160.
ˈʃku^{w}ma	160;205.
munˈtu^{w}n	240;135,185.
ˈmu^{w}tu	170;155,150.
briˈk:u^{w}n	230,230,175, 175;260.
ˈtu^{w}bu	210,220,160; 205.
taˈk:u^{w}na	190,210,140, 125,150;210, 215.
inˈtu^{w}k	280;225.
ˈʃku^{w}pa	190,140,140; 165.
ˈku^{w}tra	180,180,200, 140;180.
akˈsu^{w}k	230;185.
itsˈku^{w}k	240,160;200.
maˈdu^{w}ʃ	280,220;240.
basˈtu^{w}n	300,195,185; 250.

ˈdu^{w}du	240,240;220, 215.
ˈbu^{w}tu	250,220;185, 165,205.
inˈdu^{w}na	220,210;230, 220.
faˈmu^{w}s	280,280;220.
mikˈtu^{w}p	145,170,160; 200,210.
otˈtu^{w}bru	115;145,200.
fliʃˈku^{w}n	170;175.
buˈt:u^{w}na	-;210,170.
ˈhu^{w}ta	-;160.
ʔaˈt:u^{w}s	-;260.
ˈhu^{w}ti	-;215.
kaˈnu^{w}n	-;250.
karˈtu^{w}na	-;210.
barˈku^{w}n	-;240.
kareˈt:u^{w}n	-;260.
nerˈvu^{w}s	-;215.
ˈtu^{w}tu	-;240.
piˈt:u^{w}ra	-;200.
puˈtru^{w}na	-;200.
maˈdʒ:u^{w}r	-;135.
manˈdu^{w}ʃ	280,260;275.
maˈru^{w}f	230,180; -.
*puˈt:u^{w}na	130; -.
*poˈk:u^{w}n	165,160; -.
*piˈk:u^{w}n	170; -.
*tu^{w}pu	155; -.

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<u>Monosyllables</u> (6;7)

tʃint	130,60;155.
bint	130;145.
hit:	110;120,130.
tʃik:	80;110.
mit:	160;130.
bit:	-;140.

<u>Multisyllabic Stressed</u> (78;73)

ˈbid:el	120,100;100.
ˈbit:ra	90,80;80.
ˈbidla	110,80;100.
biˈdila	140,160;95, 115.
ˈtider	90,80;65.
tiˈʃel	80,90;90.
ˈʃitel	80,70;80.
ˈkitla	120,120,120, 50,55;85.
ˈtimʃi	70;90.
ˈpits:i	80;100,75.
ˈbinti	90;125,105.
ˈdʒisem	90;80.
ˈpindʒi	50;110.
irkipta	70;80.
id:ispra	80;90.
indʒˈbit:	115;175,155.
zeˈf:ina	-;95.
ˈipki	70;100,70.
ˈiktar	100;70.
ˈfit:eʃ	55;90.
ˈmis:ni	100,130;65.
ˈbiret	-;95.

ˈis:a	-;90.
ˈdit:a	100,80;80.
ˈbidu	-;95.
ˈbina	-;100.
ˈmin:a	80;65.
ˈpit:er	80,80,80,100; 95.
ˈpin:a	-;80.
ˈbiret	-;105.
ˈmiʃi	-;70.
ˈniʃef	-;75.
ˈwisa	-;80.
ˈridna	-;160.
ˈhit:a	-;90.
ˈʃini	-;105.
ˈsiket	-;80,70.
ˈsik:et	100,60;60.
ˈnivda	-;65.
ˈkidba	-;70.
ˈnifet	-;95.
ˈkitep	70,90,80,65,45, 60;75.
ˈtitwi	-;100.
ˈsit:a	60;95.
ˈspik:a	80,80,80;90.
ˈbitha	70;160,80.
ˈtnif:es	50;85,75.
ˈitni	70;90.
cek:nitu	55;65,80.
ˈibni	95;115.
ˈsipta	80,50;60.
it:ifel	90,70;80.
ˈitfa	80,90;85.
ˈʃita	90,80;70.
ˈmiksi	80,80,150,50;45.
ˈnitfa	100;85.
ˈkik:ra	80,40;80.
ˈiskot	80,60;75.
et:ila	-;90.
ˈfit:eʃ	-;70.
ˈzifen	-;130.
ˈzif:en	-;100.
ˈrikep	-;95.
ˈbitha	-;80.
ˈkiber	90,60; -.
ˈbnisa	70; -.
*tit:a	60; -.
*kiper	60; -.
*kip:er	55; -.
piˈt:u^{w}r	55; -.

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<u>Monosyllabic</u> (9;6)

pet:	165,120,180;160.
hen:	100,150;235.
ken:	150;165.
kem:	160;180.
met:	150,130;160.
tem:	-;180.

<u>Multisyllabic Stressed</u> (102;58)

ˈtmeʃ:i	65;100.
peˈpe	160;105,85.
ˈpetne	190;120.
ˈbek:a	140,140,140,110, 120,130;100.

imˈtet: 160,140,150; 145.
ˈteba 110,120,120, 140;100.
ˈdeb:a 130,140,150, 160;120.
ˈteb:a -;100.
ˈpesta 100,90;125.
ˈʃeba 140;110.
ˈʃeb:a 200;120.
ˈmeʃa 100,100,100, 140,140;105.
ˈmeʃ:a 80,120,120, 100,105;85.
ˈnemla 120;105.
ˈnem:en 100;105,110.
ˈfenek 140,190,100; 120.
ˈketʃ:a 120,80,80;90.
tiʃ:em:eʃ 150,100; 115,150.
iʃ:emʃ 200,150;160.
iˈsefter 160,100; 100.
iˈs:efter 150,100;90.
ˈnesa 140,110;90.
ˈnes:a 130,105;85.
ˈbeda -;115,130.
ˈkesah 120,120,120, 100;100,100.
ˈkes:ah 110,100;75, 80.
ˈkeb:ep 160,120;140.
ˈtema 90;95,120.
ˈdema 130;125,150.
ˈtem:a -;90,115.
ˈbela -;135.
ˈdeni -;225.
ˈsem:en -;210.
ˈdera -;260.
furˈket:a -;95,95.
ˈdʒema -;80.
ˈsema -;100,125.
ˈzef:en -;80,105.
seˈt:embru 105;100.
ˈtʃeknet 80;85.
ˈtʃek:en -;110.
daˈʔsek: -;155.
ˈhdʒˌej:et -;115.
skuˈtel:a -;100.
suˈp:erf -;165.
kaˈp:el: -;180.
ˈpep:u 85,100,110, 120; -.
*ˈpek:a 120; -.
*ˈtepa 100; -.
*ˈtep:a 105; -.
tʃurˈket: 240,150; -.
ˈhedʒetʃ 200,100; -.
ˈfetah 120,120,90, 100; -.
ˈfet:ah 120,100; -.
ˈtefa 120,140; -.
ˈʃedaʔ 130,110; -.
ˈsefter 110,130; -.
ˈʃema 140,110; -.
kunˈtent 240,190; -.
ˈtkeʃkeʃ 80,80; -.
ˈdʒema 100; -.
ˈdʒem:a 120; -.
tikˈ:untenta 110; -.
ˈkesha 80; -.

ˈmeta 105; -.
ip:reˈtenda 100; -.
ˈmek:a 100; -.

/a/

Monosyllables (42;17)

tap: 120,230,230, 190,160,160, 170;140.
mat: 200,160;140.
tat : 230,230,220, 200,180;170.
tʃat: 250,250,210, 180,155,120; 140.
dʒam: 220;130.
pat: 240,170,200, 180,160,150, 150,190;160.
haʔ: 160,140;185.
hat: 160,145;170, 180.
taht 110,140;160.
bank 175;200.
plat: -;140.
haps -;130.
hap: -;180.
rat: -;180.
pas: -;180.
gas: -;195.

Multisyllabic Stressed (37;38)

ˈtats:a 90,90,100,130; 100.
ˈpat:i 80;120.
ˈʃpak:a 120,100;135.
ˈkan:a 80;105.
ˈnan:a 110;105.
ˈman:a 100;95.
taˈta 230;95.
kaˈt:ar 120;110.
maˈkak: 190;180,165.
ˈtʃap:a 100;125.
ˈtʃap:as 140;110,110.
matˈʃap:asʃ 200;140.
itˈʃ:anfar 210,120; 60.
itˈʃanfar 190,120;95.
itˈʃ:as:a 120,105;100.
itˈʃ:as:aw 120,100; 80.
itˈʃaflas 150,100;120.
itˈʃ:aflas 120,100; 95.
inˈgan:a -;120.
inˈdan:a -;140.
puˈpats -;185.
iˈt:ab:ap -;135.
ˈkaʃ:a -;100.
imˈhab:a -;110.
ˈrad:a -;110.
ˈbaʔra -;90.
ˈnaʔra -;75.
ˈhabi -;80.

ˈdara -;145.
ˈʔal:u -;145.
ˈbal:a -;115.
ˈfar:u -;100,110.
ˈlaʔa -;90.
ˈhal:i -;125.
risponˈsabli -;120.

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Monosyllables (36;24)

sot: 150;130,120.
om: 200;190.
tot: 260,145;185.
tok: 130,130,210,160, 110;135.
tʃof: 230,240,200,170; 140.
stotʃ : 240;155.
tsok: 200,140;140.
moh: 220,120;140.
pon: 220,180,170;200
ʃot: 240,190;135.
gost 220;170.
tost 180,150;140.
kop: 110,150,125,140, 140,155;135.
post 150;135.
ton: 140;170.
kont 130;150.
hok: 120;130.
fost -;125.
hop: -;155.
rot: -;155.
bot: -;130.
ʃol: -;160.
flok: -;140.

Multisyllabic Stressed (56;46)

tisˈtordi -;145.
paˈpotʃ: 140,110,155, 160;205.
ˈmoh:kom 100;80,100.
ˈsod:a 100,220;100.
ˈpop:a 100,110,130, 85;100.
ˈkon:a 90,100;100.
ˈmoh:i 100,120,50; 80.
ˈtobot 110,95;130.
ˈtop:u 110,90,100, 120,80,90;135.
ˈtok:a 120,100,90;95.
ˈkotra 100,110;95.
tatomlom 100,160;105.
its:ok:or 110,100;115.
its:op: 230,160;155.
irˈʃofta 140,100;110.
ˈbok:la 140,130;95.
ˈkob:a 150,130,110;125.
ˈposta 140,130,110;125.
ˈsop:a 110,120;105.
ˈnotfa 110,100;115.
ˈfos:a 100,130;120.
ˈmof:a 100;105.

'gof:a 140;50,120.
'kom:a 100;145.
'kosksu 100;140.
'kop:la 80;110.
'tsoptu 105;130.
'stonku -;130,95.
'zokra 70;80,95.
'fo?ra -;80.
irkopti 95;80.
'sot:i 105;140.
lop:ost 140,145;180, 190.
torbotni -;115.
'?of:a -;140.
'tom:a -;160.
'rod:a -;110.
'domna -;145.
'rot:a -;90.
'kok:a 90,100;100.
'to?tol 40; -.
'tobot 90; -.

/u/

Monosyllabic (3;2)

punt 100;165.
sur -;120.

Multisyllabic Stressed (7;5)

'kuk:a 80,90;75.
'mutʃ:u 100,90;85.
'tugza 90,100;105.
'tut:u 80;95,95.

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Multisyllabic Unstressed (137;79)

'timʃi -;125.
'pits:i 150;135.
'binti 160;105.
irkipta -;55.
id:ispra -;75.
indʒbit: 90;60,75.
'ipki 90;110.
'mis:ni -;130.
it:i^{j}ni -;90.
iri^{j}dni -;155.
iri^{j}dni -;110.
ʃi^{j}ni -;165.
bi^{j}gi 270,200;155.
tkid:ni^{j} -;45.
irbi^{j}t -;90.
inti^{j}k 70;55.
niko:ti^{j}na 50,55; 65.
sik:i^{j}na -;65.
inbi^{j}t -;90.
'fi^{j}ni -;125.
'pi:di 210,180;195.
'pi:gi 160,180;170.
'mi:ʃi -;125.
tmeʃ:i -;130.

imtet: -;60.
iʃ:emʃ -;65.
isefter -;90.
is:efter -;70.
'deni -;140.
'de:ni -;80,130.
'be:dni -;140.
'be:tni -;120.
it:i:ni -;50.
it:i:ni -;155.
'miʃi -;130.
'ʃini -;180.
'miksi -;165.
'ʃi:ni -;165.
pti:hi -;190.
iksi:h -;60.
iti:h -;80.
it:i:h -;70.
idu^{w}? -;100.
id:u^{w}? -;65.
isu^{w}? -;75.
brik:u^{w}n -;75.
intu^{w}k -;75.
itsku^{w}k -;70.
'hu^{w}ti -;130.
'ta:ni -;115.
'pat:i -;135.
itʃanfar 110,50;55.
itʃ:anfar 60,50;55.
itʃ:as:a 80,20;60.
itʃas:aw 40,50;65.
itʃaflas 50,80;35.
'mo:li -;135,150.
tip:o:za 55,80;90.
irto:t -;80.
'to:kis 150;130.
pit:u^{w}ra -;85.
tistordi 60,50;60.
bidila 100,80;60.
pitra:va 70,80;65.
kidbila 70,80;65.
timʃi^{j} -;80.
'binti -;140.
politikant -;60.
politikant 40;65.
miku^{w}l 55;75.
miktu^{w}p 35,55,45; 70.
kitar:a 45;65.
sit:a:ʃ -;80.
titwi^{j}ʃ -;70.
kit:i:ba 60,60,50,70; 75.
kitibi:la 50,70,80,80; -.
tistordi 250,120; -.
'misthi 200,140; -.
tiskuzah 70,70; -.
bidejh 80,80; -.
bidilom 90; -.
'be:tni 170,150; -.
impusta: 70; -.
indu^{w}na 60,70; -.
ingan:a 60; -.
indan:a 50; -.
ingan: 30; -.
'nimʃi 160; -.
'timʃi 130; -.
'pa:t i 90; -.
'pindʒi 85; -.
tik:untenta 40; -.
at:ri^{j}t i 90; -.

istri^{j}na 115; -.
if:it:ajt 100,45; -.
mak:inarju 40; -.
pipistrel 80,65; -.
pipistrel 60; -.
impustu^{w}r 70; -.
poli^{j}tika 50; -.
matema:tika 25; -.
tis:o:gra 50; -.
titpastas 50; -.
imti:rah 40; -.
top:o:ni 105; -.
tik:untenta:h 40; -.
kostitutsjo:ni 45; -.
pultʃinel: 35; -.
'tpat:i 80; -.
far:aktni 95; -.
ip:ro:va 75; -.
ip:retenda 35; -.
it:ap:an 80; -.
ik:alma 65; -.
ik:ontrol:a 50; -.
it:ej:etʃ 75; -.
it:a:ma 50; -.
it:urufha:t 60; -.
it:i^{j}r 80; -.
it:el:a 80; -.
it:i:em 65; -.
it:ipjip 75; -.
it:af:i 65; -.
mit:i^{j}dek 60; -.
mit:kti:p 55; -.
mitejn 50; -.
imperatu^{w}r 50; -.
sit:i^{j}n 55; -.
'parti 60; -.
partitarju 55; -.
intesa 55; -.
misto?si^{j}a 25; -.
timpikah 80,80,70; -.
'moh:i 160; -.
'ho:li 140; -.
'a:ndi 150; -.
brik:u^{w}n 60; -.
tabarsi 150; -.
imta:ten 40; -.
imtet: 50; -.
bibljote:ka 100; -.
irtuk:a:r 80; -.
imka:tar 70; -.
'ka:ki 160; -.
tʃik:ula:ta 60; -.
fero:tʃi 110; -.
kit:i:p 80,80,70, 75; -.
ket :i:ni 220,170; -.

/i/

Multisyllabic Unstressed: Word-Final

(145;141)

'hu^{w}ti -;130.
'ta:ni -;115.
'pat:i -;135.
'mo:li -;135,150.
'binti 160;140,105.
'timʃi -;125.
'pits:i 150;135.
'ipki 90;110.

ˈmis:ni	-;130.
iriˈ^{j}dni	-;155.
ˈʃi^{j}ni	-;165,165.
ˈbi^{j}gi	-;155.
ˈfi^{j}ni	-;125.
ˈpi:di	210,180;195.
ˈmi:ʃi	-;125.
ˈpi:gi	160,180;170.
ˈtmeʃ:i	-;130.
ˈdeni	-;140.
ˈde:ni	-;80,130.
ˈbe:dni	-;140.
ˈbe:tni	-;120.
itˈ:i:ni	-;155.
ˈmiʃi	-;180,130.
ˈmiksi	-;165.
ˈpti:hi	-;190.
tisˈtordi	250,120; -.
ˈmisthi	200,140; -.
ˈbetni	170,150; -.
ˈnimʃi	160; -.
ˈtimʃi	130; -.
ˈpa:tʃi	90; -.
ˈpindʒi	85; -.
at:ˈri^{j}tʃi	90; -.
topˈ:o:ni	105; -.
ˈtpat:i	80; -.
farˈ:akni	95; -.
ˈitwi	80; -.
ˈmoh:i	160; -.
ˈno:li	140; -.
ˈa:ndi	150; -.
taˈparsi	150; -.
ˈka:ki	160; -.
feˈro:t i	110; -.
keˈtʃ:i:ni	220,170;-.

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Multisyllabic
Unstressed (64;56)

ˈbid:el	-;170.
ˈʃitel	-;95.
ˈdʒisem	-;135.
keˈf:ina	60;105.
ˈfit:eʃ	-;130,140.
keˈtʃ:i^{j}ni	-;80.
ˈni:ʃef	-;170.
ˈi^{j}dek	-;175.
keˈf:i:na	70;85.
ˈpetne	-;120.
ˈnem:en	120;130.
ˈfenek	100,150,85; 135.
tiˈʃ:em:eʃ	220,120;115, 145.
ˈkeb:ep	220,160;155.
ˈzef:en	-;140,125, 130.
ʃeˈi:ila	-;90,100.
ˈbiret	-;175.
ˈniʃef	-;150.
ˈsiket	80;165,160, 140.
ˈsik:et	220;135.
ˈnifet	-;175.
ˈkitep	230,170,190, 140,90,110; 160.

ˈtnif:es	95;150,145.
tʃekˈ:nitu	65;75.
keˈtʃ:i:ni	70,80;80, 80,60,85.
meʃ:i:h	120,80;65.
kareˈt:u^{w}n	-;70.
nerˈvu^{w}s	-;80.
at:enˈta:t	-;110.
eˈt:ila	-;70.
seˈt:embru	-;70.
ˈtʃek:net	-;120.
imˈta:ten	80;135.
mateˈfa:ʃ	-;80.
ˈzifen	-;165.
ˈtʃek:en	-;130.
ˈtʃeknitu	-;55.
ˈrikep	190,95;165.
ˈdaʔsek	160;135.
ˈna:fek	140;120.
ˈski:ken	-;170.
ˈhdʒej:et	-;135.
mateˈma:tika	30;60.
ˈma:k:es	-;140.
peˈpe	90; -.
pekoˈrel:a	170,70,100; -.
ˈmartek	70,200; -.
ˈharkek	80,190; -.
ˈtʃri:ket	220; -.
fiˈtʃ:itek	190; -.
ˈski:ken	170,140; -.
ˈi^{j}dek	230,160; -.
ˈla:pes	220,140; -.
ˈhedʒ:et	230,170; -.
ˈi:bes	200,160; -.
ˈniket	140,80; -.
it:raˈdejtek	190,100; -.
is:eˈftu^{w}ra	130,80; -.
iˈmis:ek	210,150; -.
pes:iˈmist	80; -.
tik:untenˈta:h	90; -.
ˈtʃkejken	50; -.
ˈprintʃep	80; -.
ˈtkeʃkeʃ	60,75; -.

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Multisyllabic
Unstressed (56;91)

ˈbidla	-;130.
ˈkitla	-;140.
irˈkipta	-;155.
ˈbina	-;155.
ˈnu^{w}na	140,180;160.
ˈʔi^{j}ma	-;205.
ˈzi^{j}da	-;195.
ˈli^{j}ma	-;200.
ˈpi^{j}na	-;140.
ˈhi^{j}ta	-;175.
ˈbi^{j}da	-;215.
taˈbi^{j}p	-;90.
it:aˈbi^{j}ba	-;75.
it:aˈbi^{j}ba	-;165.
ˈpi^{j}pa	120;160.
ˈpi^{j}ka	-;125.
ˈti^{j}gra	-;200.
ˈis:a	-;115.

ˈti^{j}na	-;165.
ˈktʃi^{j}na	-;135.
karoˈts:i^{j}n	-;80.
siˈk:i^{j}na	-;140.
ˈbi^{j}ma	-;105.
ˈi^{j}sa	-;145.
ˈdi:ta	-;160.
ˈʔi:ma	-;150.
ˈzi:da	-;175.
ˈli:ma	-;120.
ˈpi:na	-;130.
ˈbek:a	-;110.
ˈteba	-;140.
ˈpesta	80;120.
ˈʃeb:a	120;155.
ˈʃeba	120;130.
ˈmeʃa	140;140.
ˈmeʃ:a	120;105.
ˈnemla	-;140.
ˈketʃ:a	-;110.
ˈnesa	-;160.
ˈnes:a	-;100.
ˈbeda	-;160,150.
ˈkesa:h	-;95,140.
ˈkes:ah	-;120,180.
ˈtema	-;160,155.
ˈdema	-;170,170.
ˈtem:a	-;125,150.
ˈbela	-;120.
ˈdera	-;150.
ˈsema	-;120,145.
lamˈpu^{w}ka	80,180;85.
tak:u^{w}na	-;90.
ˈʃku^{w}pa	-;155.
basˈtu^{w}n	-;100.
manˈdu^{w}ʒ	-;110.
faˈmu^{w}s	-;110.
ʔaˈt:u^{w}s	-;105.
haˈnu^{w}t	-;120.
kaˈnu^{w}n	-;100.
karˈtu^{w}na	-;95.
barˈku^{w}n	-;120.
kareˈt:u^{w}n	-;85.
taˈta	-;95.
maˈkak:	-;80,85.
ˈtʃap:as	-;135,140.
matʃap:asʃ	130;70,100.
at:enˈta:t	-;95.
mak:iˈna:rju	-;60.
paˈpotʃ	80;100.
kaˈp:el:	-;85.
manˈdratʃ	-;90.
faˈtʃ:o:l	-;95.
atʃ:a:n	-;75.
maˈdu^{w}r	-;85.
mahaˈl:atʃ	40;190.
mahaˈl:atʃ	110;100.
it:ak:u^{w}na	-;100.
tak:wiˈsta:ʃ	90,70,220, 140;95.
iˈtʃ:as:a	260,140;100.
inkaʃ:a:t	-;105.
ˈbitha	120; -.
ˈtats:a	110,140,140; -.
ˈe:da	160; -.
ˈo:tja	120; -.
ˈsod:a	100; -.
ˈkon:a	120; -.
ˈkan:a	140; -.
ˈʃku^{w}ma	160; -.
ˈfa:ma	140; -.
ˈmin:a	150; -.

ˈma:na	160; -.
ˈman:a	120; -.
ˈnemla	120; -.
rum:i:na	120; -.
ˈmah:a	120; -.
ˈnefah	80; -.
ˈpi^{j}ka	180; -.
ˈspik:a	170; -.
ˈʃpak:a	130; -.
ˈbek:a	140; -.
ˈpa:ga	200; -.
pekorel:a	130; -.
tip:o:za	200; -.
it:ak:u^{W}na	110,80; -.
ˈdu^{W}ʔa	220,190; -.
ˈʃita	220,140; -.
papotʃ	90,80; -.
ˈketʃ:a	260,130; -.

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Multisyllabic
Unstressed (34;31)

mikrobu	-;80.
ˈfi^{j}kom	180,170;155, 115.
ˈbi^{j}kom	-;195.
bok:i^{j}n	-;80.
karots:i^{j}n	-;110.
nikotijna	110,90; 85,115.
ˈiskot	220,100;145.
ot:u^{W}bru	85;135,115.
top:o:ni	80;85.
kostitutsjo:ni	60;75.
poter	120,105,105; 105.
bok:i^{j}n	100,100,90, 110;80.
ˈmoh:kom	140,130;140.
ˈtobot	140;175.
tatomlom	-;120.
ˈmoh:kom	-;140.
lop:ost	-;80.
torbotni	-;100.
ˈra:tom	-;115.
risponsabli	90;85.
top:o:ni	-;115.
ik:ontrol:a	85;100.
mistoʔsi^{j}ja	40;145.
op:ozitsjo:ni	85;90,80.
op:ost	110;110.
ˈma:kom	180,120;190.
tos:erva:	-;130.

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Multisyllabic
Unstressed (63;58)

ˈmikrobu	-;150.
ˈbidu	-;195,180.
ˈti^{j}tlu	-;160.
kudʒ i^{j}n	-;50.
ˈpi:tru	-;100.
ˈbi:du	-;175,215.
tuf:i:ha	55;75.
dub:i:na	150;85,70.
furket:a	-;60,60.
ˈte:tnu	-;125.
tʃeknitu	-;180.
rum:i:na	-;135.
ˈdu^{W}ʔu	-;220,185.
ˈmutʃ:u	-;195
ˈtut:u	100,100,160; 185,100.
gustu^{W}s	100;110,90.
muntu^{W}n	100;45,50.
ˈmu^{W}tu	130;165,100.
ˈtu^{W}bu	200,200,250; 155.
ˈdu^{W}du	280,190;190.
ˈbu^{W}tu	240,180;180, 180,185.
ot:u^{W}bru	-;135.
but:u^{W}na	100,100,60; 115,75.
ˈtu^{W}tu	-;140.
ˈo:du	-;180,205.
ˈpo:plu	-;165.
tiskuzah	-;80.
ˈsko mdu	-;140.
mutu^{W}r	80;65.
pupats	80,40;85.
ʃkupilja	90,60;55.
skutel:a	90,60,60;65.
nutʃ:a:li	80;80.
putru^{W}na	60,80;85.
du^{W}du	-;215.
sup:erf	50;185.
tik:untenta:h	60,50; 55.
puza:ti	-;90.
ˈʔa:lu	-;225,120.
ʃurba:n	-;100.
ˈtop:u	115,115,150; 160.
ˈkosksu	-;185.
ˈtsoptu	80;155.
ˈstonku	-;130,180.
irtuk:a:r	100,50,60; -;
ˈki:ku	190,125; -.
ugza:h	120; -.
ˈnahzdu	260,180; -.
duʔuomli	80,60; -.
ˈduʔuom	110,70; -.
ˈla:ptu	100; -.
impustu^{W}r	70; -.
tuz:a:na	90; -.
ˈa:tu	80; -.
ˈmewtu	80; -.
kostitutsjo:ni	70; -.
ˈahptu	95; -.
kolonjalizmu	85; -.
pep:u	115; -.
*put:u^{W}na	75; -.
*pukku^{W}n	70,60; -.
*tu^{W}pu	105; -.
*tup:i:na	50; -.
ˈkuk:a	40; -.

Nasal Contexts

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ˈʔmi^{j}s	270;225.
ˈkni^{j}sja	100;140.
tkid:ni^{j}ʃ	145;190.
mentni^{j}ʃ	80,190;185.
mi:t	190,200;210.
tni:t	180;240.
ˈmi:ʃi	-;195.
ˈni:ʃef	-;205.
ˈbni:sa	145;190.
ˈbina	-;155.
ˈnu^{W}na	140,180;160.
ˈʔi^{j}ma	-;205.
ˈli^{j}ma	-;200.
ˈpi^{j}na	-;140.
ti^{j}n	-;165.
ˈktʃi^{j}na	-;135.
sik:i^{j}na	-;140.
ˈbi^{j}ma	-;105.
ˈʔi:ma	-;150.
ˈli:ma	-;120.
ˈpi:na	-;130.
ˈdema	-;170,140.
ˈtema	-;160,155.
ˈtem:a	-;125,150.
ˈsema	-;120,145.
makak:	-;80,85.
matʃap:asʃ	100; -.
mak:inarju	-;60.
madu^{W}r	-;85.
mahal:atʃ	40;190.
ˈkon:a	120; -.
ˈkan:a	140; -.
ˈʃku^{W}ma	160; -.
ˈfa:ma	140; -.
ˈmin:a	160; -.
ˈman:a	120; -.
rum:i:na	120; -.
ˈmit:	160;130.
ˈmis:ni	100,130;65.
ˈmiʃi	-;70.
ˈniʃef	-;75.
ˈnivda	-;65.
ˈnifet	-;95.
ˈtnif:es	50;85,75.
tʃeknitu	55;65,80.
ˈmiksi	80,80,150,50; 45.
ˈnitfa	100;55.
ˈmisthi	100,60; -.
ˈmikrobu	25; -.
pes:imist	100; -.
ˈmitrah	60; -.
ˈbnisa	70; -.
ˈmis:ni	-;130.
iri^{j}dni	-;155.
ˈʃi^{j}ni	-;165.
nikoti^{j}na	50,55;65.
ˈfi^{j}ni	-;125.
ˈdeni	-;140.
ˈde:ni	-;80,130.
met	220; -.
met:	150,130;160.
ˈtmeʃ:i	65;100.
ˈmeʃa	100,100,100, 140,140;105.
ˈmeʃ:a	80,120,120,100, 105;85.
ˈnesa	140,110;90.

'nes:a 130,105;85.
'meta 105; -.
'mek:a 100; -.
'petne -;120.
'fenek 100,150,85; 135.
tiʃ:eme:eʃ 220,120; 145.
meʃ:i:h 120,80;65.
nervuʷs -;80.
'tʃek:net -;120.
'na:fek 220;185.
matema:tika -;145.
'ma:k:es -;145.
'ma:kom 240,180;220.
'tna:bar 175; -.
mat: 200,160;140.
'naʔra -;75.
mo:t 190;250.
mo:s -;275.
'no:li 200;235.
'mo:li -;240.
'mo:la -;235.
moh: 220,120;140.
'moh:i 100,120,50;80.
'notfa 110,100;115.
'mof:a 100;105.
muʷt 270,210;195.
dnuʷp 140;170.
'muʷtu 170;155,150.
famuʷs 280,280;220.
'mutʃ:u 100,90;85.
'te:tnu -;125.
mutuʷr 80;65.
nutʃ:a:li 80;80.
kolonjalizmu 85; -.

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fiʲn 140;230.
ʔsiʲm 240;275.
it:iʲni -;110.
'biʲna -;175,120.
'ʔiʲma -;160.
'liʲma -;180.
'piʲna -;200.
'ʃiʲni -;185.
'tiʲna 160,180,120; 115,195.
'fiʲni -;210.
ketʃ:iʲni -;80.
bok:iʲn 220,200,130, 110,160;220.
'ktʃiʲna 125;195.
karots:iʲn 230;65.
kudʒiʲn -;90.
sik:iʲna -;95.
'niʲna 170,160; -.
'tʃiʲna 170,200; -.
'fiʲna 190; -.
'kiʲna 180; -.
pok:iʲn 155,155; -.
'smi:n -;240.
ki:n 170,180,140, 240,220;265.
dub:i:na 230,155;205, 190.
o'ti:n 140;240,310.
kef:i:na 140;220.
'ʔi:ma -;230.

'pi:na -;295.
it:i:ni -;240.
'ʃi:ni -;260.
rum:i:na 160;240.
ketʃ:i:ni 220,200;195, 190,210,265.
dub:i:n 280,220; -.
*tup:i:na 160; -.
'hzi:na 260,240; -.
tʃint 130,60;155.
bint 130;145.
'timʃi 70;90.
'binti 90;175,105.
'pindʒi 50;110.
zef:ina -;95.
'bina -;100.
'min:a 80;65.
'pin:a -;80.
'nimʃi 50; -.
'timla 50; -.
kef:ina 70; -.
indʒbit: 90;60,75.
intiʲk 70;55.
inbiʲt -;90.
imtet: -;50,60.
intuʷk 70;75.
impusta: 70; -.
induʷna 60,70; -.
ingan:a 60; -.
ingan: 30; -.
mak:inarju 40; -.
impustuʷr 70; -.
imti:rah 40; -.
pultʃinel: 35; -.
imperatuʷr 50; -.
intesa 55; -.
imta:ten 40; -.
imka:tar 70; -.
'be:dni -;120.
it:i:ni -;155.
'ʃiʲni -;180.
'ʃi:ni -;165.
'ta:ni -;115.
mikuʷl 55;75.
miktuʷp 33,55,45;70.
'bet:ni 170,150; -.
top:o:ni 105; -.
far:akni 95; -.
mi'tejn 50; -.
mistoʔ'siʲja 25; -.
ketʃ:i:ni 220,170; -.
fe:m 180,250,240, 310;280.
te:m 240;260,255, 250.
de:n -;300.
se:m -;220,185.
te:mt 160; -.
de:ni -;220,250.
e:ni -;270.
fe:ma 260,240;260.
e:na 100; -.
tʃe:na 280; -.
hen: 100,150;235.
ken: 150;165.
kem: 160;180.
tem: -;180.
'nemla 120;105.
'nem:en 100;105,110.
'fenek 140,190,100; 120.

tiʃ:em:eʃ 150,100;115, 150.
iʃ:emʃ 200,150;160.
'tema 90;95,120, 125.
'dema 130;150.
'tem:a -;90,115.
'deni -;225.
sem: -;210.
'dʒema -;80.
'sema -;100,125.
set:embru 105;100.
'ʃema 140,110; -.
kuntent 240,190; -.
'dʒema 100; -.
'dʒem:a 120; -.
tik:untenta: 110; -.
ipretenda 100; -.
'dʒisem -;135.
'nem:en 120;130.
'zef:en -;140,125,130.
at:enta:t -;110.
imta:ten 80;135.
'zifen -;165.
'tʃek:en -;130.
'ski:ken 170,140;170.
matema:tika 30;60.
tik:untenta:h 90; -.
tʃkejken 50; -.
ʔa:m 240;210,245.
sa:m -;210.
da:m -;235.
a:m -;265.
ta:m -;235,200.
ta:ni -;200.
ma:na 200;235,230.
atʃ:a:n 270;215.
kapta:n -;220.
timpa:na -;205.
vulka:n -;200.
'ka:na -;265.
'a:na -;295.
'ha:mi -;280.
'ha:mja -;200.
ʃurba:n -;245.
a:ni -;250.
tuz:a:na 180; -.
it:a:ma 200,220,250; -;
'kma:mar 155; -.
'a:ma 260; -.
'fa:ma 100,200; -.
'ændi 200; -.
'da:mu 240,180; -.
'dʒan:i 220;130.
bank 175;200.
'kan:a 80;105.
'nan:a 110;105.
'man:a 100;95.
itʃanfar 190,120;95.
itʃ:anfar 210,120;60.
ingan:a -;120.
indan:a -;140.
lampuʷka 80,180;85.
manduʷ -;110.
famuʷs -;110.
hanuʷt -;120.
kanuʷn -;100.
mandrat : -;90.
no:m 220;215.
to:n 230;200.
'sko:mdu 140,200;185.

ˈto:ma	280,240;235.
ˈsto:na	320,240;185, 280.
toˈp:o:ni	190;245,260.
ˈo:mja	-;235.
ˈko:ma	-;200.
ˈo:nja	-;220.
ˈdo:mna	-;200,195.
ˈom:	200;190.
pon:	220,180,170; 200.
ton:	140;170.
kont	130;150.
ˈkon:a	90,100;120,100.
taˈtomlom	100,160;105.
ˈkom:a	100;145.
ˈstonku	-;130,95.
ˈtom:a	-;160.
ˈdomna	-;145.
ˈfiʲkom	180,170;155, 115.
ˈbiʲkom	-;195.
ˈmoh:kom	140,130;140, 140.
taˈtomlom	-;120.
ˈra:tom	-;115.
risponˈsabli	90;85.
ik:ontrol:a	85;100.
ˈma:kom	180,120;190.
ˈnuʷna	220;200,225.
ˈʃkuʷma	160;205.
munˈtuʷn	240;135,185.
briˈk:uʷn	230,230,175, 175;260.
taˈk:uʷna	190,210,140, 125,150;210, 215.
basˈtuʷn	300,195,185; 250.
inˈduʷna	220,210;230, 220.
fliˈʃkuʷn	170;175.
buˈt:uʷna	-;210,170.
kaˈnuʷn	-;250.
karˈtuʷna	-;210.
barˈkuʷn	-;240.
kareˈt:uʷn	-;260.
puˈtruʷna	-;200.
punt	100;165.
ruˈm:i:na	-;135.
munˈtuʷn	100;45,50.
tik:untenˈta:h	60,50;55.

"Pharyngalisation"

bo:t	-;240.
so:t	-;315.
ˈo:tja	-;90.
ˈo:li	-;145.
ˈso:da	-;160,190.
ˈo:mja	-;180,135.
ˈo:mor	-;195.
ˈo:dos	-;195.
ˈto:ma	-;150,170.
fe:m	-;220.
en	-;140.
te:m	-;160,200.
de:n	-;220.
se:m	-;185.
e:p	-;220.
e:ʃ	-;220.
e:n	-;235.
ˈfe:ma	-;185.
ˈse:ma	-;170.
ˈe:na	-;195.
ˈʔe:dna	-;165.
ˈe:nep	-;160.
ˈde:ra	-;265.
ˈde:ba	-;195.
ˈbe:tni	-;190.
ˈʔa:t	-;225,250.
tʃa:ʔ	-;205.
a:nt	-;140.
a:m	-;215.
ba:t	-;235.
ˈma:na	-;155.
ˈa:dʒ:el	-;175.
ˈa:ts:a	-;155.
ˈa:na	-;225.
ˈta:ti	-;200.
ˈa:f:etʃ	-;170.
ˈa:bra	-;180.
ˈa:ndi	-;150.
ˈta:mel	-;165.
ˈsta:dʒep	-;170.
ˈa:mel	-;180.
ˈa:t:a	-;165.
ˈa:n:aʔ	-;155.
ˈa:k:es	-;135.
ˈa:da	-;200.

"Ordinary long vowels"

mo:t	-;205.
to:n	-;205.
ˈte:tnu	-;220,220, 165.
ˈpe:na	-;170.
ˈtʃe:da	-;210,170, 230.
da:m	-;220.
sa:ʔ	-;220.
ta:k	-;230.
sa:p	-;210.
da:n	-;235.
hda:n	-;220.
ka:s	-;230.
sa:m	-;230.
ra:s	-;220.
da:ʔ	-;220.
hita:n	-;230.
ba:ta	-;200.
sa:bet	-;195,170.
saˈ:bu	-;160.
ʃita:n	-;150.
ˈma:gna	-;145.
ʔutʃa:ta	-;160.
imˈka:tar	-;160.
irˈha:ma	-;145.
aˈsa:far	-;175.
lanˈdʒa:sa	-;180.
ikˈ:arˈga:t	-;210.
duˈh:a:n	-;165.
ˈpsa:ten	-;195.
ˈdo:mna	-;165.

V + j

pkejt	150;200.
fejn	190;260.
sejf	190,240;205.
dejn	200;255.
diˈsajn	220,205;330,270, 290,350.
hajt	210;190.
iˈdejk	200;220.
baˈt:ejn	170;250,215.
ajt	240;305,280.
dejf	220;300.
erˈbajn	205;325,300.
tajn	225;325.
baˈt:ejn	180;245,190.
bajt	200;265,235.
ˈbajda	180;210.
bajˈdi:t	150;170.
ˈbajdu	185;230,215.
ˈbajdet	200;200.
ˈtajtu	180;210.
fejˈʔa:n	195;185.
fejn	240;265.
beˈh:ej	-;230.
ʔaˈd:ej	-;200.
mnejn	195; -.
xejn	195; -.
ejb	200; -.
sajf	220; -.
bejt	200; -.
zejt	180; -.
dʒejt	175; -.
ˈvojta	305; -.

j + V

jasar	130,120;170.
ˈja:sar	245;240.
jismu	-;130.
ji:s	180;360.
juʷm	240;380.
juˈmejn	-;200.
ˈo:mja	-;315.

V + w

ˈewda	220;340.
ˈbewla	-;215,205.
miˈbowt	280;215.
hawh	205;200.
ˈhawha	140;190.
haˈwhi:t	160;150.
owm	255;255.
sawm	250;270.
dawˈmi:n	180;185.
ˈkewba	145;205.
mewt	180;235.
mewta	160;180.
ˈtewmiʲn	140;140,175.
ˈtewma	140;180,215.
tewm	230;255,235.
mewt	200;260.
ˈmewdʒa	150;200.
sewda	180; -.
dʒeˈwha:n	105; -.

w + V

'itwi	170;230.
tit'wi^{j}	175;240.
'wet:a?	120;190.
wi'di:n	90;115.
'wi:sa	170;260.
'wid:ep	90;170.
'wen:es	175;175.
fwi:t	145;250.

Single and Geminate

(i) Single

	V	C
'siket	50	60
	75	60
'rikep	75	60
'biki	65	65
	100	80
'gidep	95	75
	120	65
	40	90
'kiser	85	120
i'tʃanfar	40	100
	85	120
i'tʃaflas	80	45
	45	50
	40	90
i'ti:h	100	75
i'ʃandar	55	120
	100	115
i'du?	75	65
	85	75
i'daw:ar	40	70
	75	50
i'dej:a?	40	75
	70	65
i'sefter	65	95
	110	90
i'mis:ek	50	90
	80	110
i'ti^{j}k	60	70
	95	55
'o:dos	250	60
'niket	55	60
'kiser	60	105
i'ti:h	50	50
	60	60
'beka	40	60
	140	95
'meʃa	95	110
	120	135
'sema	80	80
	105	90
	120	80
	90	75
'beza	120	70
	135	130
'neza	60	95
	120	145
'fetah	80	75
	115	70
'ʃeba	85	75
	125	80

'dema	V	C
'dema	95	85
	150	100
'nefa?	100	90
	90	155
'kesah	85	120
	125	130
'e:da	290	70
'tema	105	80
'wa?a	160	70
	75	80
'hadem	100	70
	120	105
'hafer	90	120
	125	130
'sabar	85	75
	130	70
'ʃaba	105	50
	105	95
'hazen	115	145
'?asam	85	95
	130	140
'dahal	90	85
	90	175
'a:da	255	80
'a:ti	220	55
'ra?at	80	80
'nadʒar	105	110
'hazen	95	140

(ii) Geminate

	V	C
'sik:et	50	125
	75	200
'rik:ep	60	180
'bik:i	70	115
	90	170
'gid:ep	100	170
	100	180
	55	130
'kis:er	80	220
it:'ʃ:anfar	55	160
	40	255
it:'ʃ:aflas	45	110
	55	135
i't:i:h	60	200
i'ʃ:andar	60	180
	60	245
i'd:u?	45	160
	55	190
i'd:aw:ar	40	140
	45	180
	65	210
i'd:ej:a?	40	150
	70	160
i's:efter	45	155
	65	220
i'm:is:ek	40	160
	40	130
i't:i^{j}k	50	160
	80	180
'o:d:os	155	175
'nik:et	50	120
'kis:er	50	180
it:i:h	65	130
	30	170
'bek:a	85	140
	100	240
'meʃ:a	95	160
	120	235

	V	C
'sem:a	80	140
	100	235
	110	210
	90	140
'bez:a	120	155
	105	215
'nez:a	75	105
	110	275
'fet:ah	80	160
	120	190
'ʃeb:a	85	150
	105	210
'dem:a	115	120
	135	220
'nef:a?	95	165
	80	195
'kes:ah	75	180
	80	240
'a:d:a	150	200
'tem:a	90	160
'wa?:a	160	140
	75	200
'had:em	100	125
	105	200
'haf:er	60	190
	100	265
'sab:ar	85	140
	120	175
'ʃab:a	100	130
	110	215
'haz:en	100	240
'?as:am	65	165
	105	245
'dah:al	80	160
	195	230
'a:d:a	145	220
'a:t:i	195	185
'ra?:at	70	240
'nadʒ:ar	95	140
'haz:en	75	160

V:C and VC: and VC

(i) V:C

hi^{j}t	205	115
bi:t	260	110
'si:ket	200	80
i't:i:ni	230	165
'li:ma	210	115
'wi:sa	260	160
hi^{j}t	185	135
	205	115
bi^{j}t	255	80
	260	110
'si:ket	200	80
'pi^{j}ter	120	60
mi:t	240	85
mi^{j}n	115	160
'?e:da	225	80
'te:ma	265	85
	270	75
te:m	280	160
	270	170
se:m	290	165
be:t	280	95
?a:t	265	115
	360	85
	310	90

	V	C
'imka:tar	230	80
ba:t	280	90
	265	95
da:?	240	135
'a:ti	240	105
'a:ni	280	80
'ba:ta	230	55
	205	175
ra:s	295	-
'a:da	220	120
'ma:na	295	70
'ka:na	250	65
'talap	195	
bo:t	290	100
	300	120
so:t	330	105
'so:da	270	75
	225	80
'to:ma	205	110
	200	80
'ro:da	210	70
'ro:ta	300	110
'mo:ti	190	60
'do:mna	205	115
su^{w}r	240	

(ii) VC:

	V	C
hit:	150	190
bit:	150	200
'sik:et	55	200
'pit:er	60	265
mit:	145	165
min:	200	130
'tem:a	115	230
	115	240
tem:	190	215
bet:	170	200
?at:	220	200
	190	185
	230	135
bat:	210	185
	170	170
da?:	155	170
'a:t:i	130	240
'a:n:i	105	230
'bat:al	140	240
'ras:	220	-
'a:d:a	125	220
'kan:a	105	205
'tal:a p	190	150
bot:	160	200
	190	190
'sod:a	130	190
'mot:i	135	190

(iii) VC

	V	C
hi^{j}t	185	135
bi^{j}t	255	80
'siket	80	75
it:i^{j}ni	230	220
'li^{j}ma	195	95
sur	300	
'domna	120	110

APPENDIX C

Appendix C

Background to the Speech Synthesis By Rule Experiment

The material used in the experiment described in chapter 8 was synthesised on SID (the Speech Imitation Device, the synthesiser in the Phonetics Laboratory at Edinburgh University. SID is an eight-parameter series formant speech synthesiser driven by the Laboratory computer. The computer programme that generates the control parameters was written by Norman Dryden.

The speech synthesis by rule system used in this case was devised by Holmes, Mattingly and Shearme (and they give a full account of it in Language and Speech, 1964, 7, p.127) at the Joint Speech Research Unit at Eastcote, and adapted for SID by L. A. Iles to cater for the differences between the JSRU synthesiser and SID. This speech synthesis-by-rule programme was used successfully on several occasions (see L. A. Iles, 1967, 1968, 1969) on PAT (the Edinburgh Parametric Artificial Talker), the synthesiser built by W. Lawrence and J. Anthony. The programme used in these cases was that written by L. A. Iles and described fully in Stevenson 1977.

The programme used for this experiment was an adaptation of the Iles programme written by Norman Dryden in very simple language. Having chosen the phonetic elements making up the intended utterance, the user does not need to be aware of very much beyond the phonetic aspect of the synthesis in order to set the parameter values (levels) and to improve the phonetic quality of the resulting synthesised utterance.

Each utterance that is to be synthesised must be represented as a set of phonetic elements. This means that, roughly, every phoneme is converted into the symbol representing it, e.g. /a:/ is represented by the symbol AR , /ð/ by DH, etc., since the computer terminal keyboards can only deal with a limited set of symbols similar to those of an ordinary typewriter. The list of symbols used here are those deviced by Holmes, Mattingly and Shearme.

One element is fed in at any one time and the parameters are generated according to the standard values in the tables associated with them, or they can be altered individually. When one element has been entered with all its alterations, if any, the next element is then fed in, and so on, until the end of the utterance is reached.

At this stage, the element END is entered. If no alterations are required only the value for the fundamental frequency parameter need be introduced at any time for each element. The parameter values are standardized in terms of levels from 0 to 31, the equivalent value in real terms varying as follows:

For	F_1	the levels jump in steps of about	25 Hertz.
"	F_2	" " " " " " "	75 "
"	F_3	" " " " " " "	95 "
"	$F_ø$	" " " " " " "	6 "
"	$A_ø$	" " " " " " "	1.5 to 2 db.
"	AH_1	" " " " " " "	1 to 1.5 db.
"	AH_2	" " " " " " "	1 to 1.5 db.
"	FH_2	" " " " " " "	200 Hertz.

The values for F_0 can be altered for every 10 msec.

A table of standard values is associated with each phonetic element for the steady state of each of the eight parameters, the duration of the elements, the subelements (if any), the rank of each element (which determines the boundary value depending on the fixed contribution of the element and a proportion of the adjacent element) and the external and internal transitions. To give one example, the table for the standard values of /o/ is as follows:

	F_1	F_2	F_3	A_0	AH_1	AH_2	FH_2	F_0
Steady state :	17	5	14	29	0	0	10	0
Duration :	9	6	0	0	0	0	2	0
Fix. Con. :	20	17	19	23	16	16	16	0
Prop. Adj. :	5	5	5	5	10	10	10	0
Ext. Tr. :	4	4	4	4	0	0	0	0
Int. Tr. :	4	4	4	4	0	0	0	0

The synthesised utterance can be heard immediately and modifications can subsequently be made without delay.

The phonetic element tables, the values of the parameter levels examples of utterance generation, and fuller details regarding the programme are given elsewhere, and will therefore not be included here. (See Holmes, Mattingly and Shearme, 1964)

APPENDIX D

Pilot study to determine intelligibility of synthesised words

When the acoustic study of Maltese vowels reported in chapter 7 was completed, it was decided to carry out a perception test to investigate the relative roles played by formant structure, vowel duration and consonant gemination in the identification of Maltese vowels. The test is described and discussed in chapter 8. Before embarking on the project, however, it seemed essential to determine how far the synthesis by rule programme available at the Edinburgh University Phonetics Laboratory could be used. It was necessary, therefore, to synthesise several words with varying consonant-frames, present the synthesised words to native speakers of Maltese and ask them to identify the words.

The words synthesised for the pilot study were not the ones to be included in the perception test. Attention was focussed on the intelligibility of the phonetic elements used. It would have been necessary to carry out the study by means other than speech synthesis if a new programme were considered essential or if extensive alterations were to be made to the consonants, since the scope of this work did not allow for more work on the speech synthesis programme itself. The pilot study was limited to consonants that were to be used in the perception test, namely, the voiceless stop consonants, the voiceless fricative /s/, and the approximant/tap /r/, and the lateral /l/. No alterations, apart from duration, were made to the consonantal elements available. Two to three versions of the 'same' word were synthesised with vowels that differed in formant structure. The vowels were not synthesised in the same way as for the eventual perception test, so that some were highly intelligible and others highly unintelligible. The inadequacy of the vowels was considered to provide as good a frame for testing consonant intelligibility.

The words were presented to the subjects once only. They were asked to write down whatever they heard. If they could not make out the entire word, they were to transcribe whatever elements/sounds which they could identify.

The results are summarized in the table below. They show that the consonants were highly intelligible to the subjects although many of the vowels were not. Some of the errors related to the voiced/voiceless and oral/nasal distinction, others to place of articulation. Some serious errors occurred regarding /k/ in all positions and /r/ in final position. It was therefore decided to change the formant structure values of /k/.

No other alterations would be made for the other consonants unless they were subsequently considered unintelligible in the course of further synthesis. Final position /p/ was considered correctable by adding aspiration. The vowels would, of course, be changed radically since they were the focus of the perception test. The values for the three formants and duration, as well as the fundamental frequency would be entered into the computer afresh for each vowel element.

Results of Pilot Study

Position in Word: Initial	Medial	Final	Number of Occurrences	Correct Response No.	Correct Response %age	Mean %age of elements identified	Number of Errors	%age of Errors	Type of Error: Voice	Oral/Nasal	Place & Manner
p			168	120	71%		48	29%	22	7	19
	p		90	63	70%	65%	27	30%	6	0	21
		p	24	13	54%		11	46%	2	0	9
t			60	57	95%		3	5%	0	0	3
	t		102	93	91%	93%	9	7%	4	0	5
		t	66	62	94%		4	6%	2	0	2
k			36	12	33%	25%	24	67%	2	0	22
	k		30	5	17%		25	83%	2	0	23
ɹ			6	6	100%		0	0%	0	0	0
	ɾ		18	13	72%	63%	5	28%	0	0	0
		ɹ	12	2	17%		10	83%	0	0	6
	l		42	27	64%	66%	15	36%	0	0	10
		l	6	4	67%		2	33	0	0	2
s			12	11	92%	96%	1	8	0	0	1
		s	18	18	100%		0	0%	0	0	0

APPENDIX D - D2

Statistical Results Relevant to the Perception Test Reported and Discussed in Chapter 8.

D 2. Statistical Results

The following tables are the statistical results of the SID experiment discussed in Chapter 8. The statistical results were obtained by using the BMDPIR Multiple Linear Regression Test on the Edinburgh University Computer.

The results are classified in two ways below:

1. In figures D2.1 and D2.2, the results for the long close vowels are distinguished from the results of the long open vowels; the results for the short close vowels are distinguished from the results for the short open vowels. So:

A	includes the results for /i:/ monosyllables;
A2	includes the results for /i:/ in all data;
B1	includes the results for /i^j/ and /u^w/;
B2	includes the results for /o:/, /a:/ and /e:/;
C1	includes the results for /i/ and /u/;
C2	includes the results for /o/, /a/ and /e/.

2. In figures D2.3 and D2.4, the results for each vowel are presented separately. So:

AA1	includes the results for /i:/ in the context h V t only;
AA2	includes the results for /i:/ in the context b V t and z V t only;
BB1	includes the results for /i^j/;
BB2	includes the results for /u^w/;
BB3	includes the results for /o:/;
BB4	includes the results for /a:/;
BB5	includes the results for /e:/;
CC1	includes the results for /i/;
CC2	includes the results for /u/;
CC3	includes the results for /o/;
CC4	includes the results for /a/;
CC5	includes the results for /e/.

The reasons for splitting up the results in the above way are given in Chapter 8, section 8.8.2.

FIGURE D2.1. (page 1)

Results of the Multiple Linear Regression Test: the Correlation of the Independent Variables (vowel quality, particular vowel, vowel duration, vowel duration correctness, consonant duration and consonant duration correctness) with the Dependent Variable (the Score) and with each other. (See discussion in 8.8. p. 164ff.)

The table below shows the correlation of the variables for the following vowels separately or in groups as:

Group A: /i:/ in monosyllables only;
Group A2: /i:/ in all data together;
Group B1: /iʲ/ and /uʷ/ together;
Group B2: /e:/, /a:/ and /o:/ together;
Group C1: /i/ and /u/ together;
Group C2: /e/, /a/ and /o/ together.

The equivalence of the significance level at .01 and at .05 is shown in the right-hand margin. Thus, for example, 0.205 is significant at .05 whereas 0.267 is significant at .01 for /i:/ in monosyllables, i.e. in group A.

The table should be read as follows: "For /i:/ in monosyllables (i.e. group A), the score correlates positively with the score at 1.0000; vowel quality correlates positively with the score at 0.3125; particular vowel correlates negatively with the score at -0.1243; and so on. Since 0.267 is significant at .01, then the correlation of vowel quality to the score is highly significant, whereas the correlation of the particular vowel to the score is not significant.

The same variables appear on both the horizontal and vertical axes. The abbreviations on the vertical axis are as follows;

VQ = Vowel Quality; PV = Particular vowel;
VD = Vowel Duration; VDC = Vowel Duration Correctness;
CD = Consonant Duration; CDC = Consonant Duration Correctness.

A = /i:/ in monosyllables

	Score	Vowel Quality	Particular Vowel	Vowel Duration	Vowel Dur. Correctness	Consonant Duration	Con. Dur Correctness.	
Score	1.0000						(A)	.01
VQ	0.3125	1.0000						= .267
PV	-0.1243	-0.3312	1.0000					.05
VD	0.4582	-0.0291	-0.0405	1.0000				= .205
VDC	0.4832	-0.0271	-0.0258	0.9057	1.0000			
CD	-0.3995	-0.0159	-0.0151	-0.4861	-0.5367	1.0000		
CDC	0.3995	-0.0159	0.0151	0.4861	0.5367	-1.0000	1.0000	

FIGURE D2.1. (page 2)

A_2 = /iː/ in all data

	Score	Vowel Quality	Particular Vowel	Vowel Duration	Vowel Duration Correctness	Consonant Duration	Con. Dur Correctness.
Score	1·0000						(A2)
VQ	0·3380	1·0000					
PV	-0·1217	-0·3678	1·0000				
VD	0·3919	-0·0444	-0·0410	1·0000			
VDC	0·4281	-0·0384	-0·0264	0·9071	1·0000		
CD	-0·3166	0·0554	-0·0410	-0·4857	-0·5232	1·0000	
CDC	0·3992	-0·0206	0·0435	0·4755	0·5232	-0·9520	1·0000

·01 = ·254
·05 = ·195

B_1 = /iʲ/ and /uʷ/

	Score	Vowel Quality	Particular Vowel	Vowel Duration	Vowel Duration Correctness	Consonant Duration	Con. Dur Correctness.
Score	1·0000						(B1)
VQ	0·7278	1·0000					
PV	-0·0012	-0·0280	1·0000				
VD	0·0094	-0·0182	-0·0636	1·0000			
VDC	-0·0914	0·0025	-0·0104	0·8205	1·0000		
CD	-0·0236	0·0003	-0·0159	-0·4428	-0·5333	1·0000	
CDC	0·0236	-0·0003	0·0160	0·4428	0·5333	-1·0000	1·0000

·01 = ·228
·05 = ·174

B_2 = /eː/, /aː/ and /oː/

	Score	Vowel Quality	Particular Vowel	Vowel Duration	Vowel Duration Correctness	Consonant Duration	Con. Dur Correctness.
Score	1·0000						(B2)
VQ	0·1303	1·0000					
PV	-0·0406	-0·5000	1·0000				
VD	0·7898	0·0000	0·0000	1·0000			
VDC	0·7893	-0·0000	-0·0000	0·8768	1·0000		
CD	-0·0762	0·0000	0·0000	0·2220	0·0143	1·0000	
CDC	0·1206	0·0269	0·0000	-0·1561	0·0854	-0·9301	1·0000

·01 = ·267
·05 = ·205

C_1 = /i/ and /u/.

	Score	Vowel Quality	Particular Vowel	Vowel Duration	Vowel Duration Correctness	Consonant Duration	Con. Dur Correctness.
Score	1·0000						(C1)
VQ	0·5439	1·0000					
PV	0·2016	0·3991	1·0000				
VD	-0·3960	-0·0540	-0·0604	1·0000			
VDC	0·4400	0·0329	0·0115	-0·8243	1·0000		
CD	0·3178	-0·0039	-0·0466	-0·4342	0·5179	1·0000	
CDC	0·3940	0·1012	0·0162	-0·3539	0·4367	0·8026	1·0000

·01 = ·208
·05 = ·159

C_2 = /ɛ/, /a/ and /ɑ/.

	Score	Vowel Quality	Particular Vowel	Vowel Duration	Vowel Duration Correctness	Consonant Duration	Con. Dur Correctness.
Score	1·0000						(C2)
VQ	0·1391	1·0000					
PV	0·0483	0·5000	1·0000				
VD	0·7958	-0·0000	0·0000	1·0000			
VDC	0·7726	0·0000	-0·0000	0·8716	1·0000		
CD	0·0637	0·0000	0·0000	0·2220	0·0093	1·0000	
CDC	0·1821	0·0000	0·0000	0·0832	-0·0107	0·4969	1·0000

·01 = ·267
·05 = ·195

FIGURE D2.2. (page 1)

Results of the Multiple Linear Regression Test: the Contribution of each of the Independent Variables to the Score. (See discussion in 8.8 p. 164ff)

The table below shows the results of the standard statistical tests carried out to establish the significance of the independent variables (vowel quality, particular vowel, vowel duration, vowel duration correctness, consonant duration and consonant duration correctness) in accounting for vowel identification.

The following abbreviations are used:

Stand. Regr. Coefficient = Standard Regression coefficient;
DF = Degrees of freedom;
MRS = Multiple Regression Square;
VQ = Vowel Quality;
PV = Particular Vowel;
VD = Vowel Duration;
VDC = Vowel Duration Correctness;
CD = Consonant Duration;
CDC = Consonant Duration Correctness.

The results are given for the following vowels separately or in groups:

Group A: /i:/ in monosyllables only;
Group A2: /i:/ in all data together;
Group B1: /iʲ/ and /uʷ/ together;
Group B2: /e:/, /a:/ and /o:/ together;
Group C1: /i/ and /u/ together;
Group C2: /e/, /a/, and /o/ together.

The groups are shown on the right-hand side margin as (A), (A2) etc.

A	Coefficient	Standard Error	Stand. Regr. Coefficient	T-Test	P (2 Tail)	Tolerance		
Intercept	-9.20401						DF 86	(A)
VQ	3.54643	1.018	0.318	3.483	0.001	0.886181	MRS 0.3662	
PV	-0.07597	0.721	-0.010	-0.105	0.961	0.885001	F-Ratio 9.940	
VD	0.03332	0.056	0.121	0.598	0.552	0.179310	P Tail 0.0000	
VDC	2.54044	1.881	0.283	1.350	0.180	0.167488	0.1: .390	
CD							0.5: .338	
CDC	1.92972	1.071	0.184	1.802	0.075	0.709253		

<u>FIGURE D2.2</u> (page 2)

A2 Intercept	-41.36772						(A2)
VQ	3.80614	0.983	0.334	3.874	0.000	0.845250	DF 97
PV	0.00721	0.689	0.001	0.010	0.992	0.854966	MRS 0.3896
VD	0.02294	0.055	0.079	0.417	0.677	0.175450	F. Ratio 10.319
VDC	2.44736	1.804	0.264	1.357	0.178	0.165905	P. Tail 0.00000
CD	0.20426	0.083	0.646	2.456	0.016	0.090927	0.1=.390
CDC	8.99500	2.802	0.845	3.210	0.002	0.090821	0.5=.322
B1 Intercept	-2.51373						(B1)
VQ	8.73903	0.688	0.724	12.704	0.000	0.997755	DF
PV	0.08501	0.538	0.009	0.158	0.875	0.988942	MRS 0.5534
VD	-0.06084	0.029	-0.211	-2.112	0.037	0.323268	F. Ratio 34.200
VDC	2.77956	1.049	0.280	2.650	0.009	0.289576	P. Tail 0.00000
CD	0.01251	0.026	0.032	0.478	0.633	0.715039	0.1=.335
CDC	.					-0.000015	0.5=.290
B2 Intercept	-6.87141						(B2)
VQ	1.66955	0.724	0.150	2.306	0.023	0.743899	DF 89
PV	0.38162	0.722	0.034	0.529	0.598	0.748467	MRS 0.7212
VD	0.23059	0.051	0.603	4.531	0.000	0.176961	F. Ratio 38.367
VDC	2.58337	1.266	0.272	2.041	0.044	0.176088	P. Tail 38.367
CD	-0.10398	0.056	-0.293	-1.854	0.067	0.124996	0.1=.390
CDC	-0.82045	1.567	-0.085	-0.523	0.602	0.117440	0.5=.338
C1 Intercept	-8.21716						(C1)
VQ	5.23853	0.649	0.515	8.068	0.000	0.820316	DF 148
PV	-0.12305	0.513	-0.515	-0.240	0.811	0.832332	MRS 0.5054
VD	-0.00953	0.026	0.037	-0.360	0.719	0.317012	F-Ratio 25.210
VDC	2.74672	0.938	0.316	2.928	0.004	0.287399	P Tail 0.00000
CD	-0.01249	0.033	-0.039	-0.377	0.707	0.312625	.01=.308
CDC	2.02463	0.898	0.222	2.255	0.026	0.343616	.05=.266
C2 Intercept	24.42690						(C2)
VQ	1.68751	0.685	0.153	2.464	0.016	0.750002	DF 89
PV	-0.31249	0.685	-0.028	-0.456	0.649	0.750002	MRS 0.7417
VD	-0.25826	0.047	-0.684	-5.464	0.000	0.185103	F. Ratio 42.586
VDC	1.61972	1.117	0.177	1.450	0.151	0.194823	.01=.390
CD	0.04377	0.024	0.125	1.790	0.077	0.593562	.05=.338
CDC	1.73405	0.606	0.179	2.861	0.005	0.744082	

FIGURE D2.3 (page 1)

Results of the Multiple Linear Regression Test: the Correlation of the Independent Variables (vowel quality, particular vowel, vowel duration, vowel duration correctness, consonant duration and consonant duration correctness) with the Dependent Variable (the Score) and with each other. (See discussion in 8.8. p.164ff).

The Results given in the table below are similar to those given in Figure D2.1, except that the groups AA1, AA2 and so on are sub-groups of A, A2 and so on as follows:

AA1 includes the results for /i:/ in the context /h V t/ only;
AA2 includes the results for /i:/ in the contexts /b V t/ and /z V t/ only;
BB1 includes the results for /i^j/ only;
BB2 includes the results for /u^w/ only;
BB3 includes the results for /o:/ only;
BB4 includes the results for /a:/ only;
BB5 includes the results for /e:/ only;
CC1 includes the results for /i/ only;
CC2 includes the results for /u/ only;
CC3 includes the results for /o/ only;
CC4 includes the results for /a/ only;
CC5 includes the results for /e/ only.

The groups are shown on the right-hand side margin as (AA1), (AA2) etc.

As in previous tables, the following abbreviations are used:

VQ = Vowel Quality; PV = Particular Vowel;
VD = Vowel Duration; VDC = Vowel Duration Correctness;
CD = Consonant Duration; CDC = Consonant Duration Correctness.
DF = Degrees of Freedom.

The equivalence of .01 and .05 significance is given for each case in the right-hand column.

FIGURE D2.3 (page 2)

	Score	VQ	PV	VD	VDC	CD	CDC		
AA1. SCORE	1.0000							DF: 23	AA1
VQ	0.2659	1.0000							
PV	-0.1310	-0.4972	1.0000					0.1 = .505	
VD	0.3818	-0.0100	-0.0489	1.0000				0.5 = .396	
VDC	0.4091	-0.0110	-0.0539	0.9073	1.0000				
CD	-0.3608	-0.0064	-0.0315	-0.4944	-0.5449	1.0000			
CDC	0.3608	0.0064	0.0315	0.4944	0.5450	-1.0000	1.0000		
AA2 SCORE	1.0000							DF: 57	AA2
VQ	0.3544	1.0000							
PV	-0.0607	-0.2638	1.0000					0.1 = .325	
VD	0.5081	-0.0388	-0.0346	1.0000				0.5 = .250	
VDC	0.5345	-0.0353	-0.0131	0.9050	1.0000				
CD	-0.4322	-0.0207	-0.0077	-0.4824	-0.5330	1.0000			
CDC	0.4322	0.0207	0.0077	0.4824	0.5330	-1.0000	1.0000		
BB1 SCORE	1.0000							DF 36	BB1
VQ	0.7985	1.0000							
PV	0.0005	0.1261	1.0000					0.1 = .267	
VD	-0.1144	0.0002	-0.0405	1.0000				0.5 = .205	
VDC	-0.1139	0.0035	-0.0258	0.9057	1.0000				
CD	0.0987	0.0020	-0.0151	-0.4861	-0.5367	1.0000			
CDC	-0.0987	-0.0020	0.0151	0.4861	0.5367	-1.0000	1.0000		
BB2 - SCORE	1.0000							DF. 33	BB2
VQ	0.5967	1.0000							
PV	-0.1664	-0.5000	1.0000					0.1 = .418	
VD	0.4422	0.0000	-0.0000	1.0000				0.5 = .325	
VDC	0.4383	0.0000	-0.0000	0.9105	1.0000				
CD	-0.1542	-0.0000	-0.0000	-0.4617	-0.5071	1.0000			
CDC	0.1542	0.0000	-0.0000	0.4617	0.5071	-1.0000	1.0000		
BB3 SCORE	1.0000							DF: 35	BB3
VQ	0.2770	1.0000							
PV	-0.0902	-0.5000	1.0000					0.1 = .418	
VD	0.7710	0.0000	0.0000	1.0000				0.5 = .325	
VDC	0.7892	0.0000	0.0000	0.8673	1.0000				
CD	-0.1591	0.0000	0.0000	0.2089	-0.0468	1.0000			
CDC	0.2307	0.0614	0.0000	-0.1400	0.1521	-0.9116	1.0000		
BB4 SCORE	1.0000							DF: 23	BB4
VQ	-0.0186	1.0000							
PV	0.0139	-0.5000	1.0000					0.1 = .505	
VD	0.9188	-0.0000	-0.0000	1.0000				0.5 = .396	
VDC	0.8496	-0.0000	-0.0000	0.9129	1.0000				
CD	-0.0188	0.0000	0.0000	0.1664	0.0000	1.0000			
CDC	0.0199	-0.0000	-0.0000	-0.0976	0.0891	-0.9473	1.0000		

FIGURE D2.3 (page 3)

	SCORE	VQ	PV	VD	VDC	CD	CDC		
BB5 SCORE	1·0000							DF 17	BB5
VQ	0·0671	1·0000							
PV	-0·0252	-0·5000	1·0000					0·1 = ·575	
VD	0·8704	0·0000	0·0000	1·0000				0·5 = ·456	
VDC	0·8836	0·0000	0·0000	0·8702	1·0000				
CD	0·0920	0·0000	0·0000	0·3088	0·1489	1·0000			
CDC	-0·0212	-0·0000	-0·0000	-0·2485	-0·0377	-0·9416	1·0000		
CC1 SCORE	1·0000							DF 86	CC1
VQ	0·4565	1·0000							
PV	0·1543	0·2952	1·0000					0·1 = ·267	
VD	-0·4129	-0·0081	-0·0405	1·0000				0·5 = ·205	
VDC	0·4468	0·0000	0·0258	-0·9057	1·0000				
CD	0·3643	0·0000	-0·0151	-0·4861	0·5367	1·0000			
CDC	0·3643	0·0000	-0·0151	-0·4861	0·5367	1·0000	1·0000		
CC2 SCORE	1·0000							DF: 32..	CC2
VQ	0·5959	1·0000							
PV	0·1708	0·5000	1·0000					0·1: ·449	
VD	-0·4476	-0·0000	-0·0000	1·0000				0·5: ·349	
VDC	0·4440	-0·0000	-0·0000	-0·9105	1·0000				
CD	0·1527	-0·0000	-0·0000	-0·4617	0·5071	1·0000			
CDC	·0·2522	-0·0000	-0·0000	-0·2168	0·2381	0·5916	1·0000		
CC3 SCORE	1·0000							DF 36	CC3
VQ	0·3001	1·0000							
PV	0·1133	0·5000	1·0000					0·1 = ·418	
VD	-0·7469	0·0000	0·0000	1·0000				0·5 = ·325	
VDC	0·7535	-0·0000	-0·0000	-0·8673	1·0000				
CD	0·1489	0·0000	0·0000	0·2089	0·0468	1·0000			
CDC	0·1489	0·0000	0·0000	0·2089	0·0468	1·0000	1·0000		
CC4 SCORE	1·0000							DF: 23	CC4
VQ	-0·0232	1·0000							
PV	-0·0139	0·5000	1·0000					0·1 = ·505	
VD	-0·9173	0·0000	-0·0000	1·0000				0·5 = ·396	
VDC	0·8467	0·0000	0·0000	-0·9129	1·0000				
CD	0·0165	0·0000	0·0000	0·1664	0·0000	1·0000			
CDC	0·0366	-0·0000	-0·0000	0·1491	-0·1814	0·3445	1·0000		
CC5 SCORE	1·0000							DF = 18	CC5
VQ	0·0406	1·0000							
PV	-0·0000	0·5000	1·0000					0·1 = 575	
VD	-0·8846	0·0000	0·0000	1·0000				0·5 : 456	
VDC	0·8995	-0·0000	-0·0000	-0·8447	1·0000				
CD	-0·1333	0·0000	0·0000	0·3085	-0·0377	1·0000			
CDC	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000	0·0000		

FIGURE D2.4 (page 1)

Results of the Multiple Linear Regression Test: the Contribution of each of the Independent Variables to the Score. (See discussion in 8.8. p.164ff.)

The results given in the table below are similar to those given in Figure D2.2, except that the groups AA1, AA2 and so on are in fact sub-groups of A, A2 and so on, appearing in Figure D2.2., as follows:

AA1 includes the results for /i:/ in the context /h V t/ only;
AA2 includes the results for /i:/ in the contexts /b V t/ and /z V t/ only;
BB1 includes the results for /i^j/ only;
BB2 includes the results for /u^w/ only;
BB3 includes the results for /o:/ only;
BB4 includes the results for /a:/ only;
BB5 includes the results for /e:/ only;
CC1 includes the results for /i/ only;
CC2 includes the results for /u/ only;
CC3 includes the results for /o/ only;
CC4 includes the results for /a/ only;
CC5 includes the results for /e/ only.

The groups are shown on the right-hand side margin as before, as $_{AA1}$ etc.

The following abbreviations are used:

Sta. Error = Standard Error;
Sta. Reg. Coef. = Standard Regression Coefficient;
DF = Degrees of Freedom;
MRS = Multiple Regression Square;
The significance equivalence is given at .01 and .05.

As specified before the independent variables are:

VQ = Vowel Quality; PV = Particular Vowel;
VD = Vowel Duration; VDC = Vowel Duration Correctness;
CD = Consonant Duration; CDC = Consonant Duration Correctness.

FIGURE D2.4 (page 2)

	Coefficient	Sta. ERROR	Sta. Reg. Coef.	T-Test	P (2 Tail)	Tolerance		
AA1. Intercept	9.22876						DF: 23	AA1
VQ	2.65728	2.314	0.236	1.148	0.263	0.748793	MRS: 0.2698	
PV	-0.58351	1.901	-0.063	-0.307	0.762	0.742926	F-Ratio: 1.700	
VD	0.01796	0.125	0.061	0.143	0.888	0.176828	P. Tail 0.17470	
VDC	2.39568	4.289	0.246	0.559	0.582	0.164076	0.1 = .679	
CD	-0.07491	0.081	-0.197	-0.925	0.365	0.696982	0.5 = .604	
CDC								
AA2 Intercept	-12.96012						DF: 57	AA2
VQ	4.12951	1.103	0.380	3.743.	0.000	0.925348	MRS: 0.4559	
PV	0.34620	0.738	0.048	0.469	0.641	0.925689	F. Ratio: 9.552	
VD	0.04005	0.060	0.155	0.673	0.504	0.180230	P. Tail: 0.00000	
VDC	2.60246	1.995	0.310	1.305	0.197	0.168573	0.1 = .466	
CD							0.5 = 406	
CDC	1.80616	1.137	0.184	1.589	0.118	0.713658		
BB1 Intercept	1.26091						DF: 86	BB1
VQ	9.91491	0.769	0.812	12.885	0.000	0.983975	MRS 0.6641	
PV	-0.92383	0.557	-0.105	-1.659	0.101	0.980633	F-Ratio 34.006	
VD	-0.01811	0.045	-0.039	-0.399	0.691	0.179428	P. Tail 0.00000	
VDC	0.42550	1.531	-0.042	-0.278	0.782	0.167487	0.1 = .390	
CD							0.5 = .338	
CDC	-0.51682	0.870	-0.044	-0.594	0.554	0.711005		
BB2 Intercept	-13.56822						DF: 33	BB2
VQ	7.28207	1.371	0.685	5.311	0.000	0.749999	MRS: 0.5886	
PV	1.87182	1.371	0.176	1.365	0.181	0.749999	F-Ratio 9.441	
VD	0.06666	0.071	0.252	0.934	0.357	0.171053	P-Tail 0.00001	
VDC	2.22233	2.420	0.255	0.918	0.365	0.161490	.01 = .582	
CD							.05 = .512	
CDC	-0.94446	1.335	-0.092	-0.707	0.484	0.742856		
BB3 Intercept	-17.86221						DF: 35	BB3
VQ	3.48209	1.039	0.303	3.351	0.002	0.724094	MRS 0.7922	
PV	0.70531	1.026	0.061	0.688	0.496	0.743350	F-Ratio 22.227	
VD	0.26080	0.075	0.648	3.487	0.001	0.171674	P-Tail 0.00000	
VDC	1.94915	1.776	0.206	1.098	0.280	0.168751	0.1 = .582	
CD	-0.07853	0.069	-0.221	-1.135	0.264	0.155987	0.5 = .512	
CDC	0.68777	2.028	0.070	0.339	0.737	0.140725		
BB4 Intercept	13.86652						DF: 23	BB4
VQ	-0.16666	0.797	-0.015	-0.209	0.836	0.750000	MRS: 0.9054	
PV	0.06668	0.797	0.006	0.084	0.934	0.750000	F-Ratio 36.698	
VD	0.38044	0.069	0.967	5.526	0.000	0.134193	P. Tail 0.00000	
VDC	0.14755	1.583	0.016	0.093	0.927	0.132113	0.1 = .679	
CD	-0.25854	0.076	-0.711	-3.422	0.002	0.095241	0.5 = .604	
CDC	-5.38124	2.035	-0.361	-2.644	0.015	0.091376		

FIGURE D2.4 (page 3)

	Coefficient	Std Error	Std. Reg. Coef	T-Test	P(2 Tail)	Tolerance		
BB5 Intercept	-6.13354						DF: 17	(BB5)
VQ	0.54167	0.825	0.073	0.656	0.520	0.750000	MRS 0.3434	
PV	0.08334	0.825	0.011	0.101	0.921	0.750000	F-Ratio 15.257	
VD	0.11965	0.051	0.511	2.327	0.033	0.190885	P. Tail 0.00001	
VDC	3.27856	1.562	0.462	2.099	0.051	0.190073	0.1 = .749	
CD	-0.03905	0.073	-0.165	-0.538	0.597	0.097894	0.5 = .673	
CDC	-0.20266	1.972	-0.032	-0.103	0.919	0.093424		
CC1 Intercept	-7.61578							(CC1)
VQ	3.91489	0.738	0.452	5.306	0.000	0.912665	DF: 86	
PV	0.08860	0.539	0.014	0.164	0.870	0.909820	MRS 0.4300	
VD	-0.00528	0.042	-0.024	-0.125	0.901	0.179421	F-Ratio 12.978	
VDC	2.37055	1.427	0.331	1.661	0.100	0.167471	P. Tail 0.00000	
CD							0.1 = .390	
CDC	1.47337	0.811	0.175	1.817	0.073	0.710984	0.5 = .338	
CC2 Intercept	7.49363						DF: 32	(CC2)
VQ	7.20516	1.280	0.681	5.630	0.000	0.750000	MRS 0.6493	
PV	-1.79488	1.280	-0.170	-1.403	0.170	0.749999	F-Ratio 9.872	
VD	-0.06666	0.067	-0.253	-1.001	0.324	0.171053	P. Tail 0.00000	
VDC	2.49347	2.260	0.288	1.103	0.278	0.161210	0.1 = .618	
CD	-0.09800	0.050	-0.287	-1.951	0.060	0.507813	0.5 = .545	
CDC	2.58668	1.130	0.298	2.289	0.029	0.644844		
CC3 Intercept	23.90210	-				-	DF: 36	(CC3)
VQ	3.78574	1.117	0.325	3.391	0.002	0.749999	MRS 0.7526	
PV	-0.57143	1.117	-0.049	-0.512	0.612	0.749998	F-Ratio 21.897	
VD	-0.26837	0.079	-0.657	-3.410	0.002	0.185425	P. Tail 0.00000	
VDC	1.64557	1.814	0.171	0.907	0.370	0.193460	0.1 = .582	
CD							0.5 = .512	
CDC	3.00616	1.038	0.278	2.897	0.006	0.746621		
CC4 Intercept	41.57411						DF: 23	(CC4)
VQ	-0.23333	0.870	-0.022	-0.268	0.791	0.750000	MRS 0.8374	
PV	-0.03334	0.870	-0.003	-0.038	0.970	0.750000	F-Ratio 30.211	
VD	-0.38881	0.076	-0.989	-5.145	0.000	0.132538	P. Tail 0.00000	
VDC	-0.28884	1.725	-0.032	-0.167	0.868	0.132522	0.1 = .679	
CD	0.04934	0.030	0.136	1.622	0.119	0.698793	0.5 = .604	
CDC	1.28416	0.760	0.131	1.690	0.105	0.809070		
CC5 Intercept	20.41628						DF: 18	(CC5)
VQ	0.41666	0.767	0.054	0.543	0.594	0.750002	MRS 0.8663	
PV	-0.20834	0.767	-0.027	-0.272	0.789	0.750002	F-Ratio 23.321	
VD	-0.11225	0.046	-0.464	-2.462	0.024	0.209595	P. Tail 0.00000	
VDC	3.30718	1.164	0.509	2.841	0.011	0.231358	0.1 = .749	
CD	0.00710	0.025	0.029	0.288	0.777	0.730738	0.5 = .673	
CDC	-							

FIGURE D 2.5. (page 1)

Graphic Summary of the Statistical Results presented in Figures D2. 1 to D2.4 showing variable correlation and variable contribution to the score (as explained in the legends to Figures D2.1 to D2.4)

The presence of significant correlation between variables is shown first. ✓ indicates significant correlation in the case of a close vowel; O indicates significant correlation in the case of an open vowel.

When a variable contributes significantly to the score, this is shown in a similar way: for a close vowel; for an open vowel.

The results are shown for all groups and sub-groups. These are shown at the top of the figure. Thus, for example, the correlation of vowel quality to the score is significant for groups A (/i:/ in monosyllables only), A_2 (/i:/ in all data); but not for AA_1 (/i:/ in /h V t/). Further, we can see that vowel quality contributes significantly to the score in the case of groups A, (/i:/ in monosyllables only;) A_2 (/i:/ in all data) and so on , but not in the case of B_2 (/o:/, /a:/, and /e:/). In this case, vowel duration contributes significantly to the score.

FIGURE D2.5. (page 2)

√ is used for close vowels; 0 for open vowels.	/i:/ in [illegible] syllables	All of /i:/	/i:/ in /hi:t/	/i:/ in /bi:t/, /zi:t/	/i^j/ and /u^w/	/o:/, /a:/, /e:/	/i^j/	/u^w/	/o:/	/a:/	/e:/	/i/, /u/	/o/, /a/, /e/	/i/	/u/	/o/	/a/	/e/
CORRELATION	A	A_2	AA_1	AA_2	B_1	B_2	BB_1	BB_2	BB_3	BB_4	BB_5	C_1	C_2	CC_1	CC_2	CC_3	CC_4	CC_5
VQ - Score	✓	✓		✓	✓		✓	✓				✓		✓	✓			
PV "																		
VD "	✓	✓	✓	✓		0		✓	0	0	0	✓	0	✓	✓	0	0	0
VDC "	✓	✓		✓		0		✓	0	0	0	✓	0	✓	✓	0	0	0
CD "	✓	✓		✓		0						✓		✓				
CDC "	✓	✓	✓	✓								✓		✓				
PV - Vowel Quality	✓					0		✓	0	0	0	✓	0	✓	✓	0	0	0
VD "																		
VDC "																		
CD "																		
CDC "																		
VD - Particular Vowel																		
VDC																		
CD																		
CDC																		
VDC - Vowel Duration	✓	✓	✓	✓	✓	0	✓	✓	0	0	0	✓	0	✓	✓	0	0	0
CD	✓	✓	✓	✓	✓		✓	✓				✓		✓	✓			
CDC	✓	✓	✓	✓	✓		✓	✓				✓		✓				
CD Vowel Duration Correctness	✓	✓	✓	✓	✓		✓	✓				✓		✓	✓			
CDC	✓	✓	✓	✓	✓		✓	✓				✓		✓				
CDC Consonant Duration	✓	✓	✓	✓	✓	0	✓	✓	0	0	0	✓	0	✓	✓	0		
CONTRIBUTION TO THE SCORE																		
VQ	✓	✓	✓	✓	✓		✓	✓	0			✓		✓	✓	0		
PV																		
VD						0			0	0	0		0			0	0	0
VDC											0	✓						
CD										0								
CDC										0								

APPENDIX D - D 3.

Tables showing the results of the perception test reported and discussed in Chapter 8.

D3. Presentation of Results

The tables relevant to the perception test discussed in chapter 8 are organized below as follows:

1. Figures D3.1 to D3.11 : These are relevant to each part of the test concerning the vowels /i:/, /i^j/ and /i/, i.e., in the contexts /h V t/, /b V t/, /z V t/ as well as in the contexts /s V ket/ and /p V ter/.

2. Figures D3.12 to D3.15 : These are relevant to each part of the test concerning the vowels /u^w/ and /u/, i.e., in the contexts /sV r/, /t V tu/ , /t V l/.

3. Figures D3.16 to D3.20 : These are relevant to each part of the test concerning the vowels /o:/ and /o/, i.e., in the contexts /b V t/, and/s V t/.

4. Figures D3.21 to D3.25 : These are relevant to each part of the test concerning the vowels /a:/ and /a/ i.e., in the contexts /t V ta/ and /r V t/.

5. Figures D3.26 to D3.30 : These are relevant to the part of the test concerning the vowels /e:/ and /e/, i.e., in the context /t V ma/.

The tables for each of the above vowel sets (i.e., each of 1 to 5 above) appear as follows:

i. The tables showing the number of responses and their equivalent in percentage for each of the test stimuli. The order of presentation of the item in the test appears in the left hand column. In these tables, number refers to the actual number of subjects' responses. Thus, '5' under the 'number' column within the 'Responses for /i:/' - under /hi:t/(see Figure D3.1) should be read as 'Five subjects identified the stimulus item as /hi:t/ rather than /hi^{j}t/ or /hit:/. The percentage is the percentage that this number (5) represents in terms of total number of responses for that item. Thus 14% for 5 means that

5 represents a 14% of the number of responses for that item presented first in the test.

ii. The tables showing the values for the formant structure and duration of the synthesised vowel elements and the consonant duration when this is relevant. These tables are given to help the reader understand which are the varying values and to what extent these values vary. The data contained in these tables constitute the basic data fed to SID to produce the varying vowels.

iii. (a). The tables containing the results (responses) in percentages categorised by formant structure. Thus, the reader can see how many responses were given as /i:/, /i^{j}/ or /i/ etc. (as the case may be) for all stimuli where the vowel had a particular formant structure but varied in duration.

iii. (b). The tables containing the results (responses) in percentages categorised by vowel and consonant duration. The reader can thus see how many responses were obtained for each vowel for all the stimuli where the vowels and consonants were identical in duration but differed in formant structure.

FIGURE D3.1.

The results by item in chronological order for the forced choice test 1 (parts 1, 4 and 5) of the synthetic speech sets (a) /hi:t/, /hi^{J}t/, /hit:/; (b) /zi:t/, /zi^{J}t/, /zit:/; (c) /bi:t/, /bi^{J}t/, /bit:/.

The information should be read as: "Five subjects (=14%) identified test item number 1 of the /h V t/ context as /hi:t/, thirty (= 81%) as /hi^{J}t/ and two (= 5 %) as /hit:/"; and so on.

Test No.	Responses for /i:/						Responses for /iʲ/						Responses for /i/					
Items	/hi:t/		/zi:t/		/bi:t/		/hiʲt/		/ziʲt/		/biʲt/		/hit:/		/zit:/		/bit:/	
	Number	%age	No.	%age	No.	%age	No.	%age	No	%age	No.	%age	No.	%age	No.	%age	No.	%age
1	5	14	24	65	0	0	30	81	13	35	30	81	2	5	0	0	7	19
2	30	81	2	5	3	8	6	16	30	81	12	32	1	3	5	14	22	60
3	33	90	14	38	6	16	2	5	0	0	9	24	2	5	23	62	22	60
4	28	76	7	19	7	19	3	8	30	81	6	16	6	16	0	0	24	65
5	13	35	4	11	6	16	18	49	28	75	31	84	6	16	5	14	0	0
6	3	8	27	93	3	8	33	89	2	5	34	92	1	3	8	22	0	0
7	6	16	20	54	4	11	31	84	5	14	1	3	0	0	12	32	32	86
8	5	14	5	14	22	59	32	86	32	86	11	30	0	0	0	0	4	11
9	8	22	3	8	29	78	25	67	34	92	6	17	4	11	0	0	2	5
10	4	11	16	43	4	11	32	86	5	14	31	84	1	3	16	43	2	5
11	7	19	25	68	14	38	30	81	3	8	22	59	0	0	9	24	1	3
12	7	19	5	14	9	24	27	73	32	86	25	68	3	8	0	0	3	8
13	5	14	4	11	22	60	29	78	27	73	2	5	3	8	6	16	13	35
14	3	8	31	84	0	0	34	92	2	5	4	11	0	0	4	11	33	89
15	35	94	7	19	4	11	1	3	26	70	31	84	1	3	4	11	2	5
16	25	68	7	19	15	41	6	16	1	3	13	35	6	16	29	78	9	24
17	28	76	3	8	5	14	7	19	34	92	32	86	2	5	0	0	0	0
18	2	5	33	89	32	86	33	90	3	8	4	11	2	5	1	3	1	3
19	13	35	21	57	29	78	24	65	14	38	4	11	0	0	2	5	4	11
20	34	92	3	8	8	22	3	8	31	84	9	24	0	0	3	8	20	54
21	20	54	23	62	16	43	12	32	3	8	5	14	5	14	11	30	16	43
22	17	46	4	11	2	5	7	19	12	32	1	3	13	35	21	57	34	92
23	34	92	2	5	2	5	2	5	33	90	34	92	1	3	2	5	1	3
24	3	8	27	73	4	11	34	92	10	27	31	84	0	0	0	0	2	5
25	31	84	6	16	33	89	4	11	2	6	4	11	2	5	29	78	0	0
26	4	11	4	11	33	89	3	8	33	89	3	8	30	81	0	0	1	3
27	37	100	19	51	2	5	0	0	13	35	35	95	0	0	5	14	0	0
28	23	62	4	11	1	3	11	30	23	62	30	81	3	8	10	27	6	16
29	0	0	8	22			37	100	28	75			0	0	1	3		
30			31	84					5	13					1	3		
31			27	73					2	5					8	22		
32			13	35					14	38					10	27		
33			32	86					5	14					0	0		
34			8	22					2	5					27	73		
35			9	24					10	27					18	49		

FIGURE D3.2.

The results by item in chronological order for the forced choice test 1 (part 7) of the synthetic speech sets /si:ket/, /siket/, /sik:et/.

Test No. Items	Responses for /i:/ - /si:ket/		Responses for /i/ - /siket/		Responses for /i/ - /sik:et/	
	Responses Number	% age	Responses Number	% age	Responses Number	% age
1	28	100	0	0	0	0
2	0	0	0	0	28	100
3	2	7	2	7	24	86
4	18	64	6	21	4	14
5	19	68	6	21	3	11
6	6	21	6	21	14	50
7	17	61	5	18	6	21
8	16	57	8	29	4	14
9	7	25	12	43	9	32
10	19	68	6	21	3	11
11	15	54	7	25	6	21
12	20	71	5	18	3	11

FIGURE D3.3.

The results by item in chronological order for the forced choice test 1 (part 6) of the synthetic speech sets /piʲter/, /pit:er/.

Test No. Items	Responses for /i/ - /pit:er/		Responses for /iʲ/ - /piʲter/	
	Responses Number	% age	Responses Number	% age
1	0	0	35	100
2	3	9	32	91
3	0	0	35	100
4	35	100	0	0
5	3	9	32	91
6	27	77	8	23
7	6	17	29	83
8	27	77	8	23
9	12	34	23	66
10	0	0	35	100
11	1	3	34	97
12	6	17	29	83
13	0	0	35	100

FIGURE D3.4.

Values for the formant structure and duration of the synthesised vowel elements /i:/, /i^j/, /i/ in the contexts /h V t/, /z V t/, and /b V t/.

Phonemic Transcription of Target Word	Formant 1 SID Units	Formant 1 Hz	Formant 2 SID Units	Formant 2 Hz	Formant 3 SID Units	Formant 3 Hz	Vowel duration SID Units	Vowel duration msec	Arresting Consonant Duration SID Units	Arresting Consonant Duration msec	Item in order of presentation in test material /h-t/	/b-t/	/z-t/
/hi't/ /zi't/ /bi't/	3	249	23	2280	14	2480	8	80	6	60	1	23	2
							12	120	6	60	14	6	9
							16	160	6	60	24	27	8
							8	80	12	120	13	15	17
	3	249	21	2125	14	2480	8	80	6	60	29	28	12
							12	120	6	60	10	5	20
							16	160	6	60	12	12	29
							8	80	12	120	18	24	13
/hi't/ /zi't/ /bi't/ or /hi:t/ /zi:t/ /bi:t/	5	298	23	2280	14	2480	8	80	6	60	8	1	5
							12	120	6	60	11	17	26
							16	160	6	60	19	11	4
							8	80	12	120	7	10	23
/hi:t/ /zi:t/ or /hi't/ /zi't/	7	350	23	2280	14	2480	8	80	6	60	6	–	15
							12	120	6	60.	–	–	19
							16	160	6	60	–	–	1
							8	80	12	120	–	–	28
/zi:t/ or /zi't/	7	350	21	2125	14	2480	8	80	6	60	–	–	32
							12	120	6	60	–	–	11
							16	160	6	60	–	–	31
							8	80	12	120	–	–	16
/hi:t/ /zi:t/ /bi:t/	8	375	23	2280	14	2480	8	80	6	60	21	16	27
							12	120	6	60	17	8	24
							16	160	6	60	20	9	30
							8	80	12	120	9	2	22
	8	375	21	2125	14	2480	8	80	6	60	28	20	6
							12	120	6	60	15	25	–
							16	160	6	60	27	26	–
							8	80	12	120	5	3	–
/zi:t/ or /zit:/													
	10	427	23	2280	14	2480	8	80	6	60	–	–	7
/bi:t/ /zi:t/ or /bit:/ /zit:/	10	427	21	2125	14	2480	8	80	6	60	–	4	10
							12	120	6	60	–	19	–
							16	160	6	60	–	18	–
							18	180	12	120	–	14	–
/hit:/ /zit:/ /bit:/	12	477	23	2280	14	2480	8	80	6	60	16	7	34
							12	120	6	60	2	21	21
							16	160	6	60	23	13	14
							8	80	12	120	22	22	25
/hit:/ /zit:/	12	477	21	2125	14	2480	8	80	6	60	4	–	3
							12	120	6	60	3	–	18
							16	160	6	60	25	–	33
							8	80	12	120	26	–	35

FIGURE D3.5.

Values for the formant structure and duration of the synthesised vowel elements /i:/, /iʲ/ and /i/ in the contexts /s V ket/ and /p V ter/

	Formant 1 SID units	Formant 1 Hz	Formant 2 SID	Formant 2 Hz	Formant 3 SID	Formant 3 Hz	Vowel duration SID	Vowel duration msec	Arresting Consonant Duration SID	Arresting Consonant Duration msec	Item in Order of presentation in test
/si:ket/	8	375	23	2280	14	2480	8	80	8	80	5
							12	120	8	80	12
							8	80	16	160	6
	8	375	21	2125			8	80	16	160	4
/si:ket/ or /siket/	10	427	23	2280			8	80	8	80	1
							12	120	8	80	7
							8	80	16	160	3
/si:ket/ /siket/ or /sik:et/	10	427	21	2125			8	80	8	80	5
/siket/	12	477	23	2280			8	80	8	80	11
							12	120	8	80	10
/sik:et/	12	477	23	2280			8	80	16	160	2
/siket/	12	477	21	2125			8	80	8	80	9
/piʲter/	3	249	23	2280	14	2480	8	80	6	60	1
	3	249	21	2125	14	2480	8	80	6	60	3
							4	40	6	60	2
							4	40	12	120	7
/piʲter/ or /pit:er/	5		23	2280	14	2480	8	80	6	60	13
	8	375	23	2280	14	2480	8	80	6	60	10
	8	375	21	2125	14	2480	8	80	6	60	5
							4	40	6	60	12
							4	40	12	120	8
/pit:er/	12	477	23	2280	14	2480	8	80	6	60	11
	12	477	21	2125	14	2480	8	80	6	60	9
							4	40	6	60	6
							4	40	12	120	4

FIGURE D3.6.

Percentage results for Test 1 (parts 1,4, and 5) rank-ordered according to the formant structure of the vowels.

FORMANTS in Hz F3 = 2480	DURATION (IN MSEC)		/i:/ Responses in %age			/iᵊ/ Responses in %age			/i/ Responses in %age		
F1 : F2 :	Vowel	Consonant	/h-t/	/z-t/	/o-t/	/h-t/	/z-t/	/b-t/	/h-t/	/z-t/	/o-t/
249 - 2280	80	60	14	5	5	81	81	92	5	14	3
	120	60	8	5	8	92	92	92	0	0	0
	160	60	8	14	5	92	86	95	0	0	0
	80	120	14	8	11	78	92	84	8	0	5
249 - 2125	80	60	8	14	3	92	86	81	0	0	16
	120	60	11	8	16	86	84	84	3	8	0
	160	60	19	22	24	73	75	68	8	3	8
	80	120	5	11	11	90	73	84	5	16	5
298 - 2280	80	60	14	11	0	86	75	81	0	14	19
	120	60	19	11	14	81	89	86	0	0	0
	160	60	35	19	38	65	81	59	0	0	3
	80	120	16	5	11	84	90	84	0	5	5
350 - 2280	80	60	8	19	-	89	70	-	3	11	-
	120	60	-	57	-	-	38	-	-	5	-
	160	60	-	65	-	-	35	-	-	0	-
	80	120	-	11	-	-	62	-	-	27	-
350 - 2125	80	60	-	35	-	-	38	-	-	27	-
	120	60	-	89	-	-	8	-	-	3	-
	160	60	-	86	-	-	14	-	-	0	-
	80	120	-	24	-	-	27	-	-	49	-
375 - 2280	80	60	54	51	41	32	35	35	14	14	24
	120	60	76	73	59	19	27	30	5	0	11
	160	60	92	84	78	8	13	17	0	3	5
	80	120	22	11	8	67	32	32	11	57	60
375 - 2125	80	60	62	73	22	30	5	24	8	22	54
	120	60	94	-	89	3	-	11	3	-	0
	160	60	100	-	89	0	-	8	0	-	3
	80	120	35	-	16	49	-	24	16	-	60
427 2280	80	60	-	54	-	-	14	-	-	32	-
427 2125	80	60	-	43	19	-	14	16	-	43	65
	120	60	-	-	78	-	-	11	-	-	11
	160	60	-	-	86	-	-	11	-	-	3
	80	120	-	-	0	-	-	11	-	-	89
477 - 2280	80	60	65	22	11	16	5	3	16	73	86
	120	60	81	22	43	16	8	14	3	30	43
	160	60	92	57	60	5	5	5	3	11	35
	80	120	46	16	5	19	6	3	35	78	92
477 2125	80	60	76	38	-	8	0	-	16	62	-
	120	60	90	68	-	5	8	-	5	24	-
	160	60	54	73	-	11	5	-	5	22	-
	80	120	11	19	-	8	3	-	81	78	-

FIGURE D3.7.

Percentage results for Test 1 (parts 1, 4 and 5) rank-ordered according to the duration of the vowels.

FORMANTS (IN Hz) F3 = 2480		DURATION (IN MSEC)		Responses in percentage /i:/			/i'/			/ɪ/		
F1:	F2:	VOWEL	CONS.	/h-t/	/z-t/	/b-t/	/h-t/	/z-t/	/b-t/	/h-t/	/z-t/	/b-t/
249	2280	80	60	14	5	5	81	81	92	5	14	3
249	2125			8	14	3	92	96	81	0	0	16
298	2280			14	11	0	86	75	81	0	14	19
350	2280			8	19	-	89	70	-	3	11	-
350	2125			-	35	-	-	38	-	-	27	-
375	2280			54	51	41	32	35	35	14	14	24
375	2125			62	73	22	30	65	24	8	22	54
427	2280			-	54	-	-	14	-	-	32	-
427	2125			-	43	19	-	14	16	-	43	65
477	2280			62	22	11	16	5	3	16	73	86
477	2125			76	38	-	8	0	-	16	62	-
249	2280	120	60	8	8	8	92	92	92	5	14	3
249	2125			11	8	16	86	84	84	3	8	0
298	2280			19	11	14	81	89	86	0	0	0
350	2280			-	57	-	-	38	-	-	5	-
350	2125			-	89	-	-	8	-	-	3	-
375	2280			76	73	59	19	27	30	5	0	11
375	2125			94	-	89	3	-	11	3	-	0
427	2125			-	-	78	-	-	11	-	-	11
477	2280			81	62	43	16	8	14	3	30	43
477	2125			90	68	-	5	8	-	5	24	-
249	2280	160	60	8	14	5	92	86	95	0	0	0
249	2125			19	22	24	73	75	68	8	3	3
298	2280			35	19	38	65	81	59	0	0	3
350	2280			-	65	-	-	35	-	-	0	-
350	2125			-	86	-	-	14	-	-	0	-
375	2280			92	84	78	8	13	17	0	3	5
375	2125			100	-	89	0	-	8	0	-	3
427	2125			-	-	86	-	-	11	-	-	3
477	2280			92	84	60	5	5	5	3	11	35
477	2125			84	73	-	11	5	-	5	22	-
249	2280	80	120	14	8	11	78	92	84	8	0	5
249	2125			5	11	11	90	73	84	5	16	5
298	2280			16	5	11	84	90	84	0	5	5
350	2280			-	11	-	-	62	-	-	27	-
350	2125			-	24	-	-	27	-	-	49	-
375	2280			22	11	8	67	32	32	11	57	60
375	2125			35	-	16	49	-	24	16	-	60
427	2125			-	-	0	-	-	11	-	-	89
477	2280			46	16	5	19	6	3	35	78	92
477	2125			11	19	-	8	3	-	81	78	-

FIGURE D3.8.

Percentage results for Test 1 (part 7) rank-ordered according to: (a) Formant Structure and (b) Duration of the vowel.

(a) Formant Structure

Formants (in Hz) F3 = 2480, F1:	F2:	Duration (in msec) Vowel	Cons	Responses in % age /si:ket/	/siket/	/sik:et/	/siket/ & /sik:et/
375	2280	80	80	68	21	11	32
		120	80	71	18	11	29
		80	160	21	21	50	71
375	2125	80	80	64	21	14	35
427	2280	80	80	100	0	0	0
		120	80	61	18	21	39
		80	160	7	7	86	93
427	2125	80	80	57	29	14	43
477	2280	80	80	54	25	21	46
		120	80	68	21	11	32
		80	160	0	0	100	100
477	2125	80	80	25	43	32	75

(b) Duration

Formants 1 - 2 - 3	Duration Vowel	Cons	Responses in % age /si:ket/	/siket/	/sik:et/	/siket/ & /sik:et/
8 - 23 - 14	80	80	68	21	11	32
8 - 21 - 14			64	21	14	35
10 - 23 - 14			100	0	0	0
10 - 21 - 14			57	29	14	43
12 - 23 - 14			54	25	21	46
12 - 21 - 14			25	43	32	75
8 - 23 - 14	120	80	71	18	11	29
10 - 23 - 14			61	18	21	39
12 - 23 - 14			68	21	11	32
8 - 23 - 14	80	160	21	21	50	71
10 - 23 - 14			7	7	86	93
12 - 23 - 14			0	0	100	100

FIGURE D3.9.

Percentage results for Test 1 (part 6) rank-ordered according to: (a) Formant structure and (b) Duration of the vowel.

(a) Formant Structure

Formants F3 = 2480, F1:	F2	Duration Vowel	Cons	Responses in % age /pit:er/	/pi'ter/
249	2280	80	60	0	100
249	2125	80	60	0	100
		40	60	9	91
		40	120	17	83
298	2280	80	60	0	100
375	2280	80	60	0	100
375	2125	80	60	9	91
		40	60	17	83
		40	120	77	23
477	2280	80	60	3	97
477	2125	80	60	34	66
		40	60	77	23
		40	120	100	0

(b) duration.

Formants 1 - 2 - 3	Duration Vowel	Cons.	Responses in % age /pit:er/	/pi'ter/
3 - 23 - 14	80	60	0	100
3 - 21 - 14			0	100
5 - 23 - 14			0	100
8 - 23 - 14			0	100
8 - 21 - 14			9	91
12 - 23 - 14			3	97
12 - 21 - 14			34	66
3 - 21 - 14	40	60	9	91
8 - 21 - 14			17	83
12 - 21 - 14			77	23
3 - 21 - 14	40	120	17	83
8 - 21 - 14			77	23
12 - 21 - 14			100	0

FIGURE D3.10. Percentage results for Test 1, parts 1, 4 and 5, separately and as an average for the three contexts (/h V t/, /z V t/ and /b V t/) together. The results are rank-ordered according to (a) formant structure and (b) duration of the vowel.

(a) By Formant Structure

FORMANTS IN Hz F3 = 2480 F1	F2	/I:/ /h-t/	/I:/ /z-t/	/I:/ /b-t/	/I:/ {h, z, b -t}	/i'/ /h-t/	/i'/ /z-t/	/i'/ /b-t/	/i'/ {h, z, b -t}	/i/ /h-t/	/i/ /z-t/	/i/ /b-t/	/i/ {h, z, b -t}
249	{2280, 2125}	11	11	10	11	86	84	85	85	4	5	5	5
298	2280	21	12	16	16	79	84	76	80	0	5	7	4
350	{2280, 2125}	8	48	-	28	89	37	-	63	3	15	-	9
375	{2280, 2125}	67	58	50	58	26	39	23	28	7	19	27	18
427	{2280, 2125}	-	49	46	48	-	14	12	13	-	38	42	40
477	{2280, 2125}	69	48	30	49	11	5	6	7	21	47	64	44

(b) By Duration (in msec)

V	C	/I:/ /h-t/	/I:/ /z-t/	/I:/ /b-t/	/I:/ {h, z, b -t}	/i'/ /h-t/	/i'/ /z-t/	/i'/ /b-t/	/i'/ {h, z, b -t}	/i/ /h-t/	/i/ /z-t/	/i/ /b-t/	/i/ {h, z, b -t}
V 80	C 60	37	33	14	28	54	44	47	48	8	28	38	25
V 120	C 60	54	47	44	48	43	44	47	45	3	11	10	8
V 160	C 60	61	56	54	57	36	39	36	37	2	5	8	5
V 80	C 120	21	13	9	14	56	48	46	50	22	39	45	35

(1)

(a) BY FORMANT STRUCTURE

FORMANTS IN Hz F3 = 2480 F1	F2	/si:ket/	/si ket/	/sik:et/	/siket/ & /sik:et/
375	{2280 2125}	56	20	22	36
427	{2280 2125}	56	14	30	41
477	{2280 2125}	37	22	41	61
(b) By DURATION (in msec)					
V80	C 80	61	23	15	34
V120	C 80	67	19	14	24
V80	C160	9	9	79	89

(2)

(a) BY FORMANT STRUCTURE

FORMANTS IN Hz F3 = 2480 F1	F2	/pit:er/	/pi ter/
249	{2280 2125}	11	94
298	{2280 2125}	0	100
375	{2280 2125}	26	74
477	{2280 2125}	54	47
(b) BY DURATION (in msec)			
V80	C60	7	93
V40	C60	34	66
V40	C120	65	35

FIGURE D3.11. Percentage results for Test 1, parts 6 and 7 separately, undifferentiated for single or geminated consonant for the contexts /s V ket/and /p V ter/. The results in each case are rank-ordered according to (a) Formant structure and (b) Duration of the vowel.

FIGURE D3.12.

The results by item in chronological order for the forced choice test 1 (parts 2, 3 and 8) of the synthetic speech sets (a) $/su^Wr/$, /sur/; (b) $/tu^Wtu/$, /tut:u/; (c) $/tu^Wl/$, /tul:/.

Test No. of Items	$/u^w/$:- $/su^wr/$ Responses Number	% age	/u/ :- /sur/ Responses Number	% age
1	0	0	28	100
2	28	100	0	0
3	21	75	7	25
4	17	61	11	39
5	6	21	22	79
6	5	18	23	82
7	4	14	24	86
8	20	71	8	29
9	21	75	7	25
10	5	18	23	82
11	13	46	15	54
12	11	39	17	61

	$/u^w/$:- $/tu^wtu/$ Responses Number	% age	/u/ :- /tut:u/ Responses Number	% age
1	32	100	0	0
2	27	84	5	16
3	23	72	9	28
4	15	47	17	53
5	22	69	10	31
6	21	66	11	34
7	27	84	5	16
8	5	16	27	84
9	26	81	6	19
10	21	66	11	34
11	18	56	14	44
12	26	81	6	19

	$/u^w/$:- $/tu^wl/$ Responses Number	% age	/u/ :- /tul:/ Responses Number	% age
1	1	3	36	97
2	7	19	30	81
3	33	89	4	11
4	21	57	16	43
5	15	41	22	59
6	35	95	2	5
7	15	41	22	59
8	14	38	23	62
9	28	76	9	24
10	0	0	37	100
11	36	97	1	3
12	26	70	11	30
13	33	89	4	11
14	4	11	33	89
15	25	68	12	32

FIGURE D3.13.

Values for the formant structure and duration of the synthesised vowel elements /u^w/ and /u/ in the contexts /s V r/, /t V l/, and /t V tu/.

Transcription of target vowel	Formant 1.		Formant 2		Formant 3		DURATION (in msec)				Item in order of presentation in test		
	SID Units	Hz	SID Units	Hz	SID Units	Hz	Vowel		Consonant		/s-r/	/t-l/	/t-tu/
u^w	3	249	3	760	14	2450	8	80	6	60	12	12	11
							12	120	6	60	8	13	9
							16	160	6	60	9	6	12
							8	80	12	120	3	15	6
u^w	3	249	5	901	14	2480	8	80	6	60	-	3	-
u^w - u	7	350	3	760	14	2480	8	80	6	60	5	8	3
							12	120	6	60	11	9	1
							16	160	6	60	2	11	7
							8	80	12	120	7	7	2
u^w - u	7	350	5	901	14	2480	8	80	6	60	-	4	-
u	11	452	3	760	14	2480	8	80	6	60	1	2	8
							12	120	6	60	4	14	5
							16	160	6	60	10	5	10
							8	80	12	120	6	1	4
u	11	452	5	901	14	2450	8	80	6	60	-	10.	-

FIGURE D3. 14.

Percentage results for Test 1, Parts 2, 3, and 8, rank-ordered according to (a) formant structure (b) duration of the vowels.

(a) By Formant Structure

FORMANTS IN HZ F3 = 2480		DURATION IN MSEC		/uˇ/			/u/		
F1	F2	Vowel	Cons	/s - r/	/t - l/	/t - tu/	/s - r/	/t - l/	/t - tu/
249	760	80	60	39	70	56	61	30	44
		120	60	71	89	81	29	11	19
		160	60	75	95	81	5	5	19
		80	120	72	68	66	28	32	34
249	901	80	60	-	89	-	-	11	-
350	760	80	60	21	38	72	79	62	28
		120	60	46	76	100	54	24	0
		160	60	100	97	84	0	3	16
		80	120	61	41	84	39	59	16
350	901	80	60	-	57	-	-	43	-
452	760	80	60	0	19	16	100	81	84
		120	60	14	11	69	86	39	31
		160	60	18	41	66	82	59	34
		80	120	18	3	47	82	97	53
452	901	80	60	-	0	-		100	-

(b) By Duration (in Msec)

249	760	80	60	39	70	56	61	30	44
249	901			-	89	-	-	11	-
350	760			21	38	72	79	62	28
350	901			-	57	-	-	43	-
452	760			0	19	16	100	81	84
452	901			-	0	-	-	100	-
249	760	120	60	71	89	81	29	11	19
350	760			46	76	100	54	24	0
452	760			14	11	69	86	89	31
249	760	160	60	75	95	81	5	5	19
350	760			100	97	84	0	3	16
452	760			18	41	66	82	59	53
249	760	80	120	72	68	66	28	32	34
350	760			61	41	84	39	59	16
452	760			18	3	47	82	97	53

FIGURE D3.15.

Percentage results for Test 1, parts 2, 3 and 8 separately and as an average for the three contexts (/s V r/, /t V l/, and /t V tu/) together. The results are rank-ordered according to (a) Formant Structure and (b) Duration of the vowels.

(a) By Formant Structure

FORMANTS (in Hz) 1 - 2 - 3	/uʷ/ /s-r/	/uʷ/ /t-l/	/uʷ/ /t-tu/	/uʷ/ /s-r/ /t-l/ /t-tu/	/u/ /s-r/	/u/ /t-l/	/u/ /t-tu/	/u/ /s-r/ /t-l/ /t-tu/
249-{760 / 901}-2480	64	82	71	72	31	18	29	27
350 - 760 - 2480	57	62	85	68	43	38	15	32
452 - 760 - 2480	17	15	50	27	88	85	51	75

(b) By Duration

DURATION OF (IN MSEC)	/uʷ/ /s-r/	/uʷ/ /t-l/	/uʷ/ /t-tu/	/s-r/ /t-l/ /t-tu/	/u/ /s-r/	/u/ /t-l/	/u/ /t-tu/	/s-r/ /t-l/ /t-tu/
V80 C60	20	46	48	38	80	54	52	62
V120 C60	44	59	83	62	56	41	17	38
V160 C60	64	78	77	73	29	34	29	31
V80 C120	50	37	66	51	50	63	34	49

FIGURE D3.16.

The results by item in chronological order for the forced choice test 2 (parts 1 and 5) of the synthetic speech sets (a) /bo:t/, /bot:/ (b) /so:t/, /sot:/.

	Response for /o:/ in :- /bo:t/		/so:t/		Response for /o/ /bot:/		/sot:/	
Test No of Item	Responses: Number	% age	Responses Number	% age	Responses Number	% age	Responses Number	% age
1	5	18	11	39	23	82	17	61
2	5	18	3	11	23	82	25	89
3	22	79	5	18	6	21	23	82
4	28	100	5	18	0	0	23	82
5	6	21	12	43	22	79	15	53
6	23	82	21	75	5	18	6	21
7	1	4	3	14	27	96	24	86
8	18	64	26	93	10	36	2	7
9	25	89	1	4	3	11	27	96
10	14	50	23	82	14	50	5	18
11	7	25	14	50	21	75	14	50
12	4	14	4	14	24	86	24	86
13	12	43	12	43	15	54	16	57
14	23	82	9	32	5	18	19	68
15	28	100	27	96	0	0	1	4
16	8	29	4	14	21	71	24	86
17	2	7	4	14	26	93	24	86
18	27	96	28	100	1	4	0	0
19	24	86	2	7	4	14	26	93
20	25	89	16	57	3	11	12	43
21	21	75	4	14	7	25	24	86

FIGURE D3.17.

Values for the formant structure and duration of the synthesised vowel elements /o:/ and /o/ in the contexts /b V t/ and /s V t/.

TRANSCRIPTION OF TARGET WORD	FORMANT 1		FORMANT 2		FORMANT 3		DURATION in msec. - VOWEL		- CONSONANT		Item in order of presentation in test	
	SID Units	Hz	SID Units	Hz	SID Units	Hz					/b - t/	/s - t/
/bo:t/ /so:t/	13	500	6	980	14	2480	5	50	6	60	1	2
							8	80	6	60	8	1
							10	100	6	60	4	10
							12	120	6	60	18	15
							8	80	9	90	10	14
							8	80	12	120	16	4
							12	120	12	120	6	8
/so:t/ /sot:/	13	500	10	1300	14	2480	5	50	6	60	-	7
							8	80	6	60	-	5
							10	100	6	60	-	6
							12	120	6	60	-	18
							8	80	9	90	-	21
							8	80	12	120	-	17
							12	120	12	120	-	20
/bo:t/ /bot:/ /so:t/ /sot:/	18	626	6	950	14	2480	5	50	6	60	12	-
							8	80	6	60	3	-
							10	100	6	60	14	-
							12	120	6	60	20	-
							8	80	9	90	5	-
							8	80	12	120	2	-
							12	120	12	120	19	-
/bot:/ /sot:/	18	626	10	1300	14	2480	5	50	6	60	7	9
							8	80	6	60	11	3
							10	100	6	60	21	13
							12	120	6	60	15	11
							8	80	9	90	17	12
							8	80	12	120	13	19
							12	120	12	120	9	16

FIGURE D3.18.

Percentage results for Test 2 , Parts 1 and 5 , rank-ordered according to the formant structure of the vowels.

FORMANTS IN HZ F3 = 2480		DURATION IN MSEC.		/o:/		/o/		Item in order of presentation in test material	
F1:	F2:	Vowel	Cons	/b - t/	/s - t/	/b - t/	/s - t/	/b - t/	/s - t/
500	980	50	60	18	-	82	-	1	22
		80	60	61	39	36	61	8	1
		100	60	100	82	0	18	4	10
		120	60	96	96	4	4	18	15
		80	90	50	32	50	68	10	14
		80	120	29	18	71	82	16	4
		120	120	82	93	18	7	6	8
500	1300	50	60	-	14	-	86	-	7
		80	60	-	43	-	53	-	5
		100	60	-	75	-	21	-	6
		120	60	-	100	-	0	-	18
		80	90	-	14	-	86	-	21
		80	120	-	14	-	86	-	17
		120	120	-	57	-	43	-	20
626	980	50	60	14	-	82	-	12	-
		80	60	43	11	21	89	3	2
		100	60	79	-	18	-	14	-
		120	60	89	-	11	-	20	-
		80	90	21	-	79	-	5	-
		80	120	18	-	82	-	2	-
		120	120	86	-	14	-	19	-
626	1300	50	60	4	4	96	96	7	9
		80	60	25	18	71	52	11	3
		100	60	75	43	25	57	21	13
		120	60	100	50	0	50	15	11
		80	90	7	14	89	86	17	12
		80	120	43	7	54	93	13	19
		120	120	86	14	11	86	9	16

FIGURE D3.19.

Percentage results for Test 2, Parts 1 and 5, rank-ordered according to the duration of the vowels.

FORMANTS IN Hz F3 = 2480		DURATION IN MSEC		/o:/		/o/	
F1	F2	VOWEL	CONS	/b - t/	/s - t/	/b - t/	/s - t/
500	980	50	60	18	–	82	–
500	1300			-	14	-	86
626	980			14	–	82	-
626	1300			4	4	96	96
500	980	80	60	61	39	36	61
500	1300			-	43	-	53
626	980			43	11	21	89
626	1300			25	18	71	82
500	980	100	60	100	82	0	18
500	1300			-	75	-	21
626	980			79	-	18	-
626	1300			75	43	25	57
500	980	120	60	96	96	4	4
500	1300			-	100	-	0
626	980			89	-	11	-
626	1300			100	50	0	50
500	980	80	90	50	32	50	68
500	1300			-	14	-	86
626	980			21	–	79	-
626	1300			7	14	89	86
500	980	80	120	29	18	71	82
500	1300			-	14	-	86
626	980			18	-	82	-
626	1300			43	7	54	93
500	980	120	120	82	93	18	7
500	1300			-	57	–	43
626	980			86	-	14	-
626	1300			86	4	11	86

FIGURE D3.20.

Average (percentage) results for Test 2, Parts 1 and 5 together, i.e., for the contexts /b V t/and /s V t/ together. The results are rank-ordered according to (a) Formant Structure and (b) Duration of the vowels.

(a) Formant Structure

FORMANTS (Hz) 1 - 2 - 3	/o:/	/o/
500 - 980 - 2480	61	39
500 - 1300 - 2480	45	55
626 - 980 - 2480	45	55
626 - 1300 - 2480	35	65

(b) Duration.

DURATION (Msec) VOWEL	CONSONANT	/o:/	/o/
50	60	11	88
80	60	34	59
100	60	76	23
120	60	89	12
80	90	23	76
80	120	22	78
120	120	70	30

FIGURE D3.21.

The results by item in chronological order for the forced choice test 2, parts 2 and 4 of the synthetic speech sets (a) /ta:ta/, /tata/; (b) /ra:t/, /rat:/.

	Responses for /a:/ :-				Responses for /a/ :-			
Test Number of Items	/ta:ta/		/ra:t/		/tata/		/rat:/	
	Responses :- Number	%age	Responses :- Number	%age	Responses :- Number	%age	Responses :- Number	%age
1	2	7	6	22	26	93	21	78
2	28	100	14	52	0	0	12	44
3	28	100	27	100	0	0	0	0
4	22	79	10	37	6	21	17	63
5	17	61	27	100	11	39	0	0
6	0	0	4	15	28	100	23	85
7	0	0	26	96	28	100	1	4
8	9	32	13	48	19	68	14	52
9	13	46	16	59	15	54	11	41
10	24	86	7	26	4	14	20	74
11	23	82	7	26	5	18	20	74
12	23	82	26	96	5	18	1	4
13			13	48			13	48
14			21	78			6	22
15			12	44			15	56
16			17	63			10	37
17			6	22			21	78
18			20	74			6	22

FIGURE D3.22.

Values for the formant structure and duration of the synthesised vowel elements /a:/ and /a/ in the contexts /t V ta/ and /r V t/.

TARGET WORD	FORMANT 1 STD units	FORMANT 1 Hz	FORMANT 2 STD units	FORMANT 2 Hz	FORMANT 3 STD units	FORMANT 3 Hz	DURATION Vowel STD units	DURATION Vowel (ms)	DURATION Consonant STD units	DURATION Consonant (ms)	Item in order of presentation in test /t - ta/	Item in order of presentation in test /r - t/
/ta:ta/ /ra:t/	23	750	12	1450	14	2480	6	60	6	60	1	11
							8	80	6	60	9	8
							10	100	6	60	11	-
							12	120	6	60	2	7
							8	80	9	90		13
							8	80	12	120		1
							12	120	12	120		14
/ra:t/ or /rat:/	21	701	12	1450	14	2480	6	60	6	60	-	10
							8	80	6	60	-	9
							12	120	6	60	-	5
							8	80	9	90	-	16
							8	80	12	120	-	6
							12	120	12	120	-	3
/ta:ta/ or /tata/	20	676	12	1450	14	2480	6	60	6	60	6	
							8	80	6	60	8	
							10	100	6	60	12	
							12	120	6	60	10	
/tata/ /rat:/	18	626	12	1450	14	2480	6	60	6	60	7	17
							8	80	6	60	5	15
							10	100	6	60	4	-
							12	120	6	60	3	12
							8	80	9	90	-	2
							8	80	12	120	-	4
							12	120	12	120	-	18

FIGURE D3.23.

Percentage results for Test 2, parts 2 and 4, rank-ordered according to the formant structure of the vowels.

FORMANTS (IN Hz) F3= 2480	DURATION IN MSEC		/a:/		/a/		Item Order of presentation in test	
F1: F2:	Vowel	Cons	/t - ta/	/r - t/	/t - ta/	/r - t/	/t-ta/	/r-t/
750 - 1450	60	60	7	26	93	74	1	11
	80	60	46	48	54	52	9	8
	100	60	82	-	18	-	11	-
	120	60	100	96	0	4	2	7
	80	90	-	48	-	48	-	13
	80	120	-	22	-	78	-	1
	120	120	-	78	-	22	-	14
701 - 1450	60	60	-	26	-	74	-	10
	80	60	-	59	-	41	-	9
	120	60	-	100	-	0	-	5
	80	90	-	63	-	37	-	16
	80	120	-	15	-	85	-	6
	120	120	-	100	-	0	-	3
676 - 1450	60	60	0	-	100	-	6	-
	80	60	32	-	68	-	8	-
	100	60	82	-	18	-	12	-
	120	60	86	-	14	-	10	-
626 - 1450	60	60	0	22	100	78	7	17
	80	60	61	44	39	56	5	15
	100	60	79	-	21	-	4	-
	120	60	100	96	0	4	3	12
	80	90	-	52	-	44	-	2
	80	120	-	37	-	63	-	4
	120	120	-	74	-	22	-	18

FIGURE D3.24.

Percentage results for Test 2, parts 2 and 4, rank-ordered according to the duration of the vowels.

FORMANTS (IN HZ) F3= 2480		DURATION IN MSEC		/a:/		/a/	
F1	F2	VOWEL	CONS	/t - ta/	/r - t/	/t - ta/	/r - t/
750	1450	60	60	7	26	93	74
701	1450			-	26	-	74
676	1450			0	-	100	-
626	1450			0	22	100	78
750	1450	80	60	46	48	54	52
701	1450			-	59	-	41
676	1450			32	-	68	-
626	1450			61	44	39	56
750	1450	100	60	82	-	18	-
676	1450			82	-	18	-
626	1450			79	-	21	-
750	1450	120	60	100	96	0	4
701	1450			-	100	-	0
676	1450			86	-	14	-
626	1450			100	96	0	4
750	1450	80	90	-	48	-	48
701	1450			-	63	-	37
626	1450			-	52	-	44
750	1450	80	120	-	22	-	78
701	1450			-	15	-	85
626	1450			-	37	-	63
750	1450	120	120	-	78	-	22
701	1450			-	100	-	0
626	1450			-	74	-	22

FIGURE D3.25.

Percentage results for Test 2, Parts 2 and 4 as an average undifferentiated for the contexts /t V ta/ and /r V t/. The results are rank-ordered according to (a) Formant Structure and (b) Duration of the vowels.

Averages by Formant Structure		
FORMANTS IN HZ F1 - F2 - F3	/a:/	/a/
750-1450-2480	55	44
701-1450-2480	61	40
676-1450-2480	50	50
626-1450-2480	57	43

Averages by Duration (in msec)			
V. Dur in msec	C. Dur in msec	/a:/	/a/
60	60	14	87
80	60	48	52
100	60	81	19
120	60	96	4
80	90	54	43
80	120	25	75
120	120	84	15

FIGURE D3.26.

The results by item in chronological order for the forced choice test 2, part 3, of the synthetic speech set /te:ma/, /tema/, /tem:a/ .

	Response for /e:/		Response for /e/		Response for /e/	
Test Number of Items	/te:ma/		/tema/		/tem:a/	
	Responses Number	% age	Responses Number	% age	Responses Number	% age
1	12	44	5	19	3	11
2	1	4	24	89	2	7
3	1	3	5	19	14	52
4	2	7	10	37	15	56
5	16	59	4	15	7	26
6	1	4	24	89	2	7
7	1	4	13	48	12	44
8	1	4	19	70	7	26
9	2	7	20	74	5	19
10	4	15	14	52	9	33
11	3	11	18	67	5	19
12	4	15	17	63	6	22
13	7	26	3	11	17	63
14	2	7	22	81	2	8
15	12	44	12	44	2	8
16	9	33	13	48.	4	15
17	19	70	4	15	4	15
18	0	0	25	92	1	4
19	15	56	10	37	2	7
20	12	44	2	8	13	48
21	12	44	2	8	13	48
22	13	48	6	22	8	3
23	18	67	3	11	6	22
24	3	11	3	11	20	74

FIGURE D3.27.

Values for the formant structure and duration of the synthesised vowel elements /e:/ and /e/ in the context /t V ma/.

Transcription of target	Formant 1 SID units	Formant 1 Hz	Formant 2 SID units	Formant 2 Hz	Formant 3 SID units	Formant 3 Hz	Duration: Vowel SID units	Duration: Vowel ms.	Duration: Consonant SID units	Duration: Consonant ms	Item in Order of Presentation in Test.
/te:ma/	20	676	22	2205	17	2780	4	40	6	60	14
							6	60	6	60	9
							8	80	6	60	11
							10	100	6	60	15
							12	120	6	60	17
							8	80	9	90	7
							8	80	12	120	24
							12	120	12	120	23
/te:ma/ or /tema/ or /tem:a/	20	676	18	1900	17	2780	4	40	6	60	2
							6	60	6	60	6
							8	80	6	60	12
							10	100	6	60	22
							12	120	6	60	5
							8	80	9	90	16
							8	80	12	120	3
							12	120	12	120	21
/tema/ or /tem:a/	20	676	14	1595	17	2780	4	40	6	60	18
							6	60	6	60	8
							8	80	6	60	10
							10	100	6	60	19
							12	120	6	60	1
							8	80	9	90	4
							8	80	12	120	13
							12	120	12	120	20

FIGURE D3.28.

Percentage results for Test 2, part 3, rank-ordered according to the formant structure of the vowel.

FORMANTS (IN Hz) 1 2 3	DURATION IN MSEC V	C	Response for:- /te:ma/	/tema/	/tem:a/	Item No. & Order of Presentation in Test.
676- 2205- 2780	40	60	7	81	8	14
	60	60	7	74	19	9
	80	60	11	67	19	11
	100	60	44	44	8	15
	120	60	70	15	15	17
	80	90	4	48	44	7
	80	120	11	11	74	24
	120	120	67	11	22	23
676- 1900- 2780	40	60	4	89	7	2
	60	60	4	89	7	6
	80	60	15	63	22	12
	100	60	48	22	30	22
	120	60	59	15	26	5
	80	90	33	48	15	16
	80	120	3	19	52	3
	120	120	44	8	48	21
676- 1595- 2780	40	60	0	92	4	18
	60	60	4	70	26	8
	80	60	15	52	33	10
	100	60	56	37	7	19
	120	60	44	19	11	1
	80	90	7	37	56	4
	80	120	26	11	63	13
	120	120	44	8	48	20

FIGURE D3.29.

Percentage results for Test 2, part 3, rank-ordered according to the duration of the vowel.

FORMANTS (in HZ) F3 = 2780		DURATION IN MSEC		Response in %age for		
F1	F2	Vowel	Cons.	/te:mə/	/temə/	/tem:ə/
676	2205	40	60	7	81	8
676	1900			4	89	7
676	1595			0	92	4
676	2205	60	60	7	74	19
676	1900			4	89	7
676	1595			4	70	26
676	2205	80	60	11	67	19
676	1900			15	63	22
676	1595			15	52	33
676	2205	100	60	44	44	8
676	1900			48	22	30
676	1595			56	37	7
676	2205	120	60	70	15	15
676	1900			59	15	26
676	1595			44	19	11
676	2205	80	90	4	48	44
676	1900			33	48	15
676	1595			7	37	56
676	2205	80	120	11	11	74
676	1900			3	19	52
676	1595			26	11	63
676	2205	120	120	67	11	22
676	1900			44	8	48
676	1595			44	8	48

FIGURE D3.30.

Percentage (average) responses for Test 2, part 3, differentiated for single or geminate consonant contexts. The results are rank-ordered according to (a) Formant Structure and (b) Duration of the vowel.

(a) Formant Structure

FORMANTS (in Hz) F1 F2 F3	RESPONSES IN % AGE /e:/	/e/+C	/e/+C:	/e:/
676 - 2205 - 2780	28	44	26	70
676 - 1900 - 2780	26	44	26	70
676 - 1595 - 2780	25	41	31	72

(b) Duration

DURATION IN MSEC V	C	RESPONSES IN % AGE /e:/	/e/+C	/e/+C:	/e/
40	60	4	87	6	93
60	60	5	78	17	95
80	60	14	61	25	86
100	60	49	26	15	41
120	60	58	16	17	33
80	90	15	44	38	82
80	120	13	14	63	77
120	120	52	9	39	48

APPENDIX E

Appendix E

Data for the study of aspiration in 9.2.4.

The following is a list of words used for the study of aspiration found in 9.2.4. The words are classified to enable easy reference from the text. The words are transcribed phonemically. Aspiration is not indicated since the duration is shown in milliseconds: it is assumed that when the duration is 0 milliseconds, the stop is not aspirated. The number of words used for each group is shown in brackets.

A. Monosyllables

Syllable-Initial

/p/ (13)

pat:	0
pon:	35
pi:t	60
po:l	45
post	45
pawl	25
post	55
pa:	25
pet:	30
pa:r	30
pat:	25

/t/ (14)

tost	55
te:m	70
to:n	60
ton:	45
ta:	40
ta:t	45
taht	30
te:mt	50
te$_{w}$	50
tu^{w}t	60
tap:	30
ti^{j}p	55
tu^{w}k	60
ˈtok:	35

/k/ (14)

kilt	55
kont	35
ka:s	60
ko:s	45
ken:	60
kem:	75
ki^{j}f	60
ki:n	80
ku^{w}s	60
ko:S	50
kop:	50
	55
ka:p	0
	60

Syllable-Final

/p/ (8)

sa:p	20
lo:p	15
tap:	15
kti:p	60
ti^{j}p	45
ka:p	20
kop:	15

/t/ (22)

pat:	60
pi:t	60
post	45
po^{r}t	40
pet:	25
tost	20
ta:t	40
taht	30
te:mt	55
tu^{w}t	40
kilt	50
met:	40
pat:	25
mo:t	35
hi^{j}t	60
hit:	25
hi:t	40
ba:t	35
tʃat:	25
ʃot:	40
ra:t	30
hu^{w}t	40

/k/ (9)

tu^{w}k	50
hak:	40
^{r}a:k	35
di^{j}k	35
pi:k	35
tʃik:	50
hok:	40
tok:	30
ko:k	35

B. Multi-Syllabic Words - Stressed Syllables

Syllable-Initial

/p/ (11)

ˈpi:tru	30
ˈpi^{j}pa	30
ˈpa:tʃi	40
ˈpa:tʃi	35
ˈpapa	35
paˈpa	35
ˈpa:ga	40
ˈpa:p a	40
ˈpindʒi	30
ˈpesta	5
ˈpapotʃ	30

/t/ (32)

kanˈta:ta	40
ˈtiktep	25
ˈtahli	25
ˈtimla	45
ˈto?tol	40
ˈte:^{r}e?	45
ˈtatsa	25
ˈti^{j}g^{r}a	40
ˈtewma	35
ˈti^{j}na	60
k^{r}isˈto:fru	15
makˈtu:r	25
k^{r}isˈti^{j}na	15
tikonˈtenta	30
kiˈtar:a	35
arˈtist	40
mikˈtu^{w}p	45
isˈt^{r}i^{j}na	20
o:ˈti:n	55
ˈtop:u	20
i^{r}ˈta:p	30
pasˈtart	5
faˈta:t	25
ˈtik:a	20
ˈtok:a	20
impusˈtu^{w}r	5
kanˈta:ta	20
piˈt:u^{w}	50
hapˈtila	45
imˈti:rah	60

/k/ (17)

ˈkewa	60
ˈkitep	40
ˈka^{r}ta	40
miˈkul	45
ˈkosksu	25
ˈkitla	30
ˈkesha	40
ˈk^{r}uwa	35
ˈketʃ:a	35
ˈkop:la	40
ˈkap:u	25
i^{r}ˈkipta	35
maˈkak:	45
ˈkitep	35
politiˈkant	30
taˈkwista	30
ˈtʃkejken	20

Syllable-Final

/p/ (9)

mikˈtu^{w}p	50
ˈlaptu	70
ˈhapta	30
ˈkopla	50
ˈta:p	10
ˈtsoptu	55
i^{r}ˈkipta	65
inˈsta:p	10
mikˈtu^{w}p	40

/t/ (13)

artist	15
'kitla	60
'ritmu	110
indʒbit:	30
kulhat:	20
pastart	30
fata:t	40
pipist^{r}el	35
politikant	40
pes:imist	35
'mitrah	55
kuntrat:	25

/k/ (5)

'jokrop	65
jikwi	65
makak:	40
'rokna	80
mikrobu	75

<u>Syllable Boundary</u>

/p/ (2)

'o:pra	55
iddispra	5

/t/ (3)

at:ri^{j}t i	60
if:it:ajtu	20
'o:tja	65

/k/ (2)

periklu	60
'sokra	90

C. <u>Multi-Syllabic Words - Unstressed Syllables</u>

<u>Syllable Initial</u>

/p/ (14)

peri^{j}klu	20
papotʃ	0
pipistrel	15
	0
pilastru	15
impustu^{w}r	20
poli^{j}tika	40
politikant	20
pes:imist	15
pitu^{w}r	10
risponsabli	10
'pi^{j}pa	25
'pa:pra	30
pastart	0

/t/ (27)

'pi:tru	35
'pa:tri	60
'pa:pa	30
papa	20
'pesta	5
kanta:ta	25
'tiktep	15
'to?tol	25
tik:untenta	20
	30
'tikep	25
'karta	25
irkipta	20
matema:tika	40
	50
'la:ptu	30
'hapta	15
if:it:ajtu	40
pilastru	60
'kitep	30
kanta:ta	20
poli^{j}tika	30
politikant	35
'tambu^{w}	35
il:ostra	20
'bajtar	55
'meta	40
kanta:ta	45
	40
kristo:fru	25
kristi^{j}na	55
kulhat:	20
'ji:kol	35
'tik:a	30
'tok:a	20
poli^{j}tika	20
matema:tika	10
kitar:a	30
'ji:kol	40
kuru^{w}na	35
kef:i:na	15
kef:ina	20
tik:untenta:h	30
'tʃkejken	45
'tʃek:en	55
kuntrat:	25
peri^{j}klu	70
kostitutsjo:ni	15
kaval:i:r	15

<u>Syllable-Final</u>

/p/ (4)

'tiktep	40
'kitep	10
'okrop	40
haptila	10

/t/ (6)

titpastas	35
takwista	20
	5
tikuntent ah	20
kostitutsjo:ni	20
	30

/k/ (8)

'tiktep	40
maktu^{w}r	30
tik:untenta	35
miktu^{w}p	40
mak:ina:rju	45
miktu^{w}p	35
'fenek	20
'bi:rek	40

<u>Clusters</u>

/p/ (13)

'pti:hi	65
'pri:tka	50
pkejt	30
'printʃep	40
'pra:spar	30
'pre:mju	55
'p?i^{j}ja	30
'pjanta	55
'pru^{w}na	50
'ipki	75
'ahptu	40
irkoptu	40

/t/ (15)

'tli:ta	80
tnejn	85
t?i:?	30
tru^{w}ʃ	60
twi^{j}l	90
'tjas:ar	75
'tpastas	25
'tkej:el	35
'tmej:el	70
'tpaspar	30
'tpindʒi	25
'tpat:i	60
'tkeʃkeʃ	30
'pri:tka	50
imha:tra	20

/k/ (9)

'kni^{j}sja	55
'ktʃi^{j}na	35
'kti:p	40
'ktej:ep	40
'kruwa	50
'kli:m	55
'iktar	35
far:aktni	30
miktu^{w}p	40

<u>Geminates</u>

/p/ (12)

ip:ro:va	70
ip:o:za	45
ip:retend	25
itʃ:ap:as	15
top:o:ni	30
it:ap:an	15
'top:u	55
hap:	20
tap:	5
kop:	20
'ʃap:ap	5
'tʃap:a	10

/t/ (23)

it:ej:etʃ	30
'it:ra	40
it:a:ma	30
it:urufna:t	35
it:i^{j}r	45
it:el:a	20
it:i:em	35
it:ipji^{j}p	20
it:af:i	5
at:enta:t	20
ot:u^{w}bru	25
et:ila	35
hat:	40
rot:	40
mit:	45
rat:	25
met:	25
tʃat:	20
sot:	25
ret:	25
?at:ar	20
mit:i^{j}dek	45
mit:kti:p	45

/k/ (9)

ik:alma	40
ik:ontrol:a	35
'hak:a	45
'tik:a	40
'mek:a	35
hak:	30
tok:	35
tak:u^{w}na	50
'bek:a	30

<u>Plosives in Defined vowel contexts</u>

/p/ (12)(5)

'pi^{j}pa	55
pipistrel	0
	0
pi:t	20
'pit:er	0
pitats	0
'pi^{j}ka	40
'spik:a	0
timpika:	15
pi:t	60
ʃkupilja	20
'pi:gi	45
*pik:u^{w}n	0
*tup:i:na	25
*pi:b	40
*irpi^{j}t	50
'pi:ki	35

/t/ (11)(2)

ˈpat:i	40
timˈpika:	30
ˈkti:p	35
	20
ˈti^{j}p	60
ˈtip:o:za	25
ˈti^{j}tlu	40
ˈtitla	35
ˈti:kol	50
inˈti^{j}k	30
*ti:ta	55
*tit:a	35

/k/ (11)(5)

ˈto:kis	40
ˈki:per	60
ski:t	25
ki^{j}t	65
kitla	25
ˈki:ku	50
*irki^{j}k	65
ˈkik:ra	40
ˈka:ki	50
ˈbok:i^{j}n	65
ˈkiber	35
*kiper	40
*kip:er	25
*pi:ki	65
*poki^{j}n	65
*ki:p	80

/p/ (9)(5)

ˈpe:pe:	30
	25
peˈpe	15
	25
ˈpep:u	15
pet:	25
pekorel:a	10
ˈki^{j}per	30
kaˈp:el:	5
*kiper	20
*kip:er	25
*pet:ni	30
*pe:k	25
*peka	10

/t/ (8)(3)

ˈpit:er	35
poˈte:r	45
imˈta:te:n	25
imtet:	55
bibljote:ka	40
ˈmartek	20
ˈteba	40
ˈte:da	45
*tepa	35
*tep:a	20
*te:ta	40

/k/ (5)(2)

ˈrikep	35
ˈtʃri:ke:t	35
ˈsik;et	20
ˌtʃurket:	35
ˈharkek	40
*ke:p	50
*ke:k	40

/p/ (11)(3)

ˈpi^{j}pa	20
ˈpa:pra	20
paˈpotʃ	10
ˈpop:a	25
ˈpu^{w}pa	20
puˈpats	25
ˈpa:tri	20
ˈpat:i	15
spa:k	5
taˈpa:rsi	10
ˈʃku^{w}pa	30
*ʃpak:	0
*pa:ka	40
*tepa	25

/t/ (12)(2)

piˈtats	25
irˈta:p	40
tap:	30
tapa:rsi	30
imˈta:ten	40
taˈta	35
	40
ta:k	45
taˈk:u^{w}na	15
imˈka:tar	25
ˈkat:ar	25
ˈdi:ta	40
*te:ta:	45
*tit:a	20

/k/ (17)(2)

ˈpi^{j}ka	55
ˈspik:a	30
lamˈpu^{w}ka	50
timˈpika:	40
ˈtik:a	15
bibjoˈte:ka	45
irˈtuk:a:r	40
	25
ˈkuk:a	60
ˈtok:a	50
ka:p	40
kaˈp:el:	25
imˈka:tar	40
ˈkat:ar	15
ˈka:ki	40
maˈkak:	25
ˈbek:a	40
*pek:a	20
*pa:ka	45

/p/ (7)(2)

paˈpotʃ	15
ˈpo:plu	25
ˈpop:a	15
*po:t	80
poˈter	25
tiˈp:o:za	20
ˈtopot	40
ˈpo:k	45
poki^{j}n	10

/t/ (7)(1)

ˈtop:u	25
irˈto:t	35
ˈtot:	40
ˈto:kis	35
tok:	40
ˈtok:a	20
ˈtobot	40
*topo:t	30

/k/ (8)

pekoˈrel:a	35
ˈti:kol	40
skop	0
kop:	45
ˈiskot	10
ˈkotra	25
ˌko:k	35
kok:a	15

/p/ (4)(4)

ˈpep:u	40
ˈpu^{w}pa	35
puˈpats	25
lamˈpu^{w}ka	55
*puk:u^{w}n	15
*tu^{w}pu	40
*pu^{w}t	45
*put:u^{w}na	40

/t/ (7)(3)

tu^{w}t	50
ˈtut:u	20
	40
inˈtu^{w}k	60
irˈtuk:ar	25
	35
but:u^{w}na	50
*put:u^{w}na	50
*tu^{w}pu	50
*tup:i:na	35

/k/ (10)(2)

briˈk:u^{w}n	55
taˈk:u^{w}na	60
ˈʃku^{w}pa	15
ʃkuˈpilja	0
ˈku^{w}tra	40
skuˈtel:a	0

ˈki:ku	50
tsku^{w}k	15
ˈkuk:a	30
buˈk:u^{w}n	40
*puk:u^{w}n	45
*pik:u^{w}n	60

<u>Long Vowel Context</u>

/p/ (17)

ˈpi^{j}pa	55
pi:t	20
ˈpi^{j}ka	40
pi:t	60
ˈpi:gi	45
ˈpe:pe:	30
	25
pekoˈrel:a	10
*ki^{j}pe:s	30
ˈpa:pra	20
ˈpa:tri	20
spa:k	5
tapa:rsi	10
ˈpo:plu	25
tiˈp:o:za	20
ˈpu^{w}pa	35
lamˈpu^{w}ka	55

/t/ (17)

kti:p	35
	20
ˌti^{j}p	60
ˈti^{j}tlu	40
ˈti:kol	50
inˈti^{j}k	60
poˈte:r	45
imˈta:ten	25
bibljoˈte:ka	40
irˈta:p	40
imˈta:ten	40
ta:k	45
irˈto:t	35
ˈto:kis	35
tu^{w}t	50
inˈtu^{w}k	60
but:u^{w}na	50

/k/ (24)

ˈki^{j}per	60
ski:t	25
ki^{j}t	65
ˈki:ku	50
ˈka:ki	50
boˈk:i^{j}n	65
ˈtʃri:ket	35
timˈpika:ʃ	40
irˈtuk:a:r	40
	25
ka:p	40
imˈka:tar	40
ˈka:ki	40
pekoˈrel:a	35
ˈti:ko:l	40
sko:p	0

ko:k	35
brik:u^{W}n	55
tak:u^{W}na	60
'ʃku^{W}pa	15
'ku^{W}tra	40
'ki:ku	50
'buk:u^{W}n	40

Short Vowel Context

/p/ (23)

pipistrel	0
	0
'pit:er	0
'pitats	0
'spik:a	0
timpika:ʃ	15
ʃkupilja	20
pepe	15
	25
'pep:u	15
pet:	25
'pi^{J}pa	20
papotʃ	10
'pop:a	25
'pu^{W}pa	20
pupats	25
'pat:i	15
'ʃku^{W}pa	30
papotʃ	15
'pop:a	15
poter	25
'pep:u	40
pupats	25

/t/ (27)

pat:i	40
timpika:	30
tip:o:za	25
'titla	35
'tik:a	30
'pit:er	35
imtet:	55
'martek	20
'teba	40
pitats	25
tap:	30
tapa:rsi	30
tata	35
	40
tak:u^{W}na	15
imka:tar	25
'kat:ar	25
'dit:a	40
'top:u	25
tot:	40
tok:	40
'tok:a	20
'tobot	40
'tut:u	20
	40
irtuk:a:r	25
	35

/k/ (25)

to:kis	40
'kitla	25
'kik:ra	40
'kiber	35
'rikep	35
'sik:et	20
tʃurket:	35
'harkek	40
'pi^{J}ka	55
'spik:a	30
lampu:ka	50
'tik:a	15
bibljote:ka	45
'kuk:a	60
'tok:a	50
kap:el:	25
'kat:ar	15
makak:	25
'bek:a	40
kop:	45
'iskot	10
'kotra	25
ʃkupilja	0
skutel:a	0
'kuk:a	30

Miscellaneous

/p/ (11)

imperatu^{W}r	15
'parti	35
parti^{J}t	5
partita:rju	15
kap:el:a	15
kap:el:	10
'tpat:i	0
tpat:ija	0
op:ozitsjo:ni	15
op:ost	10
lop:ost	35

/t/ (36)

art	30
'da:ta	25
jiftakar	5
listo:rja	5
mitejn	40
tminta:ʃ	55
	30
tat	30
	35
imperatu^{W}r	45
tmi:nja	70
sit:i^{J}n	40
'parti	40
'partit	35
	40
partitarju	15
	30
set:embru	20
bastu^{W}n	5
tkab:ar	20
intesa	15
ʔat:ar	20
fit:e	20

mistoʔsija	20
'ʔatra	40
tkidni^{J}ʃ	25
imtet:	35
	35
'sot:a	20
'tkeʃkeʃ	20
'tpat:i	30
lop:ost	20
op:ost	0
	40
tpat:ija	0
	40

/k/ (17)

jiftakar	40
flo:k	35
flok:	35
kolonja	45
kolonja:lizmu	30
'kiser	30
ki:n	60
bak:u^{W}za	45
'tkab:ar	30
bank	50
'kap:el:a	20
kap:el	10
fliʃku^{W}n	15
flimki:n	40
tkidni^{J}ʃ	20
'tkeʃkeʃ	20
	15

Continuous Speech: Sample (i)

int^{h}rodot:^{h}ip^{h}ro:tʃe:du^{w}riat^{h}it^{h}ji^{j}p^{h}lilnisat^{h}?a:l
id:ip^{h}art^{h}ment:^{h}as:ah:aba:tʃirk^{h}o:la:rilit:^{h}ob:awil?wi:belk^{h}ol:afejn ar:af:
ombip^{h}rotʃedu^{w}rili?etjint^{h}rodu^{w}tʃit^{h}ej:ep^{h}is:ervitsilinisalijehilsuflispt^{h}
a:rt^{h}algvernjirtʃi:vuwa?t^{h}uwarat^{h}?a:lala:nt^{h}adawnilp^{h}rotʃedu^{w}r:ulijk^{h}unem:
ak^{h}t^{h}ark^{h}oordinatsjo:nifit:^{h}rat:^{h}ament:^{h}alk^{h}a:zibejnit:^{h}ob:aul?wiebelfil
p^{h}riva:t^{h}fu?nahaut:^{h}ob:a?ulist^{h}aft^{h}alisp^{h}t^{h}a:rfu?lohralist^{h}?ar:i^{j}jat^{h}komp^{h}
lilida:nuwameht^{h}i:l a: ?et^{h}jid rihaf( )nadra:bilinisat^{h}?a:ljir:ik^{h}or:ubis:
lisp^{h}ta:rflah:ardʒra:net:at?a:la:tah:omminhab:afek^{h}isi^{j}rdif:i^{j}tʃlihafnali
jinsta:p^{h}rime:djualk^{h}omp^{h}lik^{h}atsjoniji:t^{h}lijk^{h}u^{w}run?alawak^{h}t^{h}ark^{h}minifit:^{h}
?alauftʃert^{h}ik^{h}a:zilk^{h}onsegwentsijk^{h}u^{w}nuserji

Continuous Speech: Sample (ii)

bdjabe:t^{h}ed:o?fu^{w}?iumanist^{h}a:ʃna?t^{h}awdanlimbi:rek^{h}t^{h}ahelu/k^{h}i:n?et^{h}jajtli
mal:em/uji:nlan?asjek:^{h}id:e:bnimanehodlokhelwa/k^{h}em:ilt^{h}?ajnapha:rsamiksu^{w}
ralejnilvet:ri^{j}nat^{h}alheludon:ubil:ebli:babi:ʃjiʃt^{h}riuflist^{h}es:hi^{j}n?et^{h}jif
t^{h}ak^{h}arfilk^{h}li:mt^{h}at:abi^{j}p^{h}?al:i/ej:animʃuahjara:ʃjek:^{h}nip^{h}?aimwah:alawnni
ʃt^{h}rizgu^{w}rej:animʃu/uk^{h}omp^{h}lejnamiʃji^{j}nu?samnat:^{h}ri:?merk^{h}ant^{h}iudʒejna:
nizlamarawa?fit^{h}naki:net^{h}min:hal?ormiulil:imal:emk^{h}armk^{h}i:net^{h}:a:fu/mal:em
ʃitʃurk^{h}et:^{h}?alt^{h}lu/k^{h}i:net^{h}?edbihid:e:p^{h}a:ndiwk^{h}olʃihan:i:?ajek^{h}t^{h}ri^{j}t/
hu^{w}damuʃa:ljadaʃ:a:rilgri^{j}zmat^{h}atfa:lmandekʃifiljotsdis:enamal:em/k^{h}i:ku
t^{h}apar:i^{j}nuserna:mila?alila/melahutʃurk^{h}et^{h}phas:enalohraawma:radant^{h}ritle
t:^{h}li^{j}rizgu^{w}rmil:hanu^{w}t:^{h}alfatʃ:a:t^{h}abli^{j}rawnofshudulimal:emk^{h}armk^{h}ul:sena
k^{h}i:njamilat^{h}ap^{h}ar:i^{j}nuat:^{h}ifelt^{h}aʃihabi^{j}pt^{h}ijowlijk^{h}u^{w}n?di:hfʃibitʃane
gotsju

Sample (i)

/p/ (13)

protʃe'du^{w}ri	40
tit'ji^{j}p	45
id:ipar'timent	20
protʃ'edu^{w}ri	40
itej:ep	15
flis'pta:r	0
protʃe:'du^{w}ri	30
pri'va:t	60
lis'pta:r	50
'tkompli	60
lis'pta:r	15
jins'ta:p(rim-edju)	35
komplikats-joni'ji:t	20

/t/ (39)

intro'dot:i	70
	35
tit'ji^{j}p	25
	70
t?a:l	20
id:iparti-ment:a	15
'lit:ob:a	30
?et	75
jintrodu^{w}tʃi	70
itej:ep	25
flis'pta:r	10
tal	25
wa?t	50
't?a:la	25
ta	25
aktar	35
fit:rat:a'ment	40
	25
	10
'it:ob:a	20
lis'taf	15
talis'pta:r	15
	10
list?ari^{j}ja	20
'tkompli	40
meh'ti:tʃ	35
?et	60
t?a:l	30
lis'pta:r	0
'dʒra:net:at-'?a:la	30
	25
'tah:om	20
jins'ta:p	0
komplikats-joniji:t	60
'aktar	25
fit:'?a:la	30
'ftʒerti	40

/k/ (17)

'ba:tʃirko'la:ri	30
'kol:a	45
lijkune'makta*	40
	20
koordinats'jo:ni	30
'ka:zi	40
'tkompli	0
jir:'ikor:u	40
minhab:afek?	35
komplikats-joni'ji:t	20
	20
li:jku^{w}nu	40
'aktar	30
'kmi:ni	75
'ka:zi	25
konse'gwentsi	20
jku^{w}nu	30

Sample (ii)

/p/ (7)

tat:'abi^{j}p	35
'nip?a	30
kom'plejna	25
'id:e:p	0
pa'r:i^{j}nu	10
pa'r:i^{j}nu	15
ha'bi^{j}p	20

/t/ (37)

bdja'be:te	40
manis'ta:ʃ	20
'na?taw	20
ta	10
?et:	65
ilt'?ajna	35
ilvet:'ri^{j}na	70
tal	20
'jiʃtri	75
flis'tes:	20
et:	25
jif'takar	5
tata'bi^{j}p	10
	0
'niʃtri	35
'it:ri:?	40
mer'kanti	50
wa?'fitna	85
'ki:net	70
ki:'net:a:fu	25
tʃ'urket:	25
'?altlu	0

'ki:net	25
jek:'tri^{j}t	45
	0
tat'fa:l	10
ta	5
tʃu'rket	15
'tri^{j}tlet...	50
	0
	20
ha'nu^{w}t:alfatʃa:ta	20
	85
ta	10
a't:ifelta	15
	0
'ti-ow	50

/k/ (23)

im'bi:rek	15
ki:n	30
jek:	30
kem:	45
jif'takar	20
kli:m	45
jek:	45
kom'plejna	15
mer'kanti	30
'ki:net	45
'karm	55
'ki:net	55
tʃu'rket:	30
'ki:net	30
wkol	40
jek:tri^{j}t	20
'ki:ku	30
	0
tʃu'rket:	25
karm	35
kul	30
ki:n	35
lijku^{w}n	25

APPENDIX F

Appendix F.

Data for the study of consonant duration in chapter 10.

The following is a list of phonemically transcribed words together with their duration in milliseconds for one informant. The list is subclassified in the same way as figures 10.3 and 10.4. (1) separately for each phoneme; (2) each phoneme subclassification grouped according to the position in the word in which the phoneme studied occurs - initial, medial or final, and according to whether the phoneme occurs singly, geminated or in a cluster (or sequence of consonants in the case of medial clusters). The reader is reminded that initial gemination refers to geminated consonants preceded by the vowel /i/. The sub-group title (e.g. initial single) is followed by the number of words listed under the group. Thus, there are 28 words in the group illustrating /p/ as a single, word-initial phoneme. This number includes repetitions of the same word.

/p/

Initial Single (28)

pa'potʃ	70
pip:'istrel	75
	60
pi'lastru	85
politi'kant	60
po'liʲtika	60
pes:'imist	50
'pit:uʷr	70
'parti	85
parti'tarju	70
'piʲpa	90
	75
'pa:pra	100
'puʷpa	85
	75
'pep:u	95
'po:plu	100
'pop:a	80
pu'pats	60
pi:t	80
	90
'pit:uʷr	95
'pa:tri	100
'pat:i	80
'petne	100
pet:	85
'poter	95
'piʲka	100

Medial Single (19)

'piʲpa	100
	125
'pepe	65
	100
'puʷpa	90
'ʃkuʷpa	95
	55
pa'potʃ	105
	95
pipi'strel	130
	120
pu'pats	80
ta'parsi	90
	70
ʃku'pilja	85
'pa:pa	90
'papa	80
'la:pes	70
gow'lkiʲper	40

Final Single

ka:p	120
	140
sa:p	110
lo:p	155
	100
de:p	115
	140
tiʲp	165
kti:p	95
	80
bi:p	105
	140
	85
dnuʷp	80
	170
sko:p	140
'tiktep	50
mi'ktuʷp	55
	60
'kitep	90
'jokrop	50
ki'ktuʷp	60
	100
	85
'rikep	125
'kitep	145
	90
'artap	85
	95
'ktej:ep	95
sko:p	105
ta'biʲp	135
'keb:ep	125

Initial Geminate (3)

i'p:ro:va	95
i'p:o:za	120
ip:retenda	85

Medial Geminate (24)

lo'p:ost	120
'pep:u	160
'pop:a	150
ti'p:o:za	165
	160
su'p:erf	140
'kop:la	115
'kap:u	145
'tʃap:a	185
	210
'tʃap:as	140
	200
matʃ'ap:asʃ	160
to'p:o:ni	135
	165
'it:ap:an	135
'top:u	165
	155
ap:ap	140
ka'p:el:a	120
ka'p:el:	140
	160
op:ozits'jo:ni	100
o'p:ost	135

Final Geminate (8)

tap:	150
	165
hap:	185
kop:	165
	180
	155
hop:	175

Initial Cluster (20)

'ʃpak:a	85
'pti:hi	40
'pkejt	80
'printʃep	80
'pra:spar	85
'tpaspar	75
'tpastas	60
'pri:tka	75
'tpindzi	75
'tpat:i	60
	65
'premju	90
'pʔija	90
'pwa:les	80
'pjanta	75
'spik:a	80
'tʃpa:r	60
	110

tpat:ija	65
spa:k	90

Medial Cluster (25)

irkipta	60
id:ispra	80
lampu^{w}ka	60
	80
'sipta	60
timpika:ʃ	65
'pa:pra	120
'la:ptu	80
'hapta	90
'tsoptu	60
irkipta	60
id:ispra	80
'o:pra	85
	95
'po:plu	60
	100
'tpaspar	90
	90
haptila	70
risponsabli	60
titpastas	65
'pra:spar	80
'ahptu	65
irkoptu	80
kampna:r	55

Final Cluster (1)

haps	105

/t/

Initial Single (26)

tuz:a:na	45
tis:o:gra	50
tuf:i:ha	50
titpastas	20
takwista	50
tik:untenta:	65
taht	70
timpika:ʃ	80
ti^{j}p	70
tap:	80
'top:u	75
taparsi	40
'titla	75
'ta:ta	45
to:t:	80
tu^{w}t	70
'tut:u	80
'ti:kol	75
'tik:a	80
	70
ta:k	70
tak:u^{w}na	60
'to:kis	80

tobot	65
te:da	85

Medial Single (25)

'mu^{w}tu	105
	105
'hu^{w}ta	140
'bu^{w}tu	100
	140
'hu^{w}ti	105
'tu^{w}tu	100
'ta:ta	80
'ro:ta	80
'imta:ten	80
'cek:nitu	65
'kitep	65
kanta:ta	65
poli^{j}tika	35
politikant	50
'pi^{j}ter	80
'hi^{j}ta	105
nikoti^{j}na	60
'di:ta	115
'fi:tel	90
'ʃita	85
oti:n	65
'kitep	90
'dzi^{j}ta	85
'hi:ta	80

Final Single (41)

hanu^{w}t	115
irto:t	90
tʃek:nitu	115
'siket	110
a:t	115
ba:t	170
	105
ra:t	170
so:t	180
	125
mo:t	100
be:t	105
hi^{j}t	145
bi^{j}t	130
	135
zi^{j}t	125
si^{j}t	70
fti^{j}t	125
i^{j}t	105
hi:t	120
zi:t	120
pi:t	105
mi:t	120
ski:t	90
tni:t	105
tu^{w}t	110
	120
bu^{w}t	125
mu^{w}t	125
ʔa:t	235
	205
'biret	120
dzi^{j}t	75

parti^{j}t	85
irbi^{j}t	120
inbi^{j}t	120
'siket	85
'sik:et	85
'nifet	130
'iskot	80
'si:ket	125

Initial Geminate (14)

it:i^{j}ni	160
it:i:ni	210
it:ifel	180
it:i:h	185
it:ap:an	125
it:ej:et	115
it:na	120
it:a:ma	125
it:urufha:t	95
it:i^{j}r	140
it:el:a	110
it:iem	125
it:ip^{j}i^{j}p	100
it:af:a	125

Medial Geminate (29)

'bit:ra	195
'fit:e	160
furket:a	210
furket:a	190
	230
'dit:a	260
'pit:er	225
'hit:a	230
'bit:a	190
'sit:a	240
'tut:u	240
'tpat:i	175
tpat:ija	155
ot:u^{w}bru	165
but:u^{w}na	170
ʔat:u^{w}s	225
karet:u^{w}n	155
imkat:ar	200
'pat:i	260
'kat:ar	235
at:enta:t	105
	120
et:ila	105
	120
set:embru	150
pit:u^{w}ra	175
'ʔat:ar	150
	135
'ʔat:a	150

Final Geminate (26)

hat:	235
	200
	140
rot:	135
mit:	205
	165
rat:	200
	165
	140
tʃat:	160
	175
sot:	160
	140
met:	190
	150
pet:	205
bit:	240
zit:	220
mat:	200
pat:	180
plat:	190
tot:	175
ʃot:	215
rot:	200
bot:	160
imtet:	180

Initial Cluster (24)

fti^{j}t	90
kti:p	80
	85
tnejn	75
'tli:ta	60
tʔi:ʔ	100
	90
ʔta:r	70
ʔti^{j}l	115
	90
tru^{w}ʃ	95
	85
twi^{j}l	60
'tjas:ar	70
'tpastas	80
'tkej:el	70
'tmej:el	45
'pti:hi	70
'tpaspar	70
'tpindzi	50
'tpat:i	40
'ktej:ep	50
	60
	65

Medial Cluster (32)

'kitla	35
'binti	95
irkipta	100
'iktar	105
parti^{j}t	90
'mentni^{j}ʃ	40
'ti^{j}tlu	80
'pi:tru	80
'be:tni	115
'te:tnu	40
'titwi	80
'bitha	80
'itni	75

'sipta	120
'itfa	45
'nitfa	65
'petne	145
'pesta	80
gus'tuʷs	95
mun'tuʷn	65
'kuʷtra	100
bas'tuʷn	115
mik'tuʷp	130
'o:tja	75
kus'to:dju	85
at:en'ta:t	70
tis'tordi	90
im'ha:tra	65
'pri:tka	60
kan'ta:ta	50
pipis'trel	40
impus'tuʷr	45

Final Cluster (7)

taht	120
gost	170
tost	120
post	135
fost	120
politi'kant	60
pes:i'mist	50

/k/

Initial Single (26)

ku'ruʷna	50
ke'f:i:na	55
kef:ina	60
kostitutsjo:ni	50
kaval:i:r	60
ko'lonja	85
kolonja'lizmu	75
kiser	65
ki:n	70
ka'p:el:a	65
ka'p:el:	60
	70
kam'pna:r	65
ka:p	80
kop:	90
kiʲt	75
'kitla	60
'kat:ar	85
'kotra	80
'kuʷtra	60
'ki:ku	70
'kikkra	50
'ka:ki	80
ko:k	75
'kuk:a	70
'kiber	60

Medial Single (25)

'poliʲtika	60
politi'kant	60
'piʲka	80
	160
'fiʲkom	120
'biʲkom	115
niko'tiʲna	60
'siket	100
	105
'si:ket	85
lam'puʷka	90
	140
ma'kak:	95
'to:kis	65
	80
'ko:ka	110
'rikep	90
'ski:ken	85
kan'ta:ta	65
mate'matika	50
'ji:kol	80
jiftakar	80
tim'pika:ʃ	90
'ti:kol	75
bibljo'te:ka	75
	65

Final Single (27)

biʲk	130
fiʲk	130
diʲk	80
	145
pi:k	75
	110
tskuʷk	80
	100
'ituʷk	145
ko:k	85
	120
flo:k	80
	115
'fenek	65
	105
ak'suʷk	90
it'skuʷk	140
da?sek	105
	100
na'fek	100
in'tiʲk	80
spak	80
ta:k	80
'martek	65
in'tuʷk	65
'harkek	60
ra:k	65

Initial Geminate(2)

i'k:alma	120
ik:on'trol:a	95

Medial Geminate (29)

bo'k:iʲn	135
	145
si'k:iʲna	135
'sik:et	245
'spik:a	225
'kikkra	195
'bek:a	145
	250
'kuk:a	120
	225
bri'k:uʷn	105
	160
ta'k:uʷna	115
	150
'ʃpak:a	225
'tʃek:en	125
	180
'hak:a	165
'tik:a	180
	170
'mek:a	170
ba'k:uʷza	110
tik:unten'ta:h	105
'spik:a	160
irtu'k:a:r	150
	120
'tok:a	170
bu'k:uʷn	105
'fak:ar	190

Final Geminate (12)

tʃik:	140
	180
tok:	145
	140
tsok:	165
hok:	130
	125
flok:	230
	145
makak:	120
da?sek:	135
hak:	165

Initial Cluster (33)

ski:t	100
	110
tskuʷk	115
sko:p	80
ir'kipta	80
'sko:la	70
'skomdu	75
'ski:ken	95
	95
tki'd:niʲ	85
	85
'ʃkuʷma	120
'ʃkuʷpa	60
	55
pkejt	60
	70
'ipki	100
'iktar	75
'iktar	55
	65
'tʃejken	45
'tkej:el	55
'kniʲsja	60
'ktʃiʲna	40
kti:p	65
'ktej:ep	50
'krua	75
sku'tel:a	60
ʃku'pilja	60
kli:m	80
	75
'tkeʃkeʃ	55
'tkab:ar	70

Medial Cluster (27)

'mikrobu	60
furket:a	80
	105
'miksi	90
ak'suh	55
ak'suʷk	80
mik'tuʷp	55
	45
fliʃkuʷn	60
	100
bar'kuʷn	95
'tʃek:net	90
	135
tʃek'nitu	65
	115
'pri:tka	60
kan'ta:ta	50
mak'tuʷr	65
tak'wista	100
'tʃkejken	55
	60
pe'riʲklu	80
fa'r:aktni	60
fli'mki:n	45
'tkeʃkeʃ	50
fa'r:akna	80
gow'likiʲper	55

Final Cluster (4)

bank	60
a:ks	80
'idejk	80
ma'ta:kʃ	80

/?/

Initial Single (4)

'?at:ar	80
	90
'?at:a	60
'?atra	65

Medial Single (9)

'duʷ?om	60
'duʷ?a	90
'ra?ad	60
	40
mara'?atʃ	60
'tʃa:?a	80
'duʷ?u	60
du'?uom	50
du'?uomli	50

Final Single (11)

t?i:?	120
fi:?	125
duʷ?	90
	135
fuʷ?	120
i'suʷ?	105
i's:uʷ?	130
i'duʷ?	80
i'd:uʷ?	60
'dwej:a?	85
i'd:ej:a?	80

Final Geminate (2)

ha?:	180
da?:	135

Initial Cluster (5)

t?i:?	85
?ta:r	65
?tiʲl	45
p?iʲja	30
?siʲm	110

Medial Cluster (2)

misto?'siʲa	40
'da?sek	50

/b/

Initial Single (41)

be:t	115
bint	140
bit:	100
biʲk	75
biʲt	150
	90
bi:p	120
bi:s	75
bo:t	90
'bid:el	90
	90
'bit:ra	80
'bidla	105
bi'dila	50
'binti	90
'biret	100
'bidu	80
'bina	110
	85
'binti	90
'biʲda	150
'biʲgi	100
'biʲkom	95
'biʲma	105
'bi:ret	110
'be:la	90
	110
'be:da	90
'be:dni	140
'be:tni	105
'bidu	165
'bit:a	110
'bed:a	120
'beda	55
	100
'bela	90
'bi:da	120
bas'tuʷn	80
'buʷtu	115
'bi:du	100
barkuʷn	150

Medial Single (22)

'tuʷbu	90
tnaʃ	95
'tna:bar	60
'teba	80
	60
'tobot	65
'kiber	70
'mikrobu	80
ta'biʲp	80
t:a'biʲba	100
	95
'de:ba	70
'ʃeba	95
'raba	80
	85
'rebah	80
	95
'i:bes	60
'sa:ba	40
ki't:i:ba	60
kitiba	30
makitib'ili:ʃ	60

Medial Geminate (17)

dub:i:na	115
	190
'deb:a	120
	210
'teb:a	210
'ʃeb:a	210
'keb:ep	140
	170
'tkab:ar	130
'kob:a	170
	150
'tab:ap	170
	160
du'b:i:n	150
'reb:ah	160
	180
'rab:a	170

Initial Cluster (11)

bri'k:uʷn	80
	105
'dbi:rek	90
	90
'bnisa	80
	80
'bnew	105
'bna:dar	110
	105

Medial Cluster (11)

bri'k:uʷn	105
o't:uʷbru	75
	70
se't:embru	60
rispon'sabli	85
tam'buʷr	45
'ʃrobna	80
'kidba	80
'hab:ni	105
ki'dbila	70
du'blet:	80

/d/

Initial Single (24)

diʲk	95
duʷt	85
duʷr	120
da:m	80
'duʷdu	130
'di:ta	65
du'b:i:na	110
'de:ni	100
	115
'de:ba	70
	65
'de:ʃa	70
'de:ra	80
'dit:a	135
'deb:a	90
'dema	65
	95
'deni	105
'duʷ?u	70
'do:da	80
'do:mna	80
'duʷ?	70
'duʷ?u	100
duʷ'?uomli	70

Medial Single (24)

bi'dila	75
'tider	70
'biʲdu	70
'ziʲda	60
'iʲdek	65
ma'di:ʃ	75
'pi:di	100
'bi:da	100
	80
'zi:da	80
'be:da	60
'tʃe:da	80
	80
'bidu	95
'beda	80
	85
'bi:da	105
ma'duʷ	75
'duʷdu	90
'biʲda	90
'so:da	70
'do:da	75
'o:du	75
'ro:da	80

Initial Geminate (12)

i'd:ispra	110
	150
it:a'biʲba	135
i'd:uʷ?	170
	165
id:'wej:a?	100
i'd:i:hla	145
i'd:aw:ar	140
id:ut:'riʲna	100
i'd:ej:a?	150
i'd:inja	160
i'd:i:hla	140

Medial Geminate (11)

'bid:el	160
	175
ma'd:i:ʃ	250
	145
'od:u	180
'od:a	165
'sod:a	140
bi'd:ila	140
bi'd:ilom	150
'ad:a	150
	210

Initial Cluster (17)

dlikt	65
dnuʷp	100
	100
drajt	105
ˈdbe:dni	75
ˈvdajta	85
ˈdbi:rek	75
dbi:l	55
dla:m	40
	80
sdinˈga:t	110
djuʷl	85
drit:	95
ˈdbi:rek	80
	100
dmiʲr	100
	70

Medial Cluster (8)

uˈli:dna	80
ˈiriʲdna	60
ˈbi:dja	60
ˈbidla	80
kidˈbila	60
manˈduʷʃ	60
tisˈtordi	80
maˈdrajtʃ	80

/g/

Initial Single (3)

gas:	90
gusˈtuʷs	80
	100

Medial Single (8)

ˈbiʲgi	60
	70
ˈpi:gi	70
	80
t o :ga	40
	80
ˈpa:ga	80
	70

Initial Cluster (1)

igˈniʃin	55

Medial Cluster (9)

ˈtiʲgra	55
	75
ˈtugza	100
	85
iˈs:o:gra	85
tis:o:graʃ	50
ilˈgziʲra	70
uˈgza:h	40
	80

/s/

Initial Single (21)

sit:iʲn	85
set:embru	80
ˈsod:a	110
	120
ˈsot:a	100
ˈsik:et	180
	100
sa:p	130
suˈp:erf	100
ˈsit:a	80
	85
ˈsokra	120
ˈsi:fer	140
	230
ˈsefter	100
saˈtejn	150
	180
ˈsah:a	210
ˈsop:a	200
ˈsipta	220
	220

Medial Single (22)

ˈdzisem	130
ˈiʲsa	145
ˈwisa	175
ˈnesa	155
	140
ˈkesah	140
	155
ˈwi:sa	180
ˈkiser	125
inˈtesa	110
ˈbni:sa	125
ˈbnisa	120
ˈkesah	155
	130
ˈbasal	140
	120
ˈki:sah	120
	155
ˈa:sel	140
	190
maˈsuʷr	140
	150

Final Single (11)

titˈpastas	120
ˈtpaspar	115
ˈtʃap:as	100
ˈto:kis	100
ka:s	155
kos	200
kuʷs	150
ˈmakuʷs	270
ˈitʃaflas	290
itʃ:aflas	220
a:ks	230

Initial Geminate (9)

iˈs:efter	150
	195
iˈs:o:gra	195
iˈs:ah:a	220
	215
is:uʷ?	200
is:inˈjuʷr	170
	175
is:efˈtuʷra	140

Medial Geminate (18)

ˈmis:ni	250
ˈis:a	265
ˈnes:a	240
ˈkes:ah	240
	245
iˈtʃ:as:a	260
	270
itʃ:aˈs:aw	220
	240
pes:ˈimist	165
tiˈs:o:gra	180
ˈtjas:ar	190
ˈtʃas:a	240
ˈas:a	210
	240
iˈmis:ek	230
	240
iˈros:u	270

Initial Cluster (22)

ksi:h	190
	240
?siʲm	200
skutel:a	80
	110
spik:a	140
	130
spa:k	240
	130
sko:p	200
	170
ski:t	240
	155
sto:na	270
ˈski:ken	190
stotʃ:	300
ksuʷr	170
ˈskuʷza	115
	100
ksuʷr	100
	140
	150

Medial Cluster (24)

ˈkniʲsa	130
ˈid:ispra	130
ˈmiksi	195
ˈpesta	170
ˈkniʲsja	190
ak suʷh	160
gusˈtuʷs	95
akˈsuʷk	130
basˈtuʷn	95
kusˈto:dju	100
tisˈtordi	115
pipisˈtrel	115
	120
titˈpastas	110
takˈwista	120
kostitutsˈjo:ni	80
ˈtpastas	140
ˈpra:spar	105
ˈknisja	140
lisˈto:rja	120
basˈtuʷn	125
misto?sija	80
	125

Final Cluster (11)

gost	175
tost	140
	195
post	200
	155
fost	130
op:ost	130
lop:ost	140
arˈtist	155
dzust	200
matʃap:astʃ	150

/f/

Initial Single (14)

ˈfenek	80
faˈr:aktni	115
flo:k	120
flok:	130
ˈfit:eʃ	85
faˈr:akna	85
ˈfi:tel	220
	240
ˈfiʲkom	190
ˈfetah	220
ˈfa:ma	210
ˈfak:ar	180

'fet:ah	140
'ferrah	140

Medial Single (10)

'tefa	120
'si:fer	160
	95
'nifet	110
matefa:ʃ	90
'zifen	120
'na:fek	145
re'fa:tom	110
it:ifel	130
'ki:fer	140

Final Single (3)

kiʲf	230
	160
sup:erf	120

Medial Geminate (14)

kef:ina	180
	170
tuf:i:ha	165
	170
kef:i:na	180
	185
'zef:en	220
	165
'tnif:es	165
	205
'zif:en	225
it:af:a	205
tuf:i:h	230
listuf:a:t	190

Initial Cluster (5)

fliʃkuʷn	85
flimkiin	100
fki:ren	320
ftiʲt	130
tfejt	205

Medial Cluster(18)

'nitfa	190
i'tʃanfar	100
	155
itʃ:anfar	90
	175
itʃaflas	180
	140
itʃ:aflas	190
	140

it:urufna:t	135
jiftakar	100
'sefter	160
'notfa	160
'itfa	190
itfia	160
itfiom	170
i'sefter	150
is:efter	150

/ /

Initial Single (6)

'ʃap:ap	110
'ʃitla	100
'ʃitel	240
'ʃeda?	260
'ʃot:	280
i'ʃandar	100

Medial Single (16)

'tiʃel	140
	135
'miʃi	190
'ni:ʃef	175
'de:ʃa	140
	155
'miʃi	140
'niʃef	145
'meʃa	155
	145
igniʃin	135
miʃowl	120
ha'ʃiʲʃ	105
	130
ir'ʃoʃta	125
	150

Final Single (14)

truʷʃ	115
tkeʃkeʃ	105
	100
fit:eʃ	100
tked:niʲʃ	130
tminta:	95
timpika:	120
tiᵗwiʲʃ	65
	150
ha'ʃiʲʃ	110
mata:ʃ	220
ti'ʃ:em:eʃ	300
iʃ:emʃ	280
'tiʃwiʲ	100

Initial Geminate(4)

iʃ:emʃ	230
	215

i'ʃ:andar	200
i'ʃ:itla	200

Medial Geminate (7)

tmeʃ:i	180
	260
'meʃ:a	240
	250
'tiʃ:em:eʃ	200
	165
meʃ:i:h	215

Initial Cluster (8)

ʃkuʷpa	105
	110
'ʃrobna	140
'ʃkupilja	180
	95
'inʃtehet	100
'ʃpak:a	210

Medial Cluster (13)

timʃi	180
fliʃkuʷn	105
	120
'tkeʃkeʃ	130
	110
'nimʃi	160
'miʃwi	180
inʃtehet	125
'tiʃwiʲ	135
	160
'miʃtri	140
irʃoʃta	140
	200

/h/

Initial Single (9)

hat:	120
'hak:a	95
hak:	220
	110
'hab:ni	100
hok:	145
haʔ:	240
hat:	350
'haʔ:a	230

Medial Single (7)

'pti:hi	90
	95
riha:na	200

in'ʃtehet	140
'dahal	120
inʃtehet	120
mahal:atʃ	100

Medial Geminate (4)

sah:a	250
dah:al	230
dah:ala	165
is:ah:a	170

Medial Cluster (6)

ahptu	95
'tahli	135
kul'hat:	95
'misthi	140
'bitha	215
'di:hla	80

Final Cluster (2)

taht	140
	165

/z/

Initial Single (5)

zi:t	120
'zi:da	125
'zef:en	100
	110
'zifen	140

Medial Single (3)

op:ozitsjo:ni	200
tiskuza:h	100
tip:o:za	150

Medial Geminate (1)

tuz:a:na	140

Initial Cluster (1)

'hzi:na	150

Medial Cluster (4)

ˈtugza	185
kolonjalizmu	95
ˈahzen	170
ugza:h	110

/v/

Initial Cluster (1)

ˈvledza	100

Medial Cluster (2)

nerˈvuʷs	120
ˈnivda	130

/t /

Initial Single (13)

tʃik:	85+ 100
ˈtʃiʲna	120+ 100
ˈtʃanfar	55+ 55
ˈtʃap:as	60+ 45
ˈtʃap:a	65+ 45
tʃat:	80+ 40
ˈtʃek:net	70+ 65
ˈtʃek:en	70+ 45
iˈtʃaflas	75+ 40
tʃek:ˈnitu	55+ 35
tʃurˈket:	65+ 70
ˈtʃat:	90+ 70
ˈtʃiʲna	80+ 100

Medial Single (4)

ˈpa:tʃi	80+ 75
at:ˈriʲtʃi	60+ 85
feˈro:tʃi	80+ 80
fit:ʃitek	90+ 100

Final Single (3)

iˈt:ej:etʃ	60+ 65
itʃ:ˈwi:tʃ	40+ 110
metʃ	60+ 180

Initial Geminate (5)

itˈʃ:anfar	145+ 60
itˈʃ:wi:t	70+ 140
itˈʃ:as:a	165+ 45
itˈʃ:as:aw	120+ 35
itˈʃ:aflas	135+ 35

Medial Geminate (10)

ˈketʃ:a	110+ 90
	130+ 130
keˈtʃiʲni	125+ 65
ketʃ:i:ni	120+ 90
ˈmutʃ:u	140+ 135
ketʃ:iʲni	155+ 65
nutʃ:a:li	100+ 80
paˈrotʃ:a	110+ 100
fatʃ:o:l	120+ 70
atʃ:a:n	130+ 90

Final Geminate (5)

paˈpotʃ	95+ 80
a:tʃ	95+ 65
tatʃ:	130+ -
stotʃ:	110+ -

Initial Cluster (5)

ˈktʃiʲna	55+ 90
ˈktʃiʲna	90+ 85
ˈtʃkejken	60+ 55
	55+ 55
ˈtʃri:ket	60+ 100

Medial Cluster (2)

ˈprintʃep	30+ 70
pultʃˈinel:	55+ 80

/ts/

Initial Single (9)

its:ˈkuʷk	115+ 45
	50+ 140
tskuʷk	40+ 85
ˈtsoptu	60+ 60
ˈits:ok:or	100+ 110
ˈits:op:	110+ 140
ˈits:altsa	80+ 120
its:iˈji:t	90+ 110
ˈtsok:	100+ 90

Medial Single (8)

ˈpitsi	200+ 65
kostitutsjo:ni	60+ 130
opozitsjo:ni	65+ 95
ˈtats:a	95+ 115
ˈa:ts:a	110+ 130
ˈrats:a	140+ 140
kaˈrots:a	100+ 120
karoˈts:iʲn	100+ 120

Final Single (3)

filjots	145+ 45
puˈpats	90+ 80
mats	100+ 170

/d /

Initial Single (12)

dʒam:	80+ 90
ˈdʒisem	80+ 30
	60+ 40
ˈdʒema	65+ 40
	60+ 60
ˈdʒiʲta	65+ 75
ˈdʒi:t	100+ 80
ˈdʒema:	100+ 50
ˈdʒust	80+ 70
ˈdʒuʷh	40+ 60
idʒe:lna	60+ 80
dʒan:i	90+ 50

Medial Single (4)

kudʒiʲn	105+ 120
redʒa	105+ 40
ridʒel	40+ 40
ra:dʒel	70+ 40

Final Single (3)

majirˈto:t	120+ 170
maraˈʔatʃ	160+ 150
mahaˈl:at	150+ 190

Medial Geminate (10)

ˈa:dʒel	100+ 100
adˈʒ:ilna	40+ 80
tidʒudiˈka:ʃ	30+ 40

'viedʒ:a	50+
	30
nidʒ:i:let	50
	100
'hedʒ:etʃ	60
	90
hedʒ:idʒom	60
	80
madʒ:uʷr	110
	40
'redʒ:a	63+
	70
midʒnuʷn	130+
	50
	60+
	120

/m/

Initial Single (27)

'muʷtu	65
makak:	95
'mo:li	100
'mo:la	95
met:	65
mit:	115
mit:	75
muʷt	80
mat:	85
moh:	40
mo:t	110
mo:s	90
'mikrobu	50
mis:ni	55
mit:iʲdek	65
mentniʲʃ	145
madi:ʃ	50
'mi:ʃi	95
'min:a	85
'miʃi	80
'miksi	80
'meʃa	50
'meʃ:a	65
'meʃ:i:h	55
'mutʃ:u	85
'muntuʷn	90
'maduʷʃ	80

Medial Single (25)

famuʷs	90
	100
'to:ma	80
'ko:ma	75
'ʔiʲma	160
'liʲma	105
'biʲma	90
'li:ma	100
'dʒema	90
	100
'sema	90
	95
'fe:ma	80
'tema	95
	90

'dema	90
	95
'ʃkuʷma	160
'tewma	100
'fe:ma	80
'fema	80
'fa:ma	100
'to:ma	100
'it:a:ma	110

Final Single (27)

fe:m	100
	120
te:m	105
	120
ʔsiʲm	85
ʔa:m	105
	150
sa:m	100
da:m	110
	100
ra:m	105
a:m	155
dʒisem	70
	50
se:m	155
	130
te:m	140
	115
no:m	105
kli:m	90
it:iem	80
bid:ilom	170
'fiʲkom	110
'biʲkom	120
refa:tom	120
hedʒ:id om	140
itfiom	120

Medial Geminate(9)

'nem:en	175
	185
tiʃ:em:eʃ	200
	145
'tem:a	225
	200
rum:i:na	120
'kom:a	160
'dʒem:a	140

Final Geminate (5)

kem:	175
dʒam:	215
om:	195
sem:	140
kem:	150

Initial Cluster (13)

smi:n	120
	105
ʔmiʲs	90
	85
'tmeʃ:i	75
	70
'tmej:el	90
	80
tminta:ʃ	65
	80
'tmi:nja	70
'kma:mar	55
tmuʷr	75

Medial Cluster (20)

'sko:mdu	70
'o:mja	100
'domna	90
set:embru	115
'timʃi	100
'nemla	95
'numri	105
lampuʷka	100
	75
tambuʷr	80
'premju	60
flimki:n	115
kampna:r	65
'timla	100
'tewma	100
'ritmu	65
'nimʃi	130
'ahmar	70
ta:tomlom	90
timpikah	100

Final Cluster (6)

te:mt	90
	110
iʃ:emʃ	100
	105
tewm	140
mada:mʃ	150

/n/

Initial Single (22)

'nuʷna	95
	80
nervuʷs	85
'no:li	50
'na:fek	75
nem:en	70
	80
no:m	60
niko:tiʲna	85
'ni:ʃef	85

'nivda	140
'nifet	45
'nitfa	55
'nemla	90
'nesa	90
'nes:a	85
'numri	95
'notfa	60
'nesa	105
'nes:a	85
nidʒ:i:let	80

Medial Single (38)

'nuʷna	100
	995
	100
tak:uʷna	80
	80
induʷna	80
but:uʷna	85
hanuʷt	60
kanuʷn	80
'ma:na	70
'sto:na	50
	90
top:o:ni	60
ketʃi:ni	80
	75
kef:ina	70
it:iʲni	200
'piʲna	80
'ʃiʲni	85
etʒ:iʲni	175
'tiʲna	105
	180
'ktʃiʲna	135
nikotiʲna	120
sik:iʲna	170
'fiʲni	100
'pi:na	70
'de:ni	90
	90
kef:i:na	60
'ejni	80
it:i:ni	65
'biʲna	80
'ʃini	60
'fenek	80
'deni	60
'ʃi:ni	75
rum:i:na	65

Final Single (23)

brik:uʷn	60
	60
kanuʷn	95
zifen	70
zif:en	80
	70
nem:en	70
	40
'ski:ken	115
de:n	155
fiʲn	85

smi:n	90
ki:n	95
ʔruʷn	85
to:n	120
karoˈtsiʲn	135
kuˈdʒiʲn	120
duˈb:i:n	90
oˈti:n	95
fliˈʃkuʷn	210
munˈtuʷn	145
barˈkuʷn	90
kareˈt:uʷn	100

Medial Geminate (6)

ˈta:n:i	190
ˈkan:a	230
ˈnan:a	235
ˈman:a	220
ˈmin:a	245
ˈpin:a	250

Final Geminate (5)

hen:	145
ken:	230
pon:	180
	190
ton:	140

Initial Cluster (7)

ˈtnif:es	75
	65
tni:t	115
ˈkniʲsja	100
ˈbni:sa	105
dnuʷp	100
	130

Medial Cluster (23)

iˈtʃanfar	120
ˌitʃ:anfar	125
domna	80
at:enˈta:t	70
ˈtʃek:net	65
ˌtʃek:nitu	65
ˈbinti	105
ˈpindʒi	100
ˈmis:ni	120
iˈriʲdni	100
tkid:niʲ	75
mentniʲ	75
ˌmentniʲ	70
ˈbe:dni	110
ˈbe:tni	75
ˈte:tnu	95
ˈridna	65

ˈitni	120
ˈibni	80
ˈpetne	75
ˈi:dna	100
munˈtuʷn	120
manˈduʷʃ	80

Final Cluster (11)

tʃint	135
	105
bint	165
	75
punt	135
	130
bank	90
	80
kont	115
	100
kunˈtent	140

/l/

Initial Single (5)

lo:p	90
lot:	80
lo:k	90
ˈliʲma	100
lamˈpuʷka	55

Medial Single (6)

ˈsko:la	75
ˈko:la	70
ˈo:la	65
ˈno:li	80
ˈmo:li	65
ˈmo:la	100

Final Single (2)

ˈbid:el	60
itel	100

Medial Geminate (3)

ˈʃel:ila	120
	130
ˈo:l:a	175

Medial Cluster (7)

ˈbidla	190
ˈkitla	105
ˈtiʲtlu	85
ˈnemla	115
iˈtʃaflas	85
iˈtʃ:aflas	55
ˈpo:plu	100

/r/

Initial Single (8)

rat:	105
ˈridna	125
ˈri:dna	110
ruˈm:i:na	65
ˈro:ta	80
ˈro:da	80
ˈrikep	55
ˈra:ni	60

Medial Single (6)

ˈbiret	75
karoˈtsiʲn	35
piˈt:uʷra	85
ˈdera	65
ˈde:ra	45
karet:uʷn	80

Final Single (1)

suʷr	155

Initial Cluster (4)

briˈk:uʷn	55
trot:	75
briʲm	80
ˈkra:fes	80

Medial Cluster (16)

ˈpi:tru	75
ˈmikrobu	60
ˈtiʲgra	100
ˈfurket:a	55
parˈtiʲt	100
ˈkik:ra	80
ˈnumri	80
ˈkuʷtra	80
ˈbrik:uʷn	55
ˈot:uʷbru	125
ˈbarkuʷn	60
ˈnervuʷs	60
ˈo:pra	60
iˈs:o:gra	100
seˈt:embru	50
tisˈtordi	100

APPENDIX G

APPENDIX G .

This Appendix includes samples of the electrokymographic data used in this thesis to illustrate various points. The data is discussed in the appropriate sections of the thesis.

The words and phrases constituting the data were spoken within the context /erdʒaidli ____ is:a/ (meaning: Tell me ____ now) or /erdʒait ____ malajr/ (meaning: Repeat ______quickly). The words and phrases used for electrokymograms 9 to 18 were, however, decontexualised. Some problems occur when the speaker pauses within the context just after the first part of the 'constant' context, before the changing element - hence the unjoined segmentation lines in some cases.

In each electrokymogram shown, the top trace is the nasal air flow, the second from top is the oral (mouth) air flow, the third from top is the larynx microphone trace and the bottom trace is the time trace.

The Appendix is subdivided as follows:

G.1. A Study of Vowel Duration.
- G.1.1. EKG 1, 2, 3.
- G.1.2. EKG 4, 5.
- G.1.3. EKG 6, 7.

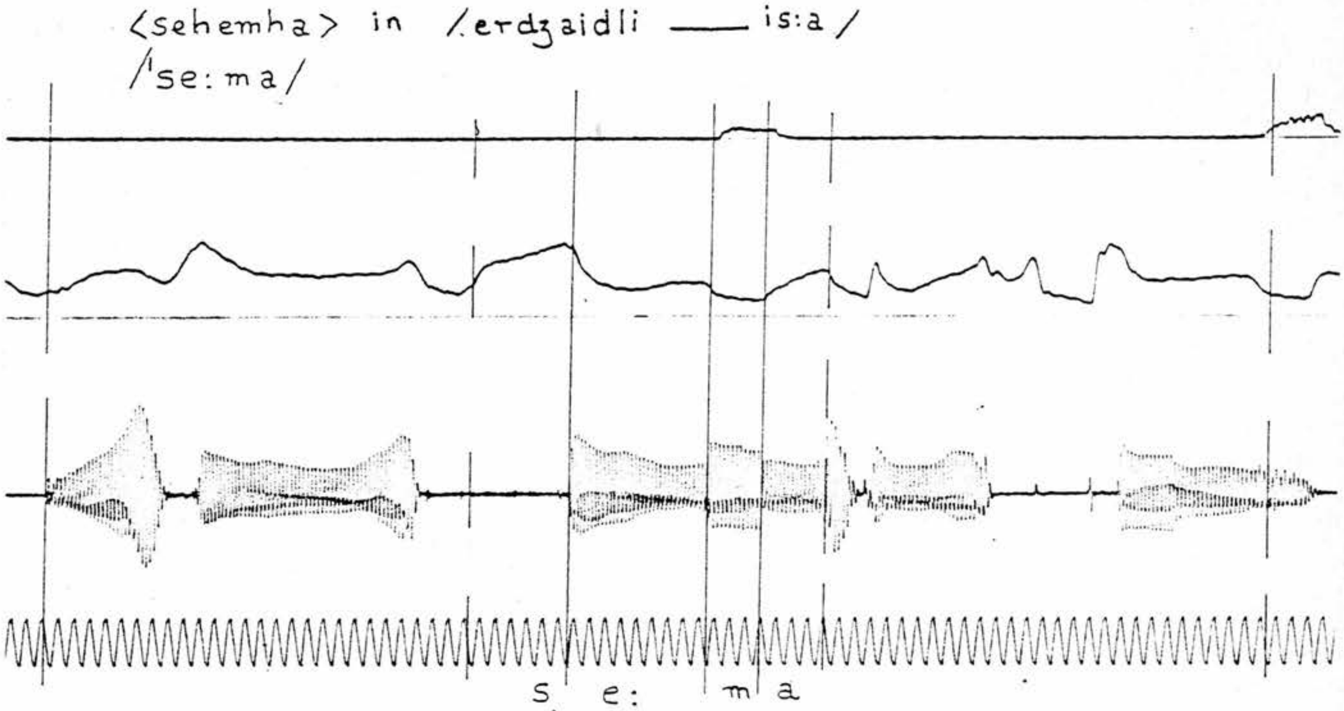
G.2. The Description of Consonants.
- G.2.1. EKG 8, 9.
- G.2.2. EKG 10, 11, 12.
- G.2.3. EKG 13, 14, 15, 16.
- G.2.4. EKG 17, 18.
  - EKG 19.
- G.2.5. EKG 20, 21.
  - EKG 22, 23, 24, 25, 26, 27, 28, 29, 30.
  - EKG 31, 32, 33, 34.

G.3. Consonant Duration
- G.3. EKG 35, 36, 37, 38.

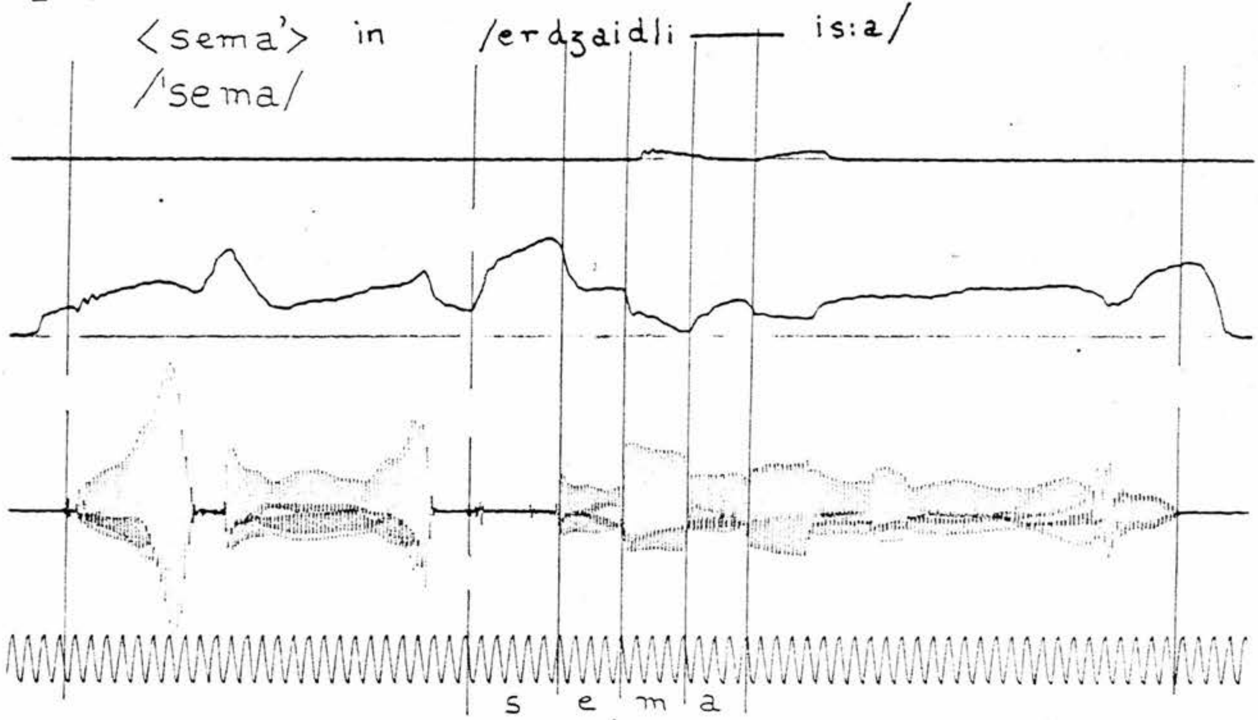
G.1. A Study of Vowel Duration.

G.1.1. Electrokymograms 1 and 2 illustrate the contrast between the long vowel /e:/ and the short vowel /e/ . Electrokymograms 2 and 3 illustrate the contrast between /e/followed by a single consonant and /e/ followed by a geminate consonant.

EKG. 1.



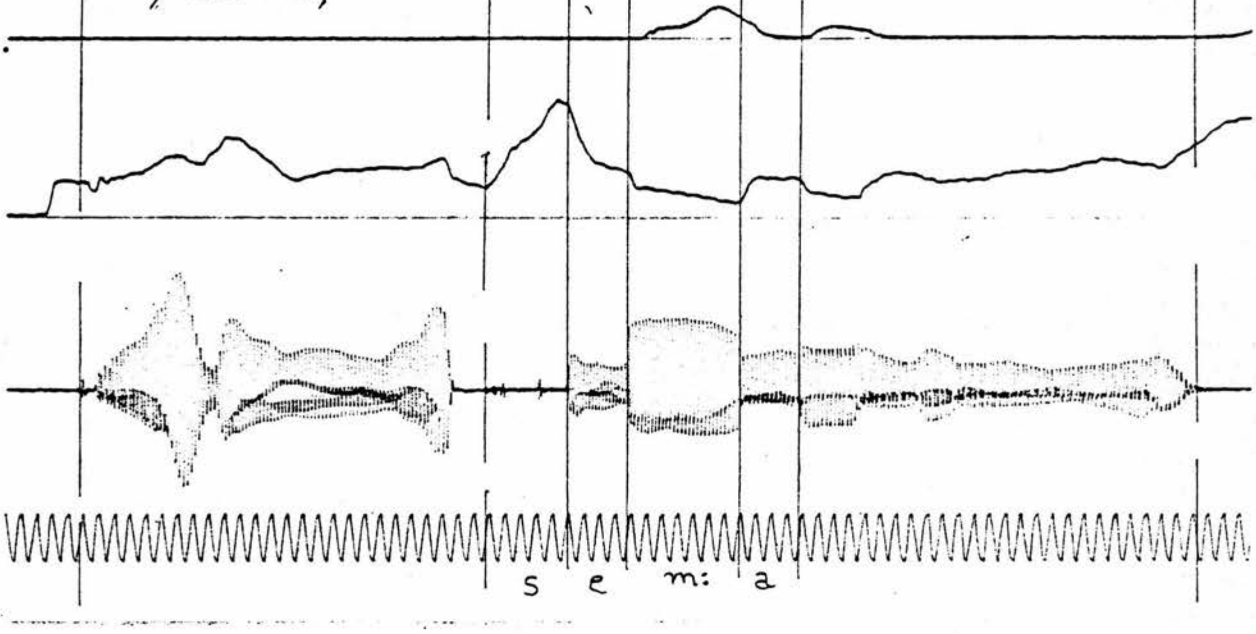
E.KG. 2



EKG. 3.

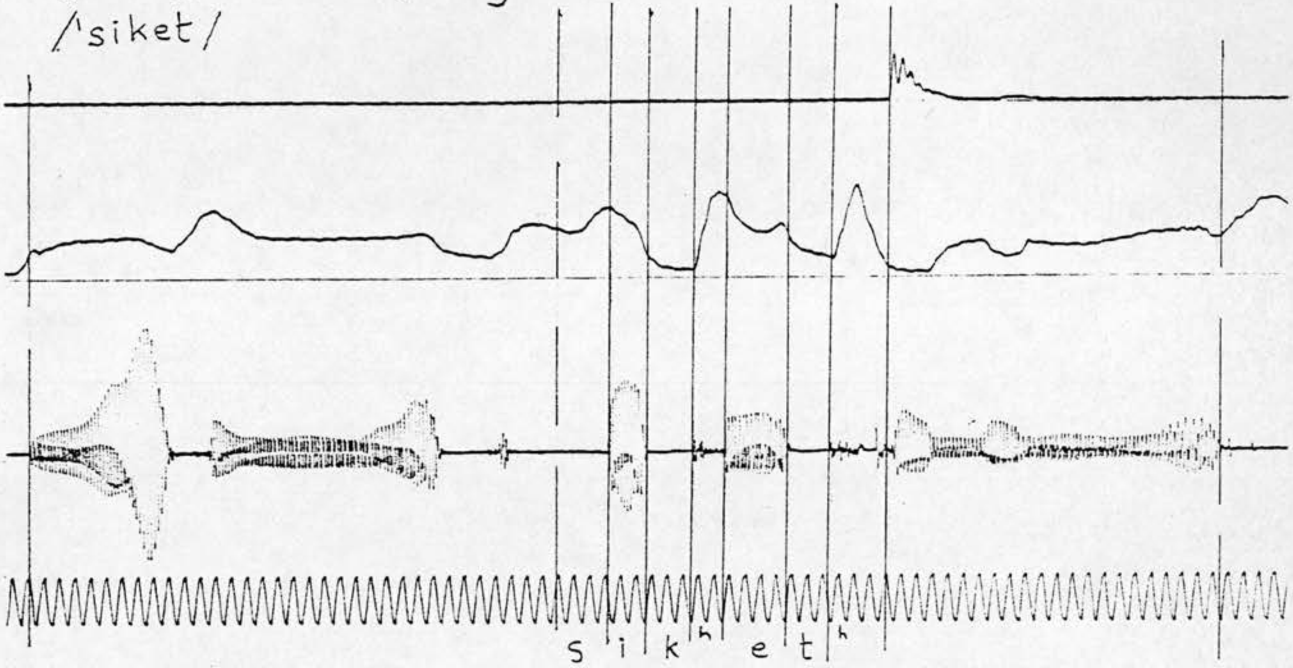
<semmá> in /erdzaidli ___ is:a/

/'sem:a/

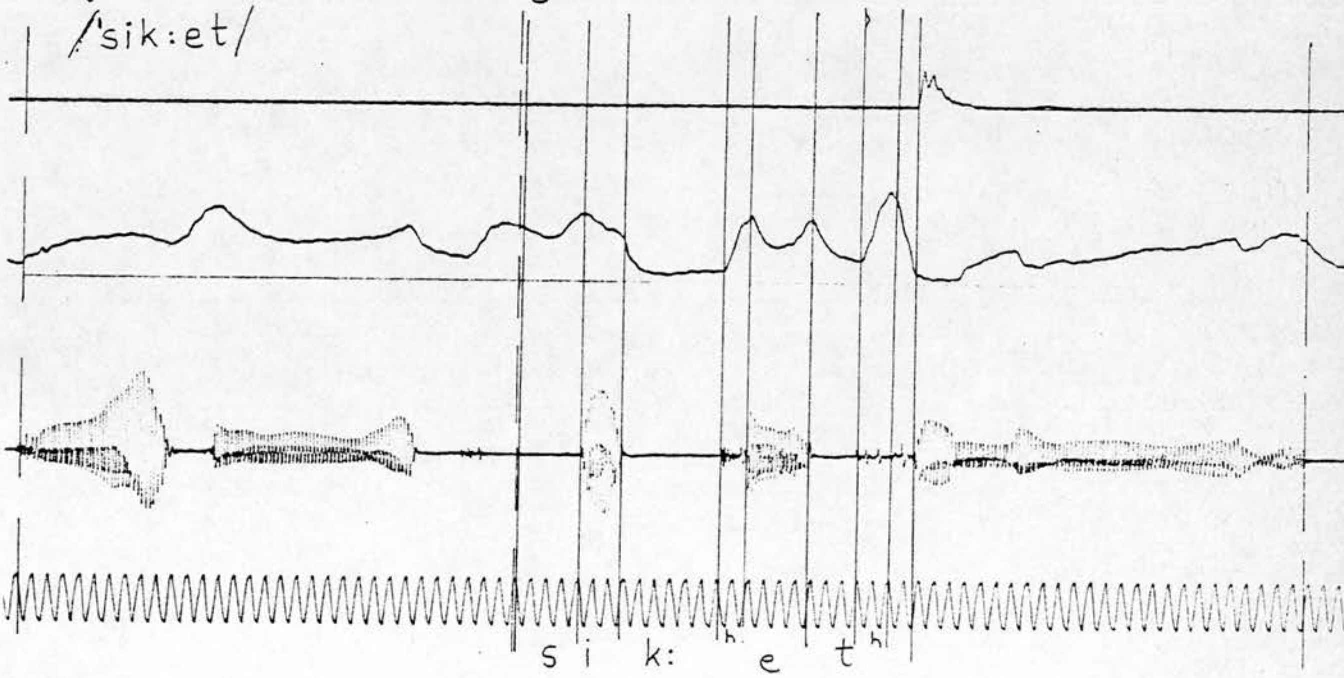


G.1.2. Electrokymograms 4 and 5 illustrate the duration of /i/ followed by a single consonant and /i/ followed by a geminate consonant.

EKG. 4.
<siket> in /erdʒaidli ___ is:a/
/'siket/

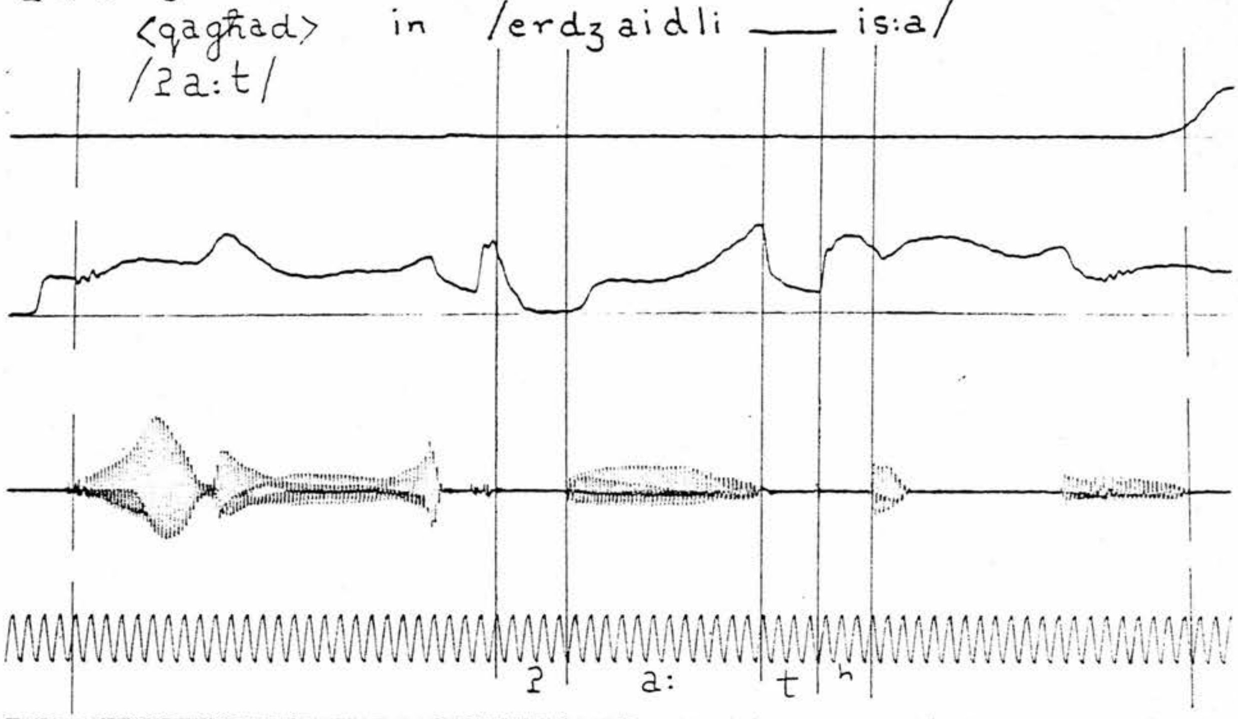


EKG. 5.
<sikket> in /erdʒaidli ___ is:a/
/'sik:et/

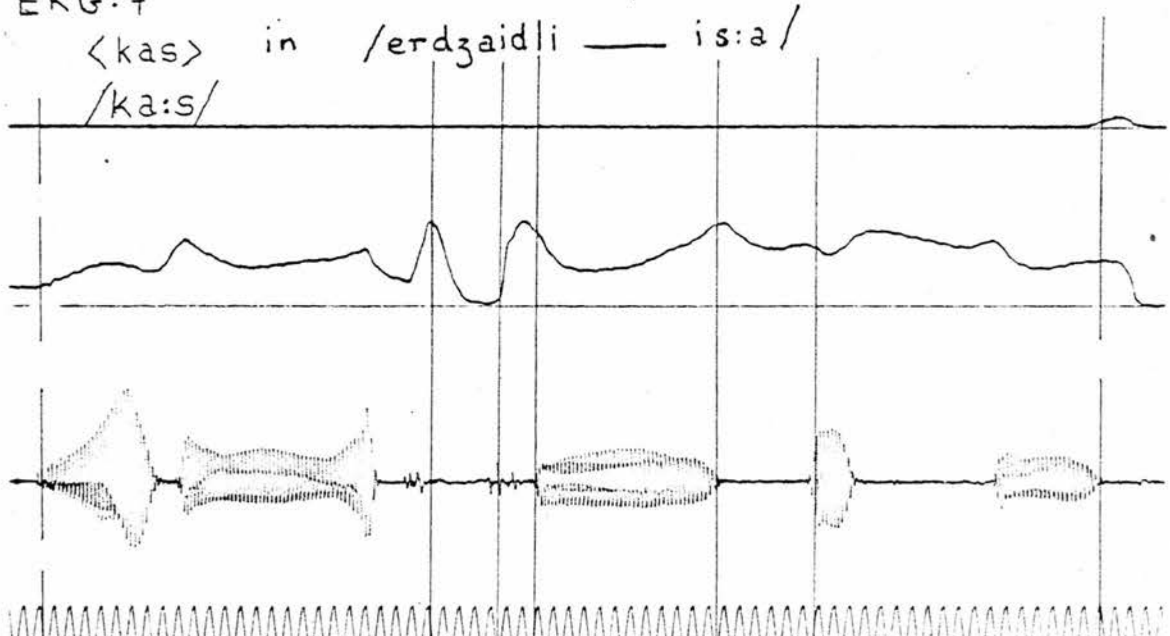


G.1.3. Electrokymograms 6 and 7 illustrate the duration of the vowel /a:/ in two words: (i)⟨qagħad⟩, where the vowel could have been pharyngalised originally and (ii) ⟨ras⟩, where it is an 'ordinary' vowel. My claim in chapter 6 is that there is no qualitative or quantitative difference.

EKG 6

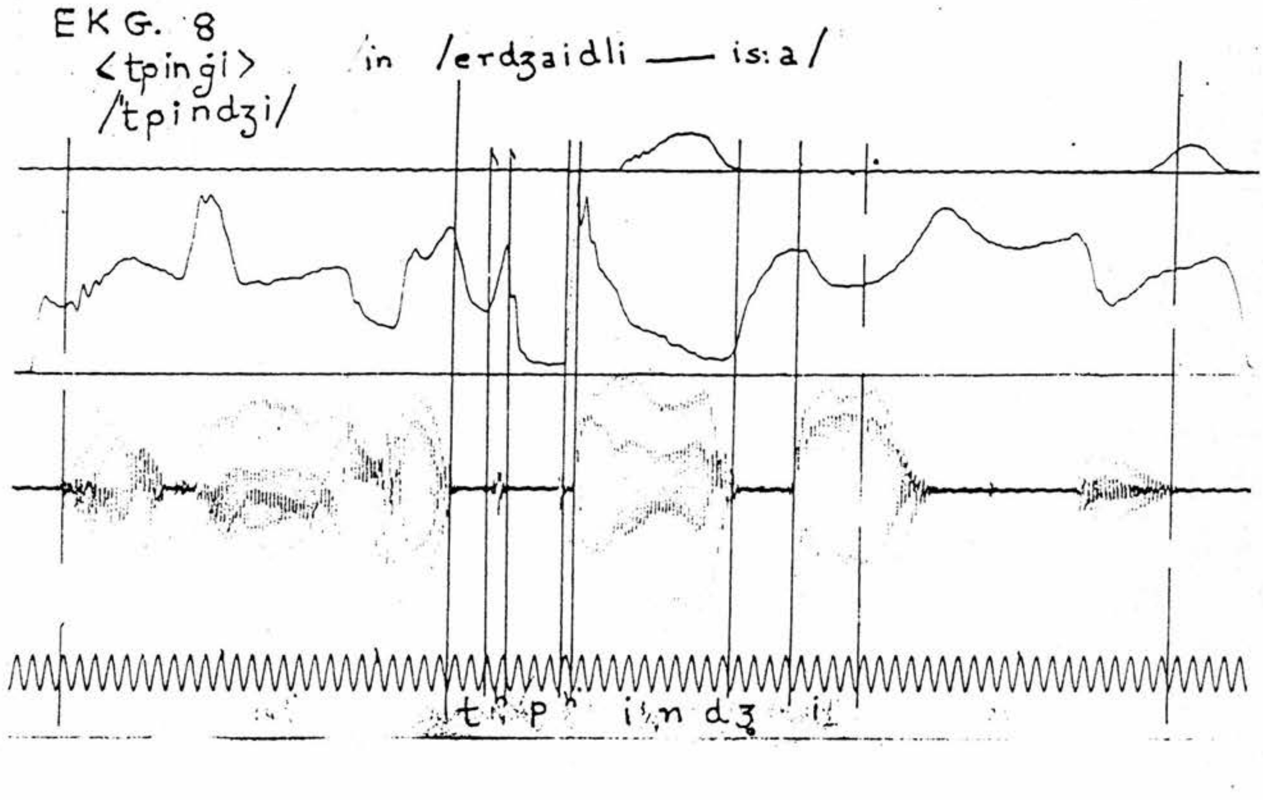


EKG.7



G.2. The Description of Consonants.

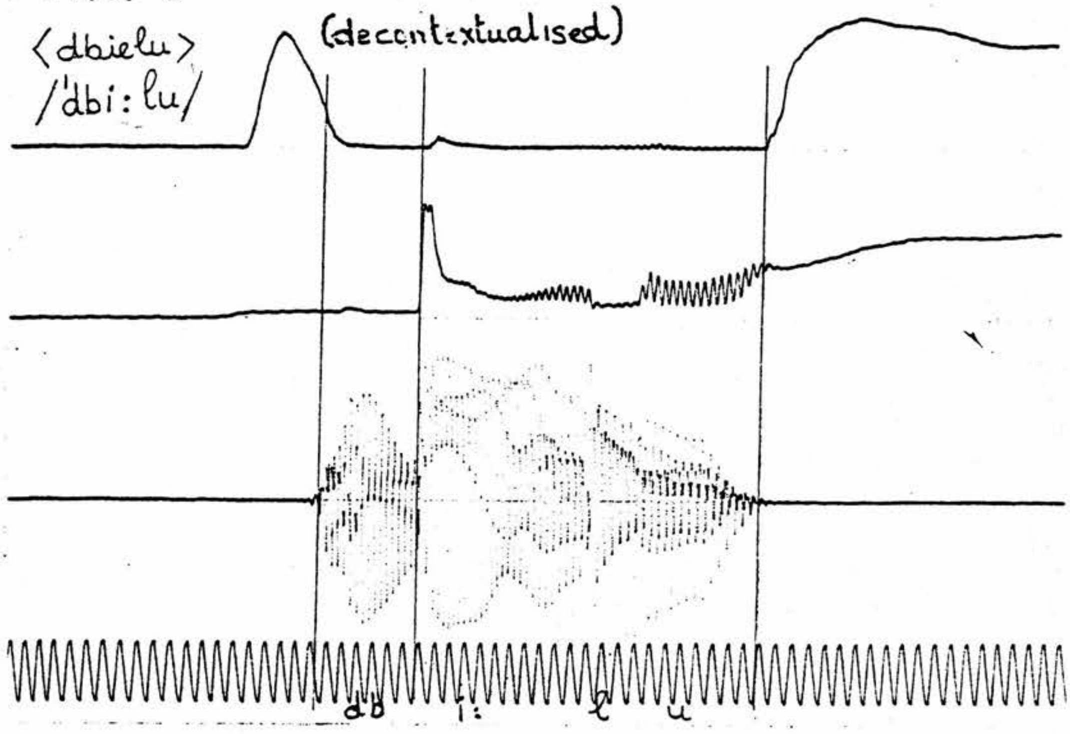
G.2.1. Electrokymograms 8 and 9 illustrate the contrast between sequential and simultaneous release of plosives in a consonant cluster.



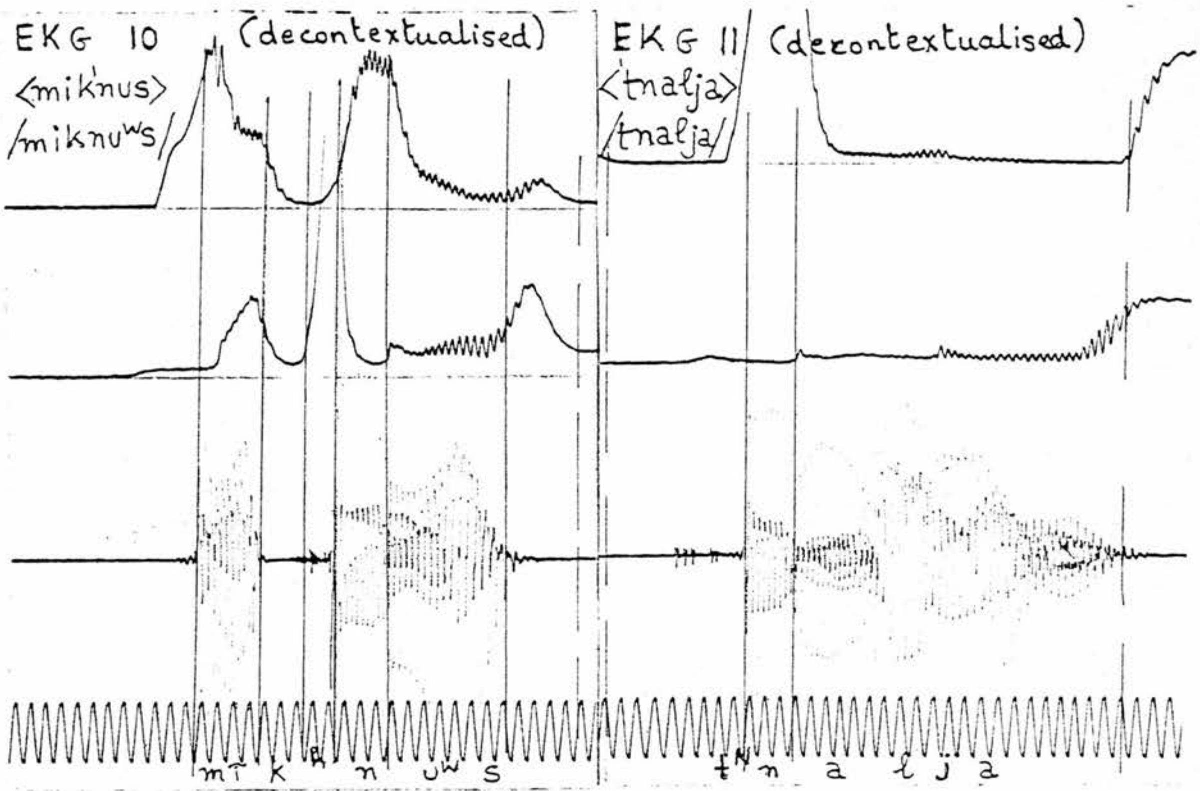
EKG. 9.

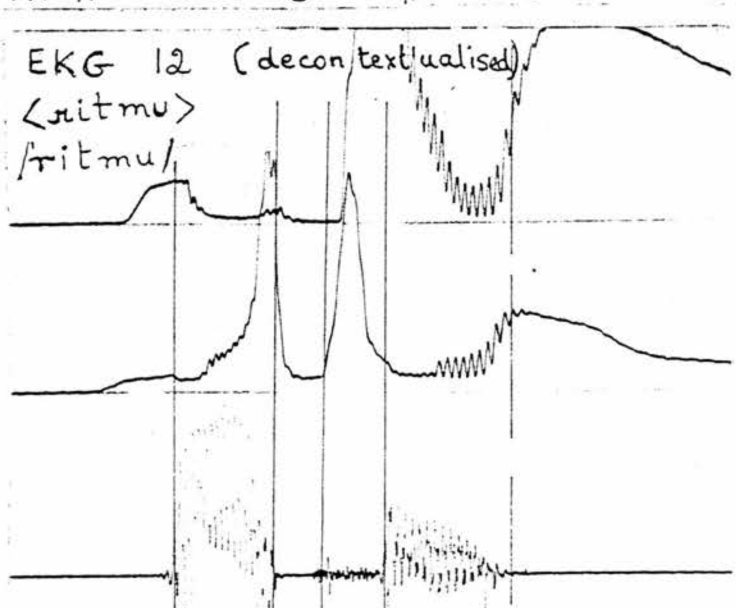
⟨dbielu⟩

/'dbi:lu/



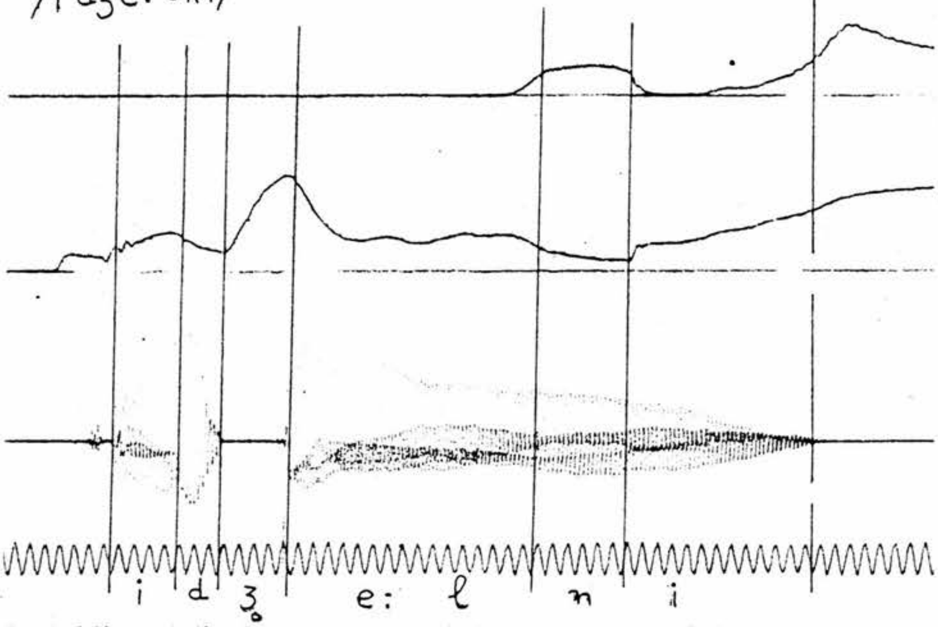
G.2.2. Electrokymograms 10 to 12 illustrate the different ways in which a plosive can be released when followed by a nasal stop. EKG 10 shows oral release; EKG 11 shows nasal release; EKG 12 shows simultaneous oral and nasal release.



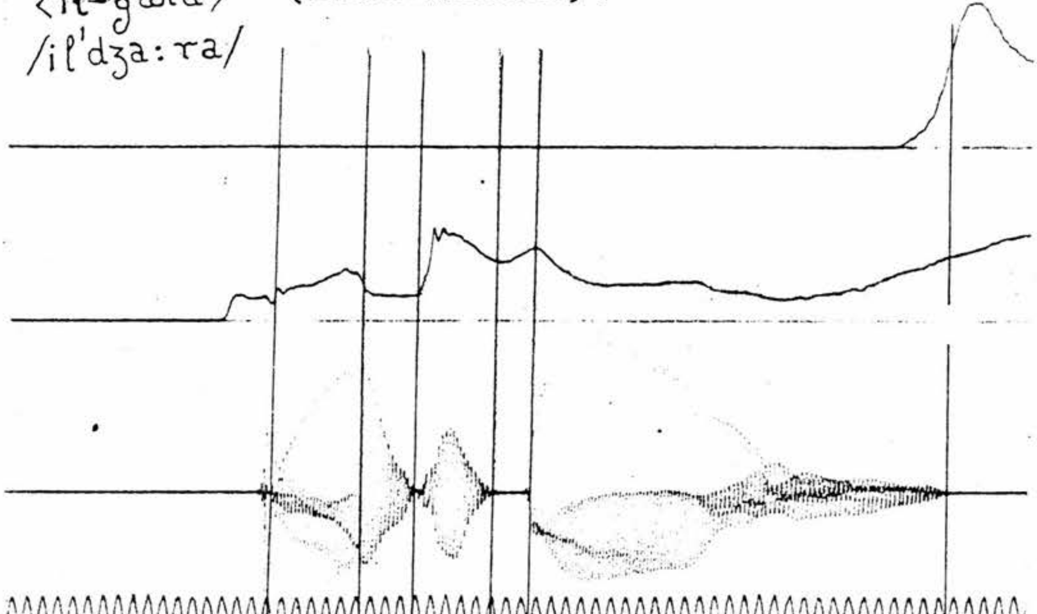


G.2.3. Electrokymograms 13 to 17 show four different occurrences of the affricate /dʒ/. They illustrate varying degrees (and duration) of voicing during the stop and the fricative phases.

EKG. 13.
<iġegħelni> (decontextualised)
/i'dʒe:lni/



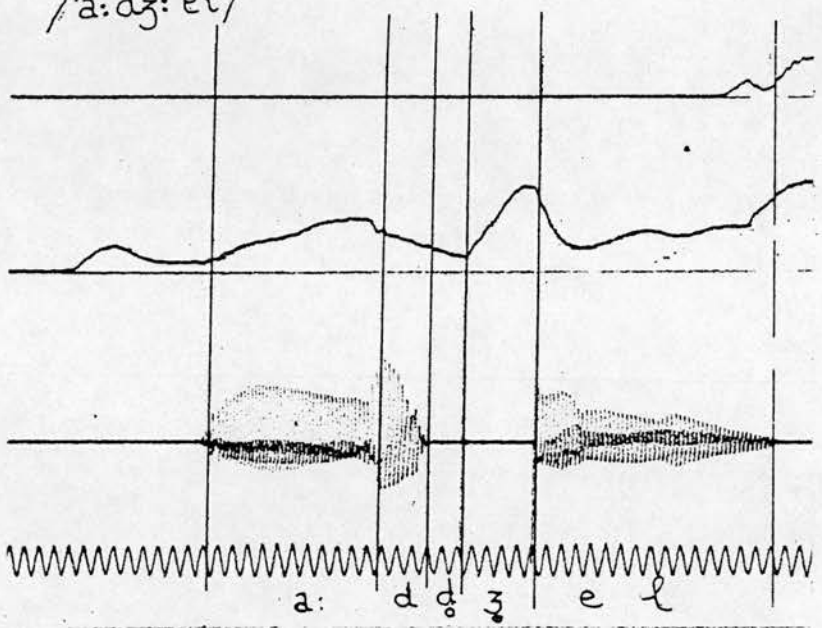
EKG. 14.
<il-ġara> (decontextualised)
/il'dʒa:ra/



EKG. 15

<għaġġel> (decontextualised)

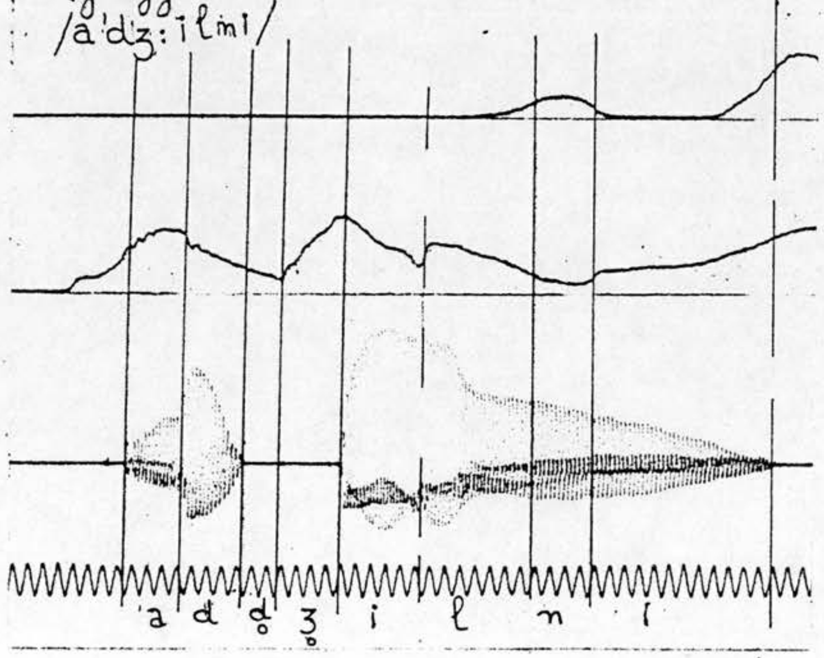
/'a:dʒ:el/



EKG. 16.

<għaġġilni> (decontextualised)

/a'dʒ:ilni/



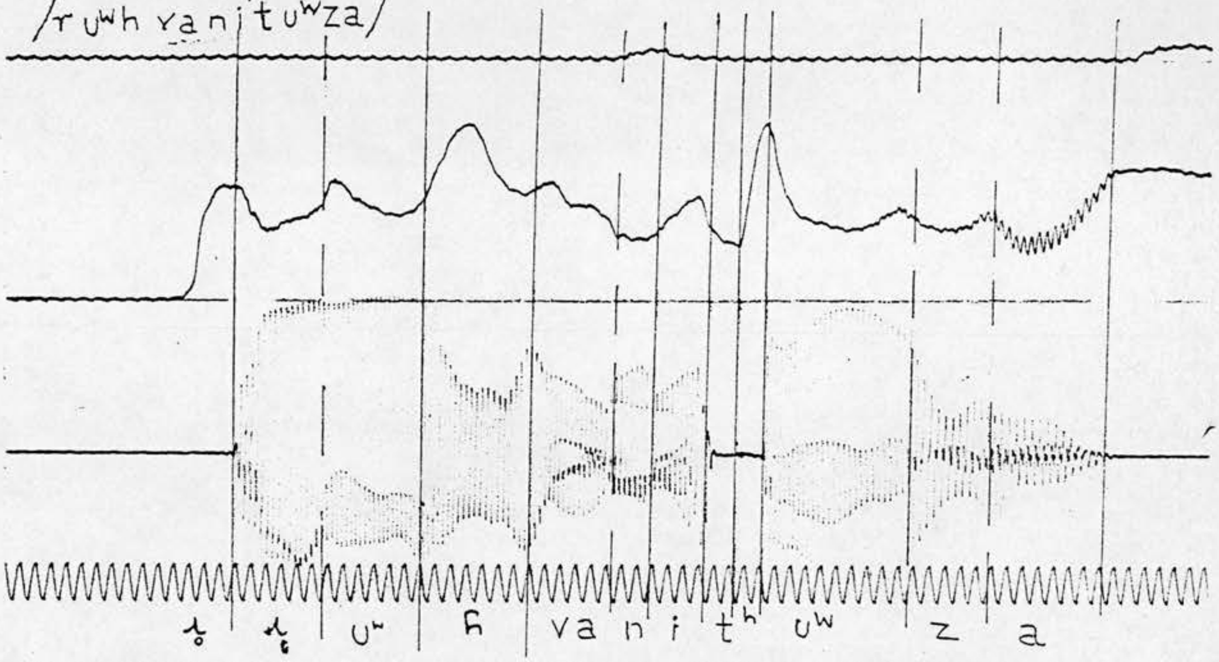
G.2.4. Voicing Harmony.

(a) Electrokymograms 17 and 18 illustrate two occurrences of /h/ realized as voiced.

EKG. 17

<ruħ vanituża> (decontextualised)

/ruʷh ɣanituʷza/



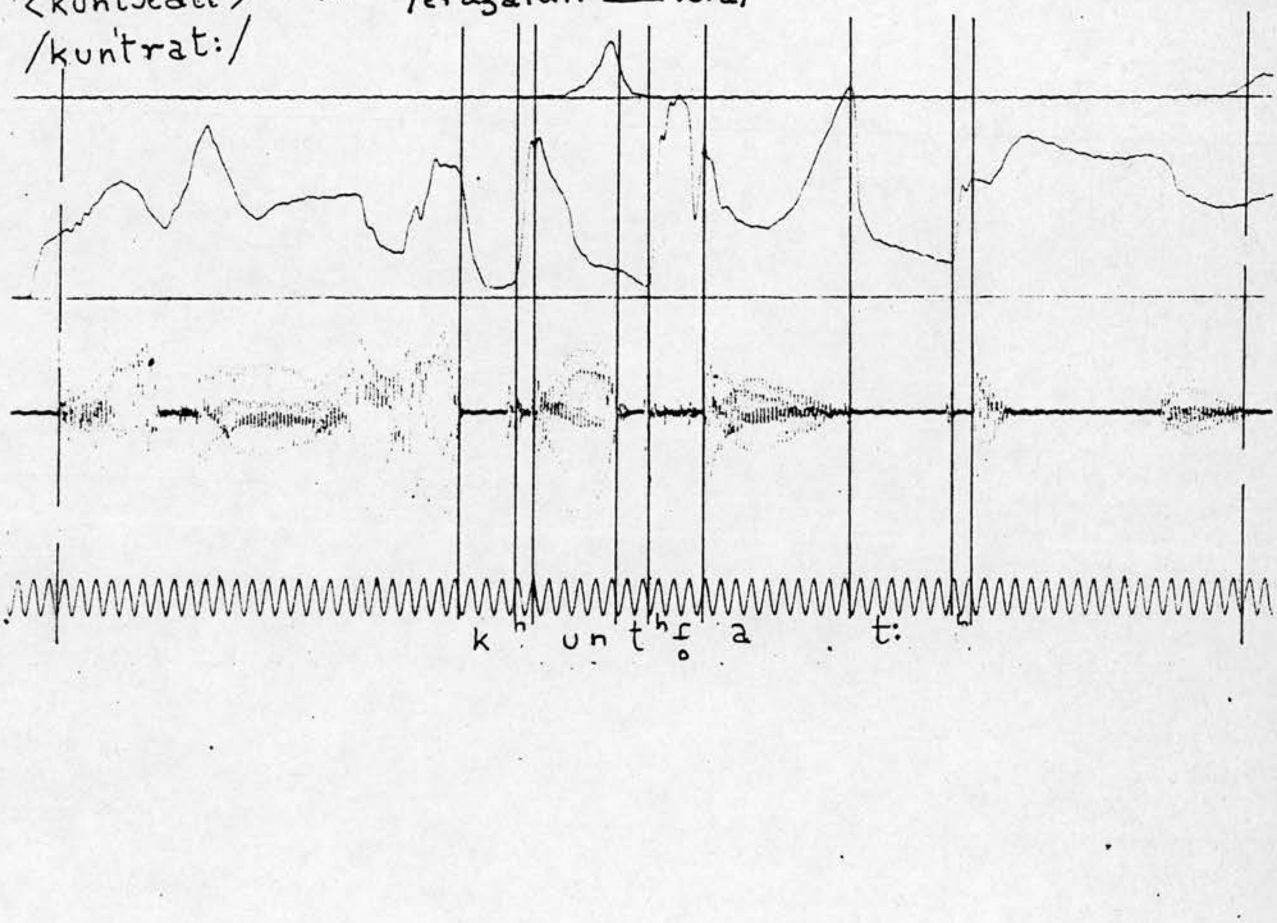
EKG. 18

<taħ żarbun> (decontextualised)

/tah zarbuʷn/

(b) Electrokymogram 19 illustrates one occurrence of /r/ realized as voiceless [ɾ̥].

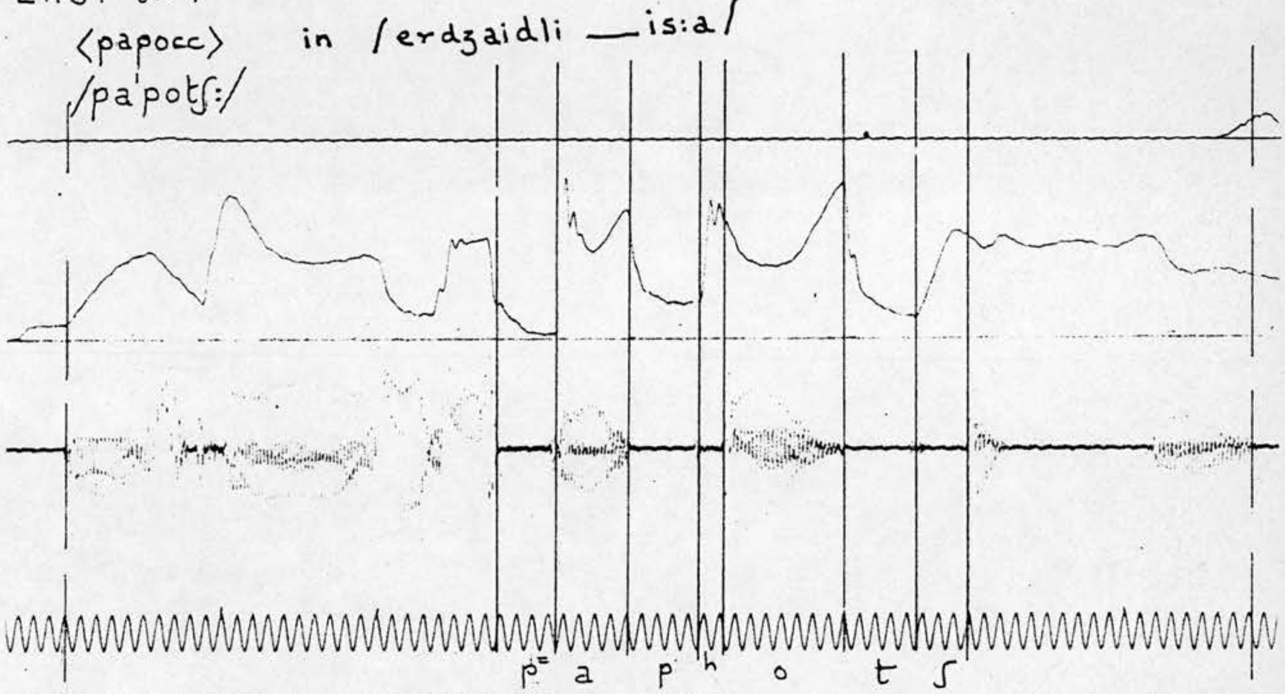
EKG. 19
<kuntratt> in /erdzaidli — is:a/
/kun'trat:/



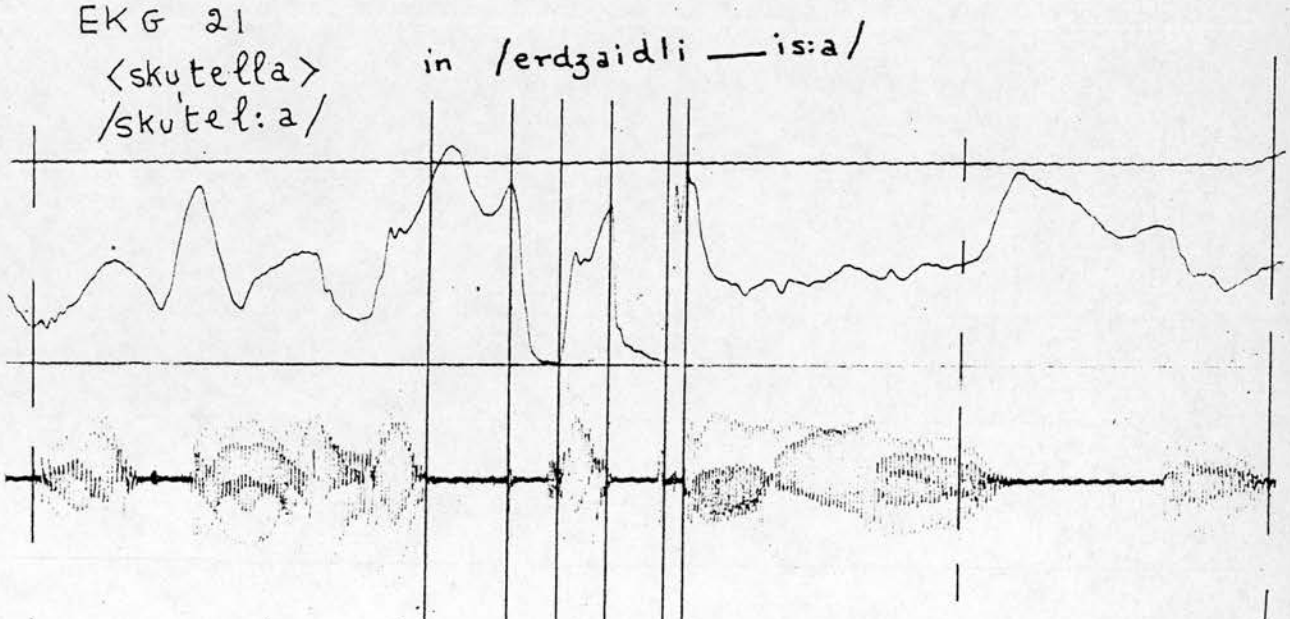
G.2.5. Aspiration of /p/, /t/ and /k/.

(a) Electrokymograms 20 to 21 illustrate two atypical examples of unaspirated plosives.

EKG. 20.

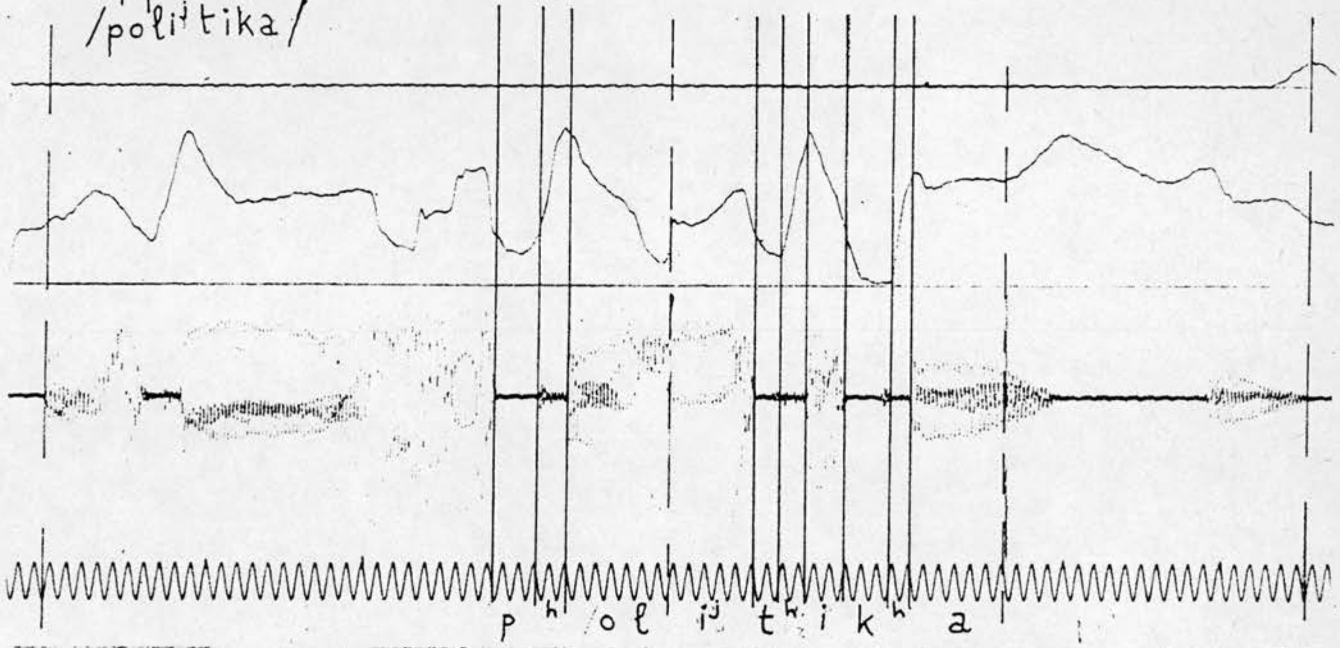


EKG 21



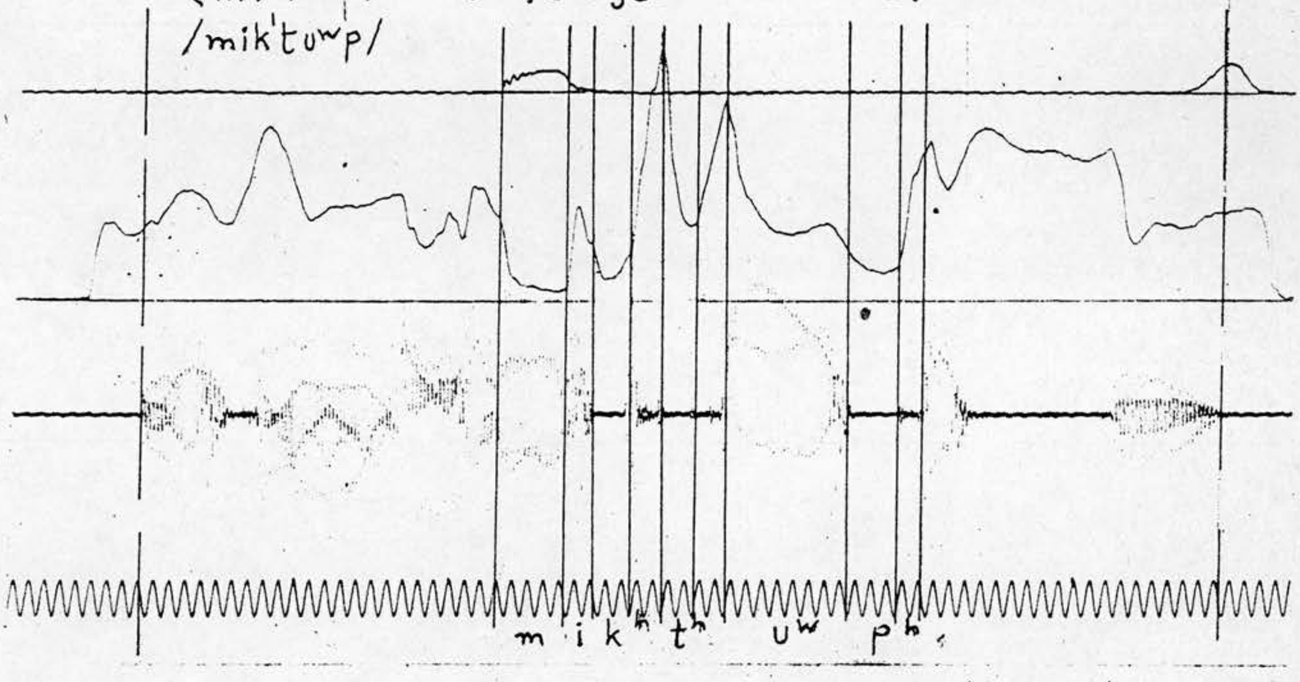
(b) Electrokymograms 22 to 30 illustrate aspiration of /p/, /t/ and /k/ in word-initial, word- medial and word-final position.

EKG 22
<politika> in /erdʒaidli — is:a/
/po'li'tika/

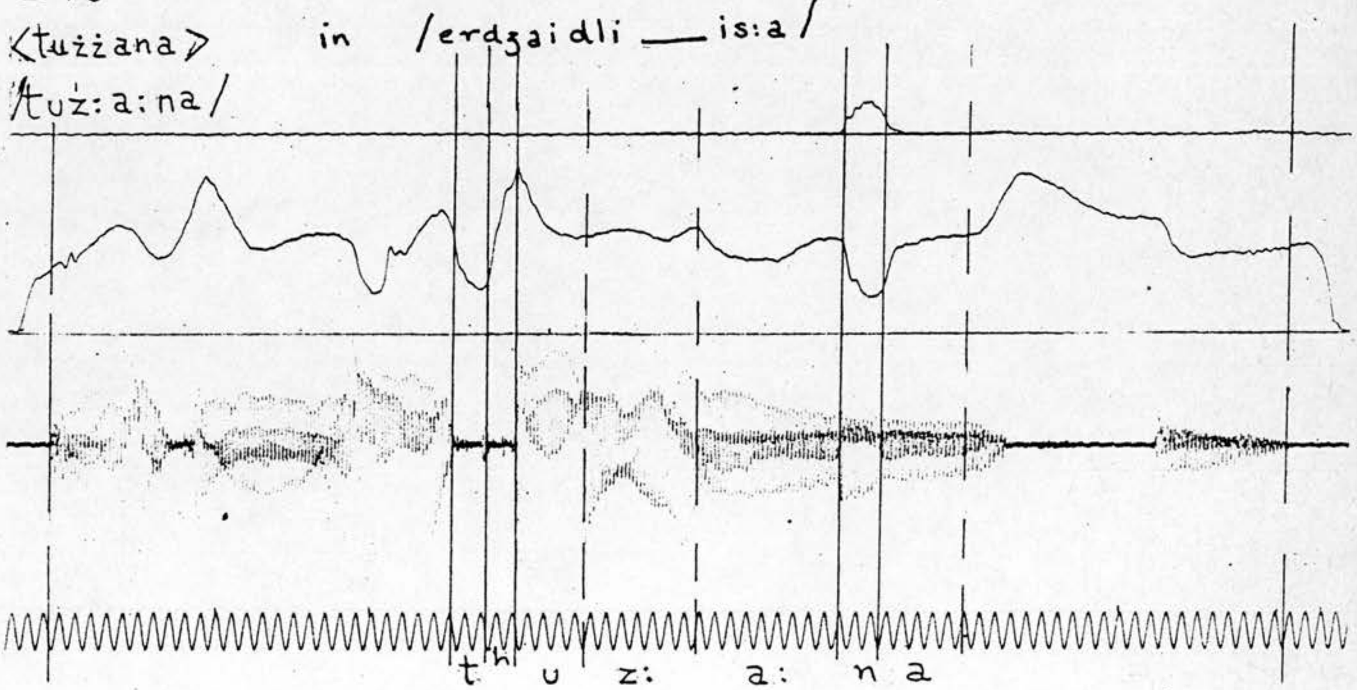


EKG 23
<xkupa> in /erdʒaidli — is:a/
/ʃkuʷpa/

EKG 24
<miktub> in /erdzaidli — is:a/
/mik'tuwp/



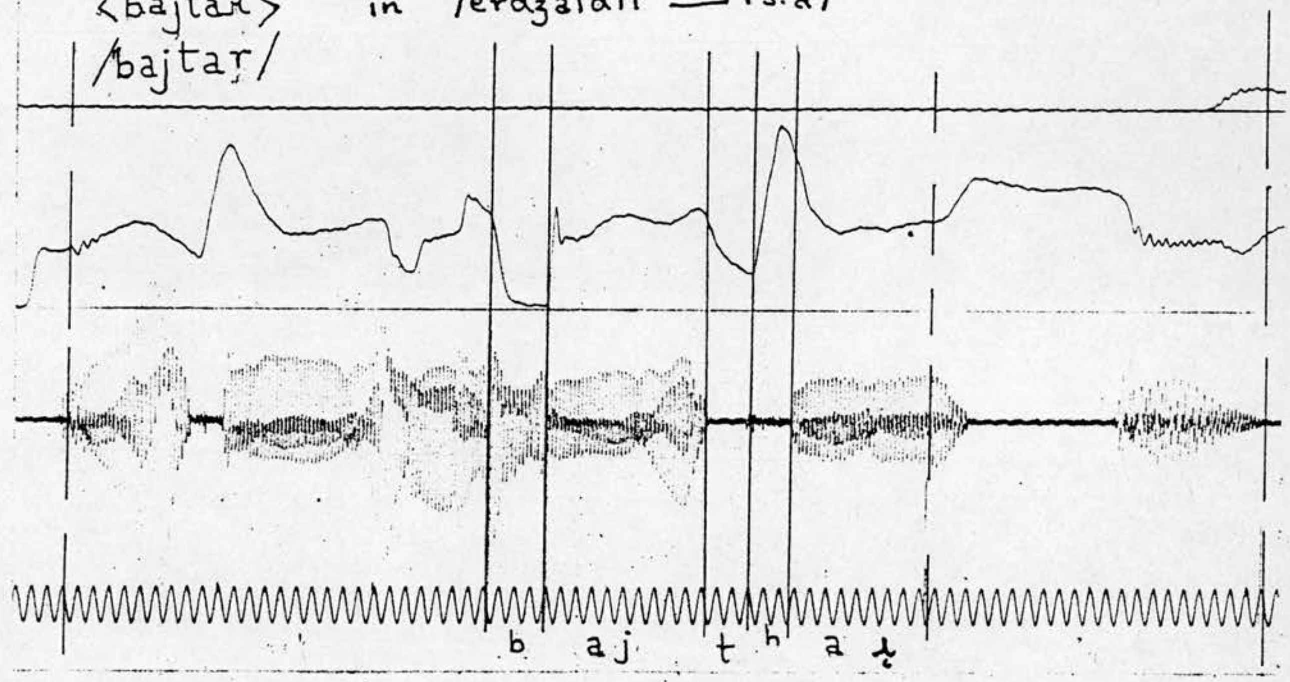
EKG. 25.
<tużżana> in /erdzaidli — is:a/
/tuż:a:na/



EKG 26

<bajtaɹ> in /erdʒaidli — is:a/

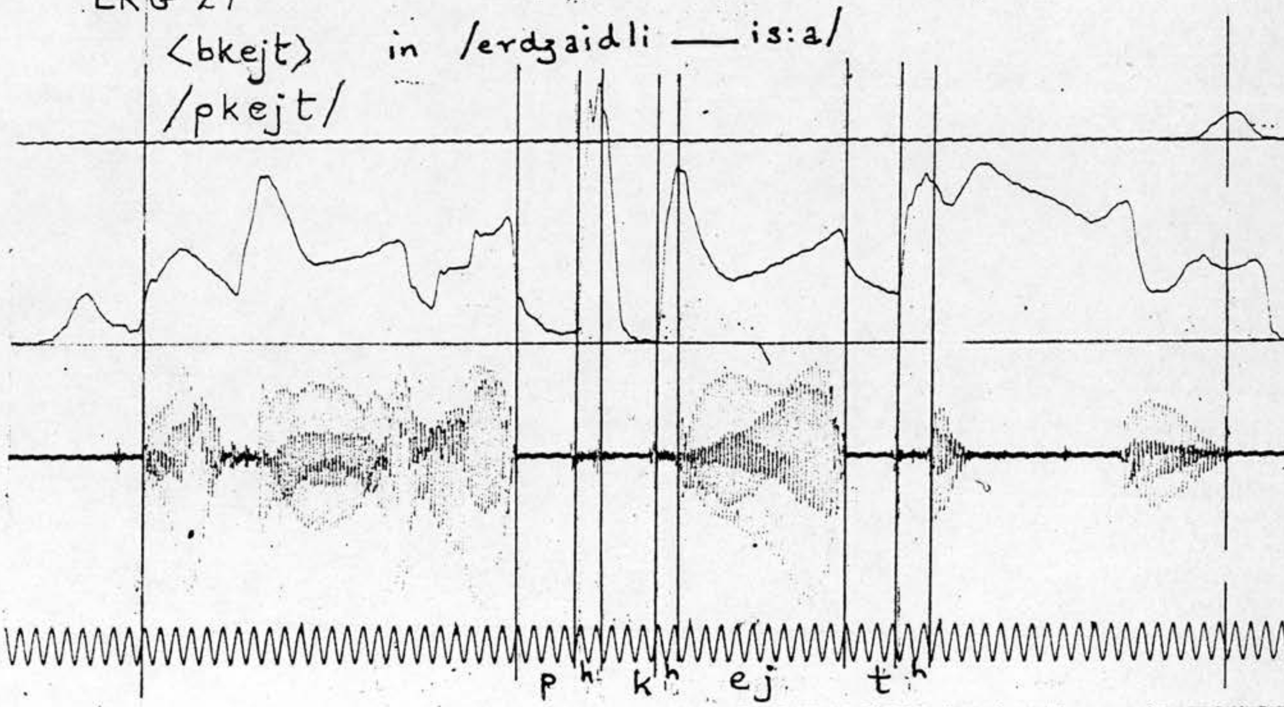
/bajtaɽ/



EKG 27

<bkejt> in /erdʒaidli — is:a/

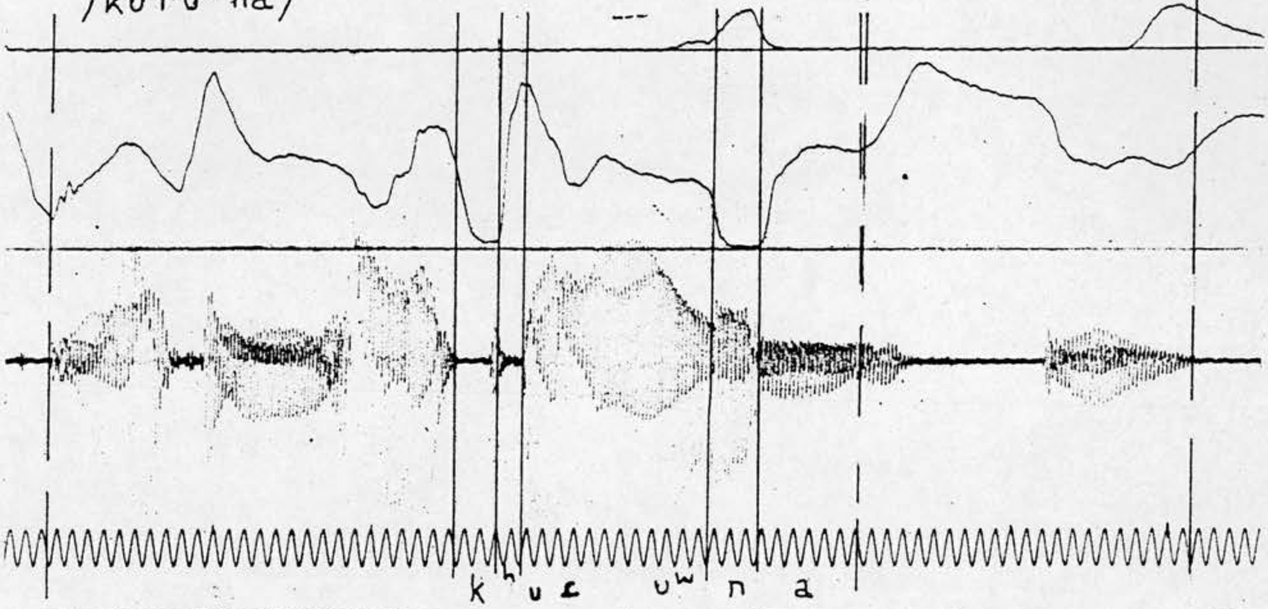
/pkejt/



EKG 28

<kuɹuna> in /erdʒaidli ___ is:a/

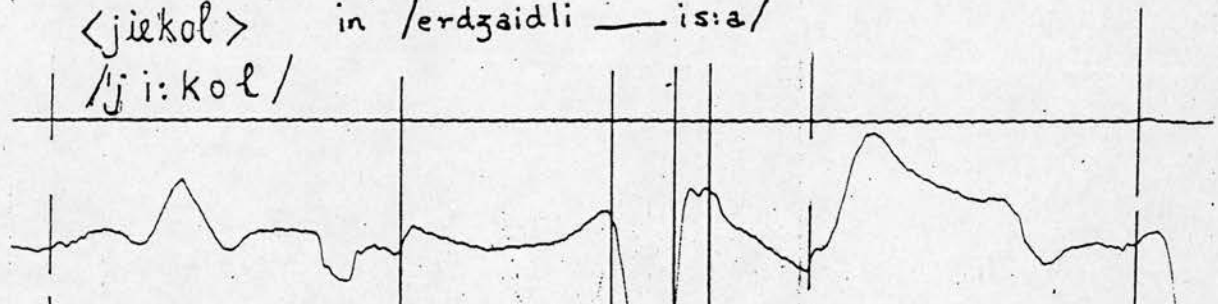
/ku'ɾuʷna/



EKG 29

<jiekol> in /erdʒaidli ___ is:a/

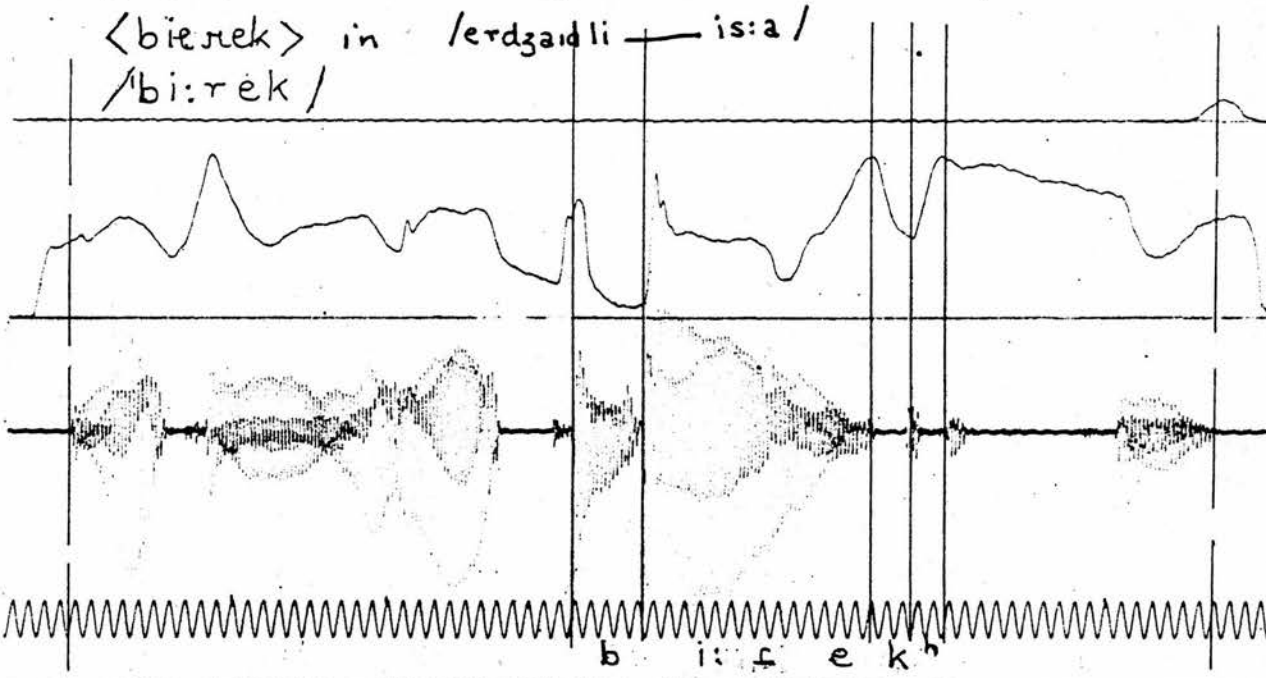
/'ji:koɫ/



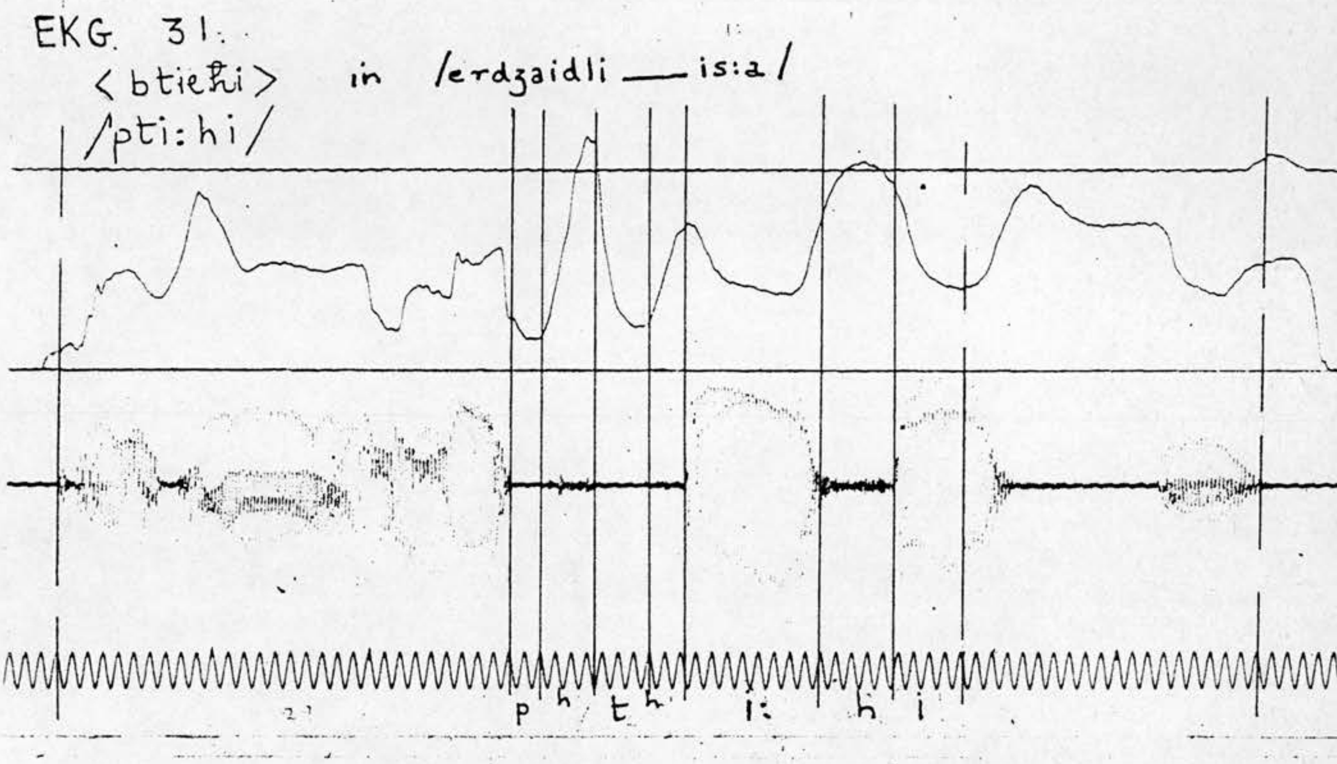
EKG. 30.

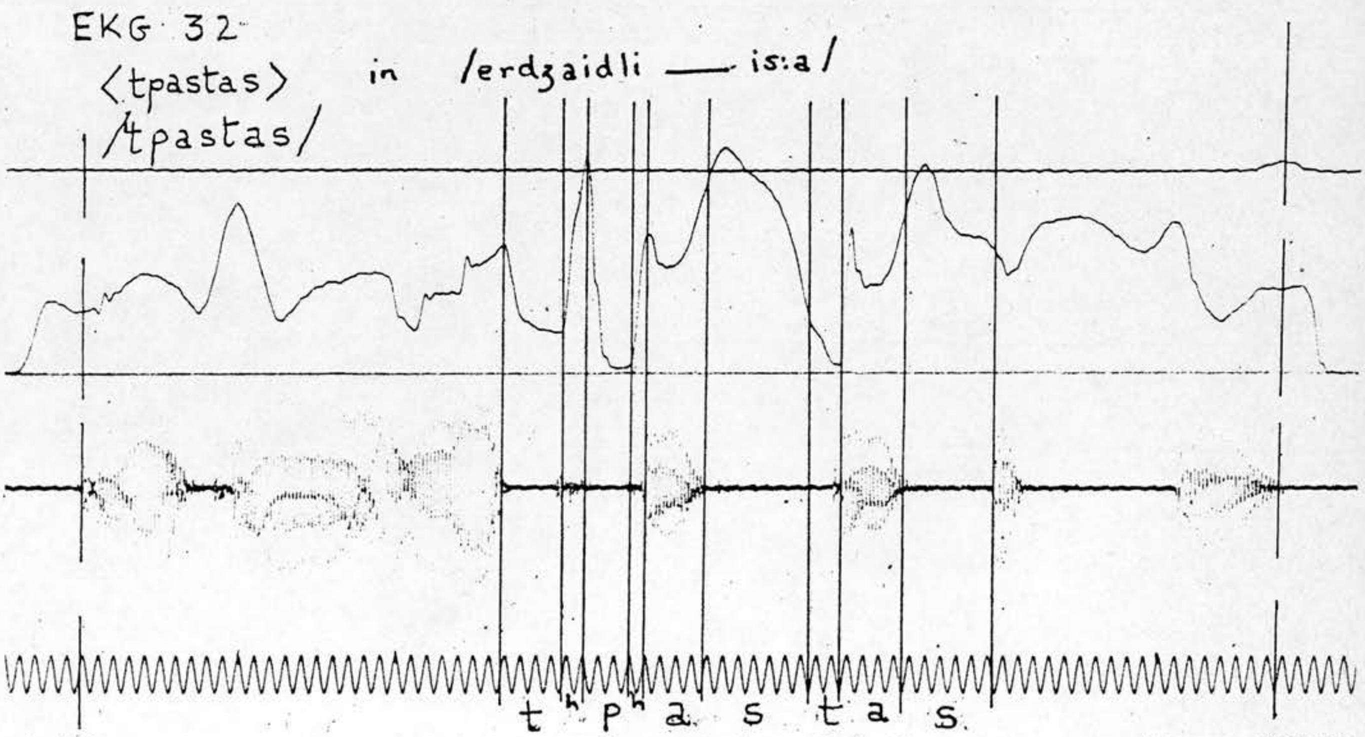
<bieɹek> in /erdʒaidli — is:a/

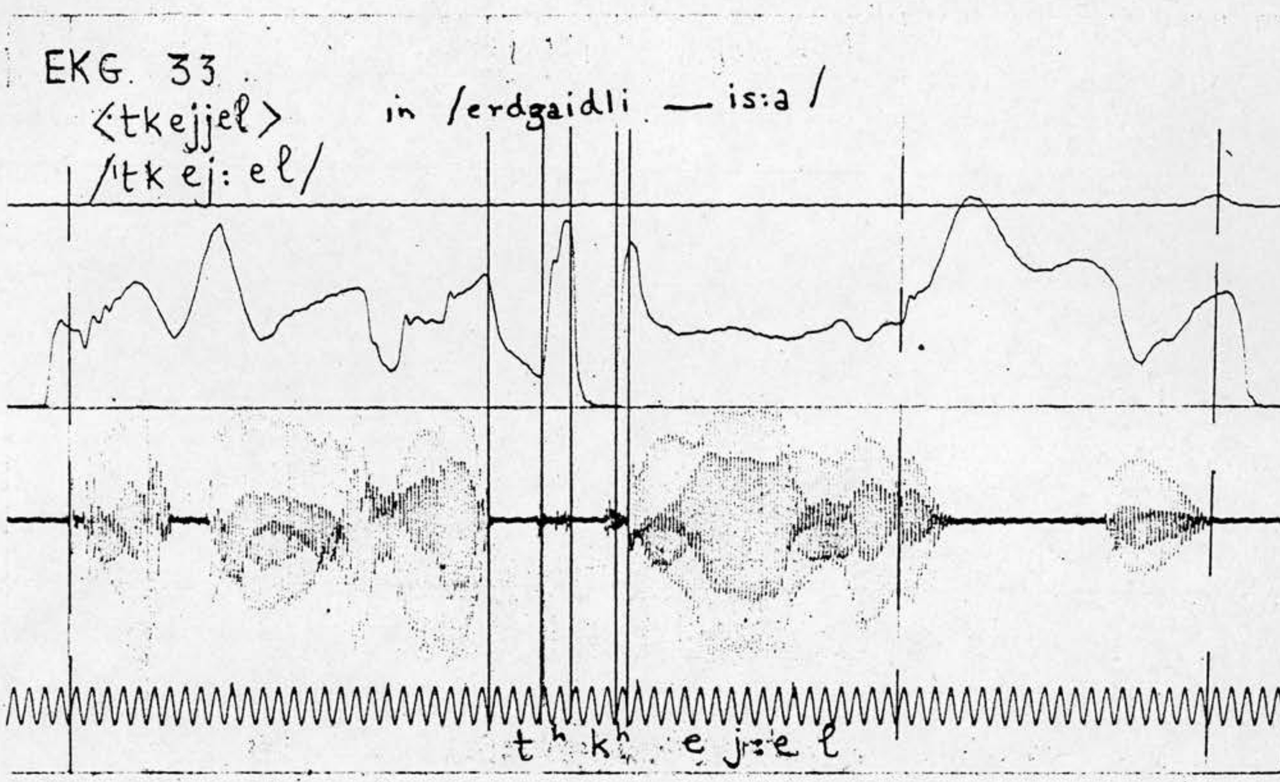
/ˈbi:rek/

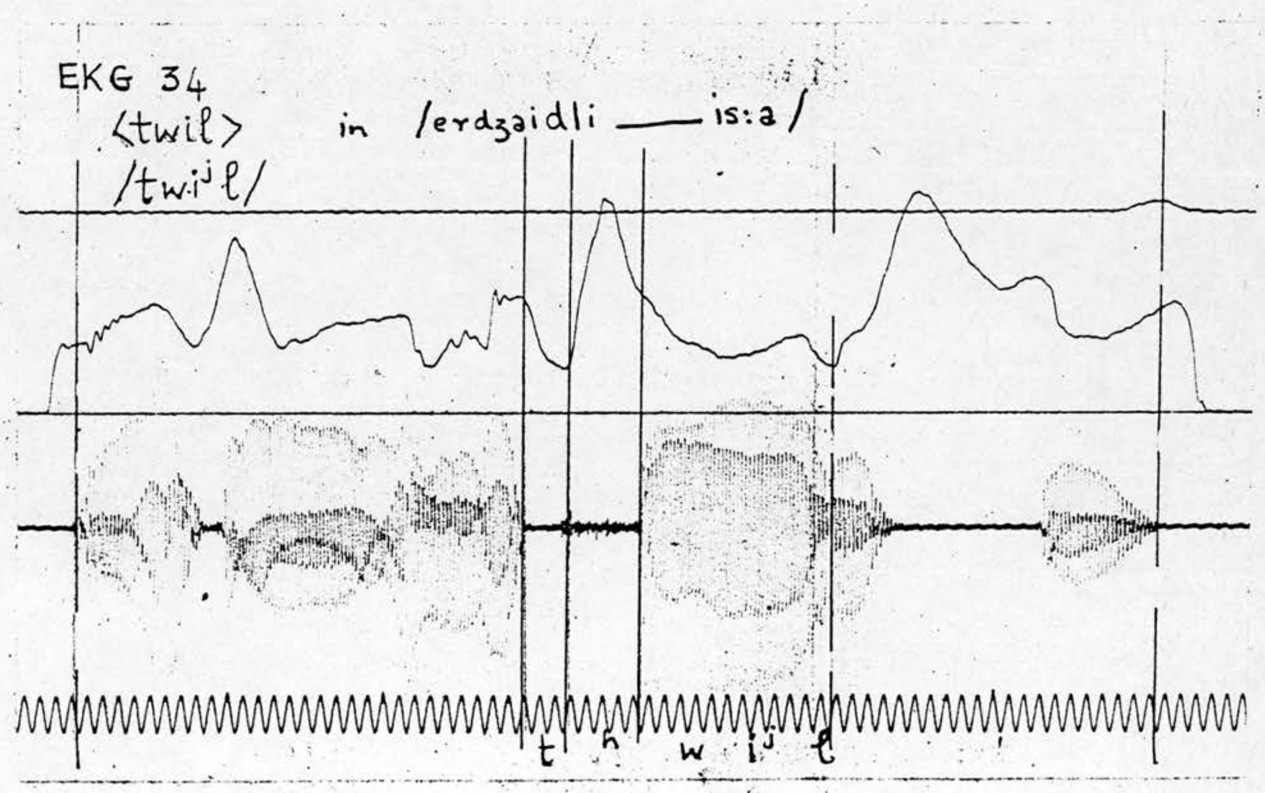


(c) Electrokymograms 31 to 34 illustrate the plosion/aspiration of /p/, /t/ and /k/ when these consonants are the first or second element in a releasing cluster





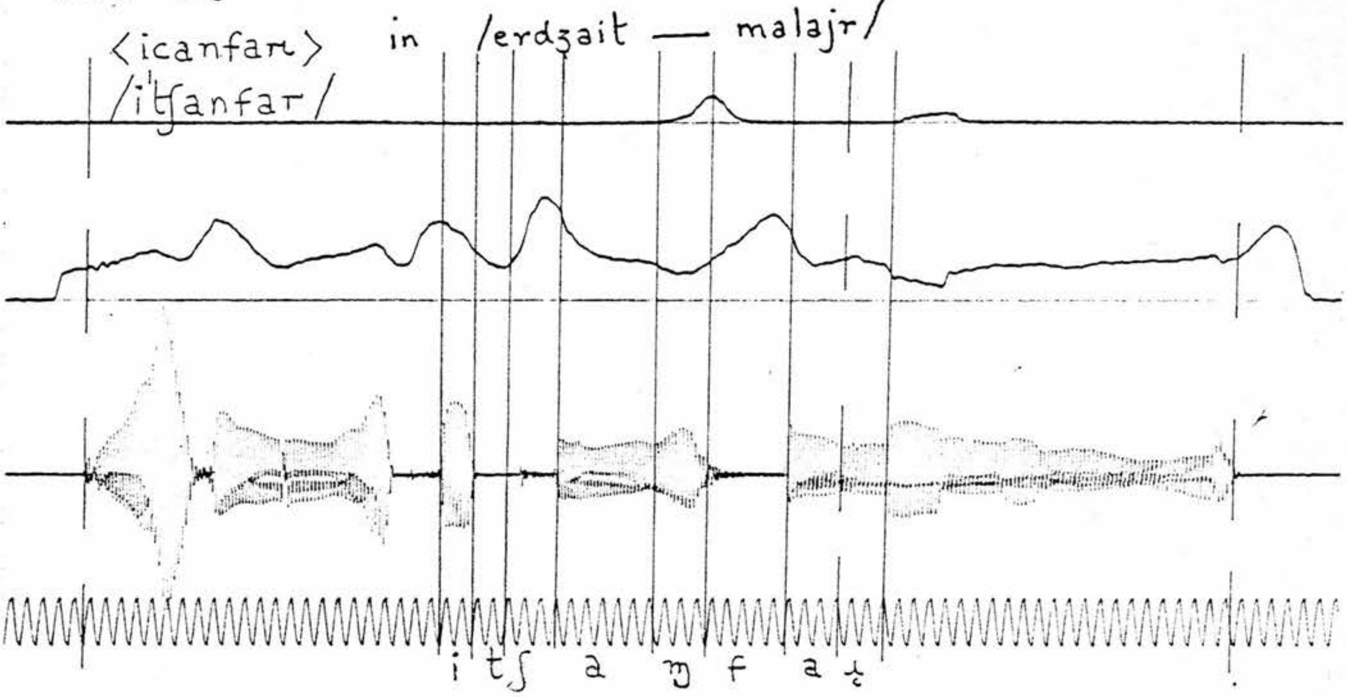

EKG 33
<tkejjel> in /erdʒaidli — is:a/
/ˈtk ej: el/
tʰ kʰ e j:e l


EKG 34
<twil> in /erdʒaidli —— is:a/
/twiʲl/
t ʰ w iʲ l

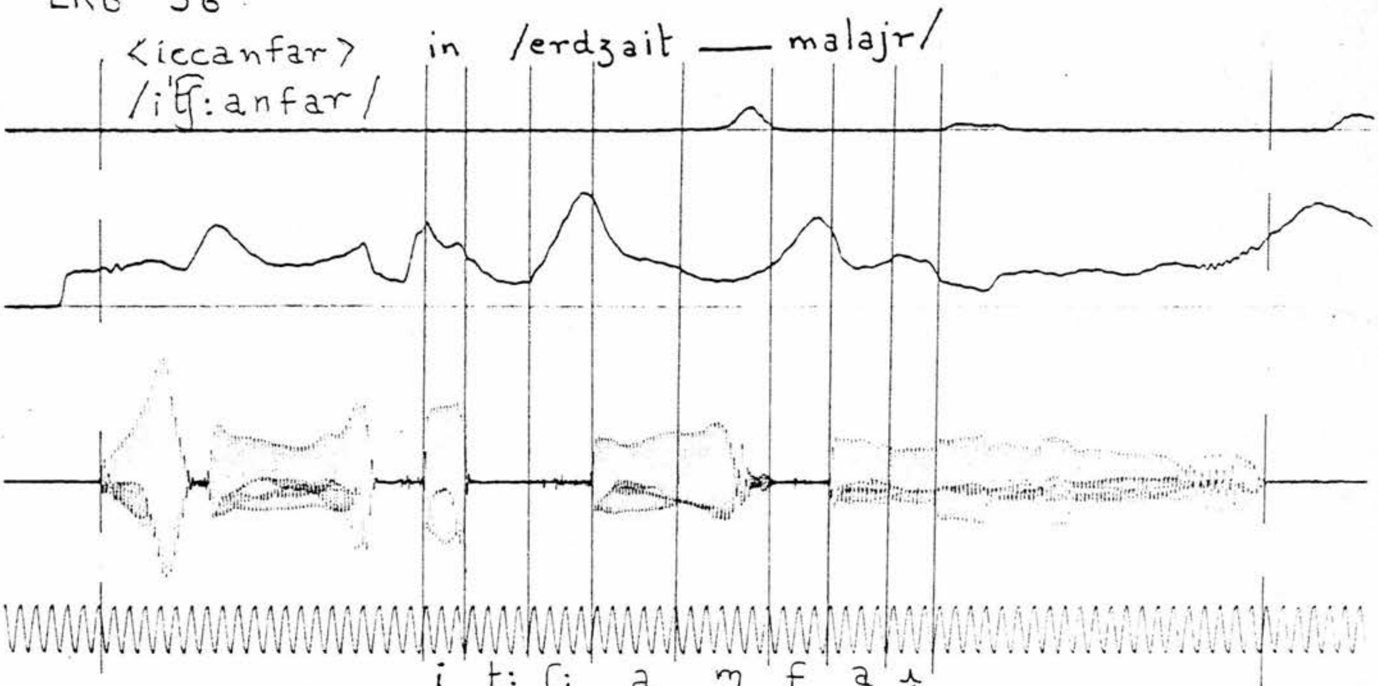
G. 3. Consonant Duration.

Electrokymograms 35 to 38 illustrate the contrast between /tʃ/ occurring as a single consonant, and /tʃ/ occurring as a geminated consonant.

EKG 35



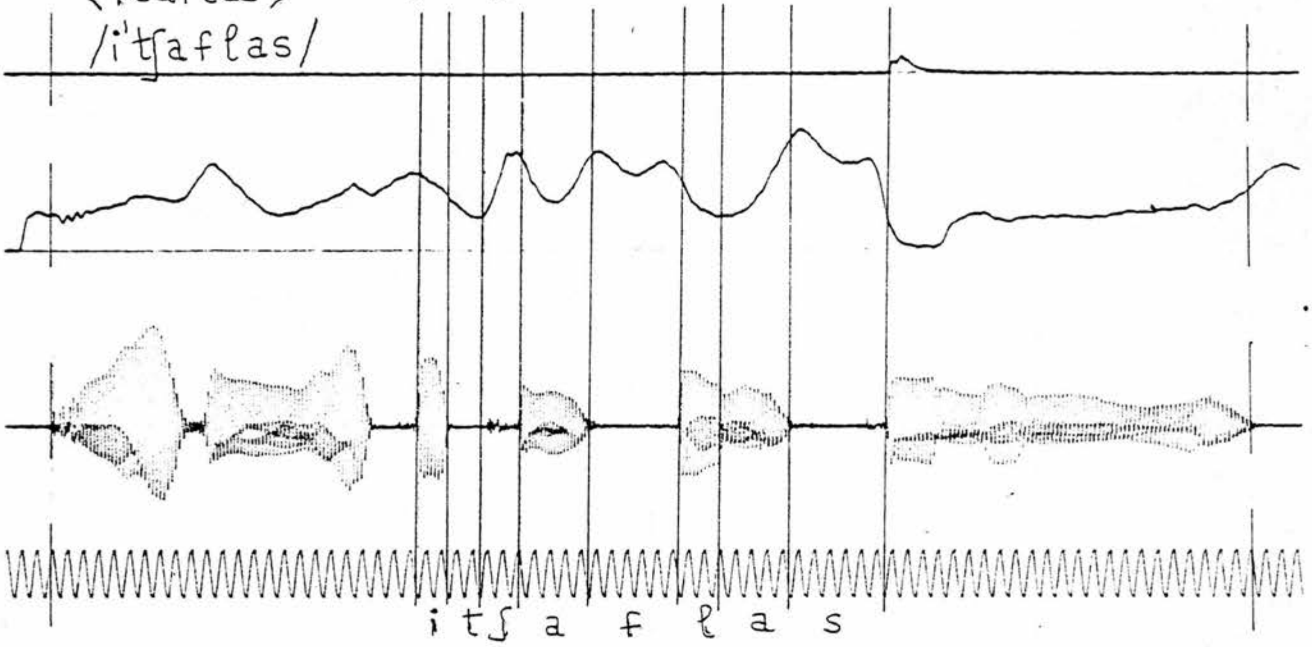
EKG 36



EKG 37

<icaflas> in /erdʒait — malajr/

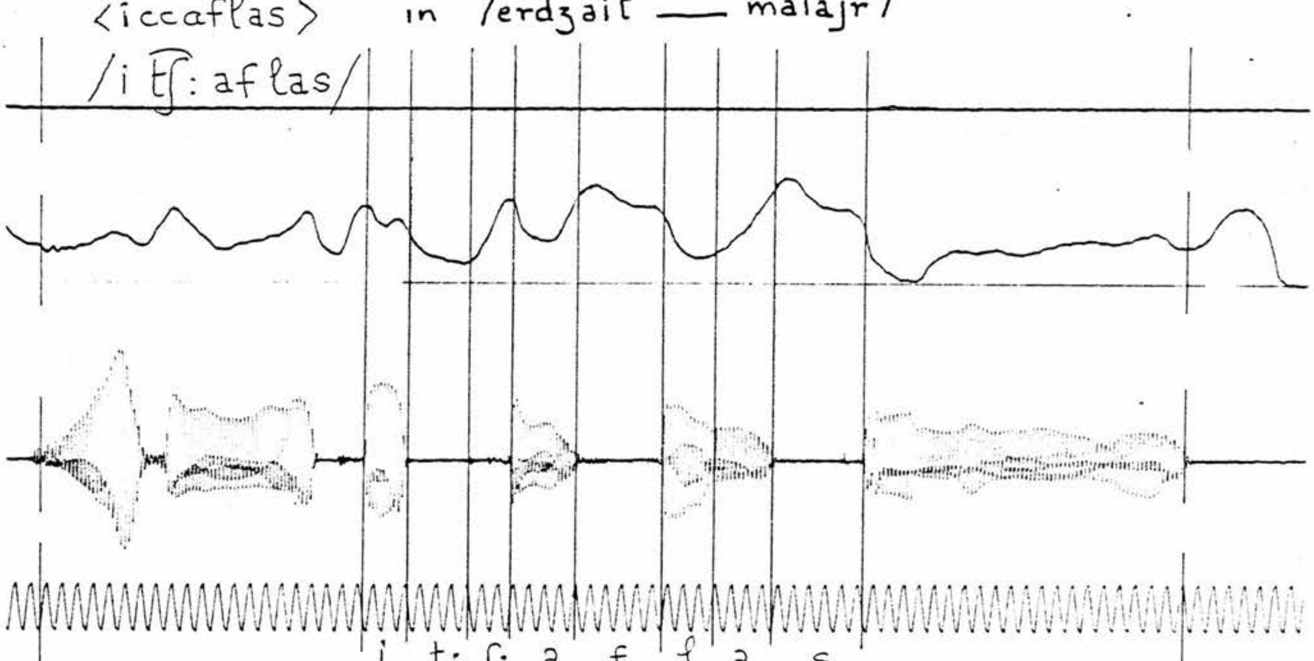
/i'tʃaflas/



EKG. 38

<iccaflas> in /erdʒait — malajr/

/i t͡ʃ: aflas/



APPENDIX H

Appendix H

Data for the Study of Visual Patterns:

This Appendix consists of charts containing the measurements in millimetres of various dimensions of the lip parameters studied in Chapter 12 and converted to graph form there. The dimensions (e.g. EE, EA, etc.) are explained in Chapter 12. The measurements are given for both Informants A and B (under columns o and x respectively). The measurements are taken from the visiograms made for the study of prolonged articulation. The sound prolonged in each case appears in the left hand column. The average for each sound class appears at the end after the examples of that particular sound class have been presented.

Figure H 1.1 shows the measurements for the vowel examples. Figure H 1.2 shows the measurements for the examples of the consonants as syllable-releasing single consonants. Figure H 1.3 and Figure H 1.4 show the measurements for the consonants in CC clusters as C_1 and as C_2 respectively. Figure H 2 shows the deviation from the neutral position for each dimension for each speaker. The measurements for the neutral dimensions appear at the top of Figure H 2. Thus, for example "EE = +2" means that the measurement is 2 mm. more than the measurement for EE when the speaker's lips are in "neutral rest" position.

V

FIGURE H.1.1 (p.1) Measurements in mm. along the parameters studied for Informant A (shown as O) and Informant B (shown as X). The segment studied appears in the left hand column.

Segment Studied	Context	EE O	EE X	EA O	EA X	AA O	AA X	AX O	AX X	XB O	XB X	BB O	BB X	BE O	BE X	CC O	CC X	YY O	YY X	HD1 O	HD1 X	HD2 O	HD2 X	DD O	DD X	ZD1 X	ZD2 X	ZH X
/i/	pipistrel	77	63 / 62	35	32 / 30	6	4 / 4	6	5 / 7	4	1 / 2	11	11 / 11	15	10 / 8	55	43 / 44	39	29 / 30	23	19 / 20	17	16 / 17	24	20 / 23	25 / 24	44 / 44	38 / 38
/i/	ʃini	78	57	34	26	6	4	10	9	4	4	11	10	13	4	57	41	43	26	22	17	16	16	26	26	21	46	39
/i/	'ikel	78	61	35	30	6	4	6	6	4	2	11	10	16	9	54	45	45	33	24	20	18	18	24	23	23	46	38
bi	Average	78	61	35	30	6	4	7	7	4	2	11	11	15	8	55	43	42	30	23	19	17	17	25	23	23	45	37
/iː/	biːp	77	63	34	30	6	4	7	7	3	2	11	11	16	9	55	45	47	32	24	22	18	17	24	23	25	44	40
/iː/	im'ʃiːt	79	58	33	27	7	3	12	10	5	4	10	9	12	5	58	42	38	29	23	19	17	17	28	27	22	48	35
/iː/	'iː kol	79	62	35	30	5	5	9	6	4	1	10	11	16	9	56	44	46	34	24	19	18	17	24	24	22	46	37
biːa	Average	78	61	34	29	6	4	9	8	4	2	10	10	15	8	56	44	44	32	24	20	18	17	25	25	23	46	37
/iˀ/	'piˀpa	73	63	35	29	6	4	6	8	4	1	11	12	15	9	56	47	40	33	20	22	17	17	23	24	23	47	39
/iˀ/	tme'ʃiˀja	79	59 / 63	34	25 / 27	6	3 / 2	12	14 / 14	4	3 / 2	11	10 / 12	12	4 / 6	58	42 / 42	44	27 / 33	23	19 / 20	17	17 / 18	28	29 / 26	21 / 23	49 / 49	36 / 38
/iˀ/	'iˀdi	79	61	34	31	6	4	9	6	4	1	11	10	15	9	56	46	42	30	23	18	18	18	25	21	24	45	36
biˀa	Average	77	61	34	28	6	3	9	10	4	2	11	11	14	7	57	44	42	31	22	20	17	18	25	25	23	48	37
/e/	be'tːiːh	80	63	35	30	7	4	9	8	4	2	11	11	14	8	56	45	46	37	25	24	18	20	27	27	25	51	42
/e/	'ʃedaʔ	83	63	34	27	5	2	14	17	4	4	11	10	15	3	56	41	45	27	25	22	19	19	29	32	23	54	40
/e/	eˀːaːla	82	65	35	31	6	4	11	8	4	2	11	11	15	9	53	43	45	36	24	21	18	19	27	24	24	48	40
bea	Average	82	64	35	29	6	3	11	11	4	3	11	11	15	7	55	43	45	33	25	22	18	19	28	28	24	51	41
/eː/	beːtni	81	62	35	31	6	4	9	7	3	2	11	11	17	8	56	45	46	36	25	24	19	19	26	25	26	51	43

FIGURE H 1:1 (p.2)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		H D$_1$		H D$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/e:/	'ʃe:reʔ	84	63	34	29	6	4	15	10	4	2	11	11	14	7	55	43	45	28	26	20	20	18	29	25	24	48	38
/e:/	'e:ri	86	64	35	31	5	4	15	8	4	1	11	11	16	9	54	45	45	36	25	21	19	18	30	24	25	49	41
	Average	84	63	35	30	6	4	13	8	4	2	11	11	16	8	55	44	45	33	25	22	19	18	28	25	25	49	41
/a/	bat:	79	68	35	31	7	5	7	9	3	3	11	11	16	9	55	43	43	34	24	25	17	19	24	29	25	54	44
/a/	ʃat:	84	61	34	26	5	4	17	14	5	4	10	10	13	3	55	41	44	28	25	21	18	20	32	30	22	52	38
/a/	an'ti:k	81	67	34	30	6	5	11	11	5	2	10	11	15	8	54	37	43	43	24	23	18	19	26	29	24	52	42
	Average	81	65	34	29	6	5	12	11	4	3	10	11	15	7	55	40	43	35	24	23	18	19	27	29	24	53	41
/a:/	ba:l	79	68	35	29	5	4	9	13	3	3	11	11	16	8	54	43	46	36	25	25	18	21	25	30	24	54	44
/a:/	'ʃa:laʔ	84	67	33	29	6	5	17	16	5	3	10	10	13	6	55	43	43	30	25	22	18	20	32	31	23	53	39
/a:/	'a:ni	81	64	35	30	5	4	11	9	4	2	10	11	16	8	55	44	43	35	24	22	18	19	27	26	24	50	41
	Average	81	66	34	29	5	4	12	13	4	3	10	11	15	7	55	43	44	34	25	25	18	20	28	29	24	52	41
/o/	bot:	80	64	32	29	6	4	16	7	5	4	10	11	11	6	52	39	28	22	22	18	16	15	32	26	24	48	36
/o/	ir'ʃoʃta	75	55	33	26	7	4	7	9	4	5	12	9	12	4	57	41	33	21	21	18	14	14	24	25	20	44	55
/o/	'ot:u	83	59	30	28	8	6	19	5	6	3	9	11	11	6	48	40	24	24	24	18	17	25	36	23	23	46	37
	Average	79	58	32	28	7	5	14	7	5	3	10	10	11	5	52	40	28	22	22	18	16	18	31	25	22	46	35
/o:/	bo:t	76	57	34	24	6	5	6	5	3	4	12	10	15	5	55	38	31	22	21	18	15	14	23	25	22	46	35
/o:/	ʃo:l	76	55 58	32	25 27	7	5 5	8	6 7	5	4	10	10 10	14	5 6	46	40 42	34	19 19	21	16 17	15	13 14	25	23 25	21 19	43 44	32 33

FIGURE H 1.1 (p.3)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	Y
/o:/	'o:tja	81	61	31	29	7	6	16	4	5	3	10	12	12	7	49	39	25	17	22	18	17	14	32	22	24	46	38
/o:/	Average	78	58	32	27	7	5	10	6	4	4	11	11	14	6	50	40	30	19	21	17	16	14	27	24	22	45	35
/u/	bu't:uʷna	71	56	32	28	8	5	5	0	7	3	9	11	10	7	54	39	26	8	19	16	12	12	24	21	23	43	34
/u/	irʃu'ʃta:	73	54 56	35	26 27	8	4 6	4	4 3	5	4 3	10	11 11	13	5 6	56	39 41	22	17 15	19	16 16	12	13 15	23	24 24	20 21	42 45	31 32
/u/	uz'a:h	78 76	58	33 31	29	11 10	7	4 8	2	6 6	3	12 10	11	13 10	6	49 50	40	14 21	9	18 20	16	14 14	14	26 29	22	23	45	36
/u/	Average	75	56	32	28	9	6	5	2	6	3	10	11	12	6	52	40	21	12	19	16	13	13	26	23	22	44	33
/uʷ/	buʷt	73	56	33	28	9	6	5	0	5	4	10	11	11	7	49	38	20	0	19	17	13	13	26	21	24	44	34
/uʷ/	'ʃuʷʃa	73	56	33	26	9	7	2	0	5	4	11	12	13	6	54	37	18	0	19	16	11	13	21	23	23	45	34
/uʷ/	'uʷza	77	60	33	28	10	7	4	1	8	2	10	13	12	8	46	41	15	5	19	17	12	13	25	23	23	45	36
/uʷ/	Average	74	57	33	27	9	7	4	0	6	3	10	12	12	7	50	39	18	2	19	17	12	13	24	22	23	45	35

FIGURE H 1.2 (p.1)

Cv

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	Y
/p/	pi'tats	74	59	43	31	2	5	0	0	0	0	5	11	24	12	58	44	0	0	17	15	16	14	6	15	27	41	37
/p/	'pi:na	79		42		4		0	0	0	0	8		25		55		0		16		14		10				
/p/	'pi'pa	72	57	39	31	5	4	0	0	0	0	9	9	19	13	59	46	0	0	18	14	17	14	11	14	27	41	35
/p/	'pepe	71	58	37	31	5	5	0	0	0	0	7	10	21	12	53	45	0	0	18	15	15	13	10	14	27	40	36
/p/	'pe:pe	75	58	39	30	5	6	0	0	0	0	9	10	22	12	54	46	0	0	17	16	16	14	11	14	27	40	36
/p/	pa'pa	76	57	42	31	4	5	0	0	0	0	8	10	22	11	55	43	0	0	18	15	16	14	11	14	26	40	35

FIGURE H 1.2 (p.2)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD₁		HD₂		DD		ZD₁	ZD₂	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/p/	'pa:pa:	71	58	38	31	5	5	0	0	0	0	9	11	19	11	59	44	0	0	19	15	17	15	12	17	27	43	36
/p/	'pop:a	78	56	38	30	8	5	0	0	1	0	12	11	19	10	46	44	0	0	17	15	13	14	18	16	24	40	34
/p/	'po:plu	78	58	38	30	9	5	0	0	4	0	11	13	16	10	45	43	0	0	17	15	12	13	20	17	24	41	35
/p/	pu'pats	71	57	34	29	10	6	0	0	4	0	11	11	11	11	44	44	0	0	17	15	11	13	21	16	25	41	35
/p/	'pu~pa	73	58	34	30	10	7	0	0	3	0	12	12	13	9	45	40	0	0	18	16	11	15	22	18	24	43	36
pp	Average	74	58	39	30	6	5	0	0	1	0	9	11	19	11	52	44	0	0	17	15	14	14	14	14	26	41	36
/w/	'twi'la	75	60 62	33	29 32	11	8 7	1	1 0	6	4 7	11	10 13	13	8 10	43	38 41	2	3 0	20	15 14	11	12 12	24	23 20	21 24	43 44	33 35
/w/	'we:dni	77	63	35	31	10	8	1	0	6	4	12	12	13	8	43	39	2	0	19	19	11	15	25	23	25	47	38
/w/	is:'wa:li	74	64	33	31	10	8	1	1	6	4	11	11	13	9	44	36	2	2	19	16	11	13	24	22	24	46	36
/w/	'kwo:ta	78	63	35	30	11	8	2	2	7	2	11	12	12	9	41	38	4	7	19	16	12	13	27	23	23	45	36
/w/	'ilwu	79	64	35	31	10	8	1	3	5	3	12	12	16	7	46	38	3	5	19	16	11	14	24	24	23	46	36
pw	Average	77	63	34	31	10	8	1	1	6	4	11	12	15	9	43	38	3	3	19	16	11	13	25	23	23	45	36
/f/	'fi'di	73	58	31	18	6	5	4	2	3	3	11	8	18	12	49	45	19	9	21	17	9	12	22	19	22	41	35
/f/	'fe:m	75	59	32	29	6	5	2	1	2	2	11	10	21	12	51	45	22	9	22	16	11	12	21	17	24	40	35
/f/	'fa:ma	76	59	31	29	7	5	3	2	2	1	12	10	21	12	50	44	23	9	23	16	9	12	22	18	24	41	35
/f/	'fo:ga	75	60	30	29	7	5	3	0	3	3	12	10	20	13	49	43	18	0	23	16	9	12	22	17	23	40	34
/f/	'fu~r	74 72	58	33 30	29	5 10	6	2 1	0	0 6	3	11 11	9	23 14	11	49 49	42	12 13	0	22 18	16	9 12	11	19 23	18	23	41	35

FIGURE H 1.2 (p.3)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		H D$_1$		H D$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
Dʃə	Average	74	59	31	27	7	5	3	1	3	2	11	9	20	12	50	44	18	5	22	16	10	12	22	18	23	41	35
/ʃ/	ʃiᵊt	77	63	31	27	6	4	15	12	5	4	10	9	10	7	55	41	34	26	21	17	17	17	31	28	21	48	34
/ʃ/	ʃe:l	78	62	30	27	7	3	16	12	7	2	8	10	10	8	52	40	28	24	22	18	16	14	31	25	20	44	34
/ʃ/	ʃa:r	77	63	30	27	7	4	15	14	6	3	10	10	9	5	54	41	31	26	22	21	17	19	32	29	20	48	35
/ʃ/	'ʃo:li	77	60	28	26	8	4	18	10	7	3	7	10	9	7	50	41	25	29	23	19	16	15	35	26	20	44	33
/ʃ/	'ʃuʷʃa	76	61	29	28	9	5	13	6	7	4	9	10	9	8	48	40	22	16	22	16	15	13	31	23	21	43	33
Dʃə	Average	77	62	30	27	7	4	15	11	6	3	9	10	9	7	52	41	28	23	22	18	16	16	32	26	20	45	34
/r/	ri:t	80	59	35	29	6	4	10	5	3	1	11	10	16	10	54	45	39	18	22	16	15	14	26	18	24	41	35
/r/	re:ʃ	79	60	34	29	6	4	11	4	3	2	11	11	14	10	52	45	41	19	24	17	17	15	26	20	23	42	34
/r/	ra:t	76	60	32	30	6	4	8	3	4	3	11	10	14	10	51	45	37	22	24	15	15	14	26	19	24	42	35
/r/	ro:za	76	57	30	26	8	4	13	6	6	3	9	9	10	9	48	41	26	19	24	16	14	14	31	19	21	40	32
/r/	ruʷma	71	60	32	29	9	6	3	2	7	3	10	10	10	10	43	44	12	12	18	25	11	14	24	21	23	43	35
Drə	Average	76	59	33	29	7	4	9	4	5	2	10	10	13	10	50	44	31	18	22	18	14	14	27	19	23	43	34
/t/	'ti:tlu	74	58 61	35	29 30	6	4 5	3	4 4	3	2 2	11	11 11	16	8 9	56	45 44	33	31 30	23	18 19	16	16 17	20	19 18	25 25	44 44	37 38
/t/	'te:ma	76	63	35	31	6	5	5	5	3	1	11	11	16	10	55	42	33	35	23	20	16	18	22	22	24	45	38
/t/	'ta:ta	74	59 62	34	29 28	7	4 5	2	5 7	3	2 1	12	11 11	16	9 10	55	44 45	34	33 38	24	19 19	16	11 16	21	21 22	24 23	45 45	38 38
/t/	'to:ma	77	58	32	29	8	5	8	4	6	2	11	11	12	7	52	43	26	22	21	17	14	14	27	21	22	44	36

FIGURE H 1.2 (p.4)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD$_1$		HD$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/t/	'tu~tu	74	58	32	28	10	5	5	3	6	2	10	12	11	8	45	43	12	12	20	17	11	14	27	20	22	42	34
btd	Average	75	60	34	29	7	5	5	5	4	2	11	11	14	9	53	44	28	29	22	18	15	16	23	21	24	44	37
/j/	'ji:hu	81	63	35	30	6	4	12	6	5	2	10	12	13	9	55	45	43	31	22	20	17	18	28	24	23	47	38
/j/	'je:lep	84	65	34	31	6	5	15	6	4	2	11	11	14	10	52	47	44	38	25	21	18	17	30	23	24	47	40
/j/	'ja:sar	77	65	33	31	6	4	12	8	4	2	10	10	12	10	53	44	43	36	24	20	17	17	29	23	24	48	39
/j/	'jo:la	79	59	30	27	7	4	16	8	6	3	10	10	10	7	51	42	32	22	21	17	17	14	31	23	21	44	34
/j/	ju~m	73	62	31	30	7	5	9	4	5	4	10	11	11	8	50	44	28	26	19	16	13	14	26	22	23	45	36
bjo	Average	79	63	33	30	6	4	13	6	5	3	10	11	12	9	52	44	38	31	22	19	16	16	29	23	23	46	57
/k/	ki'f	75	58	35	30	6	4	5	2	3	2	11	11	15	9	55	45	41	34	24	18	15	16	22	20	25	44	37
/k/	'piske.ma	76	61	35	29	6	4	7	5	5	2	10	11	13	10	56	47	43	39	23	21	18	17	25	21	24	45	39
/k/	'kaki	75	63	36	29	6	5	4	8	3	2	10	11	10	8	56	43	37	34	24	21	16	18	21	24	24	48	40
/k/	'ko:ka	77	59	31	29	8	5	12	3	7	3	10	12	10	7	49	40	25	18	22	17	17	14	32	20	25	44	58
/k/	'ku~tra	74	58	32	29	9	6	7	1	6	3	10	12	10	7	45	41	15	7	20	15	13	12	27	20	23	43	35
bkd	Average	75	60	34	29	7	5	7	4	5	2	10	11	12	8	52	43	32	26	23	18	16	15	25	21	24	45	38
/h/	hi:l	86	65	35	29	6	5	18	8	4	2	10	11	13	10	55	45	43	35	24	20	18	18	33	24	24	47	38
/h/	'he:la	84	64	34	30	6	5	16	8	4	2	11	11	14	8	52	45	44	36	26	22	18	18	31	25	25	49	42
/h/	'ha:res	78	66	33	41	6	5	12	9	4	2	10	11	13	8	51	43	40	38	24	23	16	18	29	26	24	50	42

FIGURE H 1.2 (p.5)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/h/	'hodor	80	61 60	31	29 29	7	5 3	16	7 10	6	4 2	9	10 10	11	6 6	49	39 42	31	24 25	24	17 17	16	15 16	32	26 25	21 21	48 47	36 35
/h/	huʷt	73	62	31	31	8	6	11	3	5	2	9	11	9	9	45	41	21	10	20	16	14	13	29	21	24	45	37
pha	Average	80	63	33	32	7	5	15	8	5	2	10	11	12	8	50	43	36	28	24	19	16	16	31	25	23	48	38
/ʔ/	'ʔi et	77	64	33	30	6	4	8	7	3	2	10	11	17	10	52	45	44	35	23	21	15	17	23	24	24	47	39
/ʔ/	'ʔe:da	78	65	34	31	5	5	9	8	4	2	11	11	15	8	51	41	42	38	23	22	15	19	25	25	25	50	41
/ʔ/	'ʔa:la	74	65	33	30	6	5	7	9	3	2	11	10	14	9	51	43	38	28	23	21	14	17	24	23	24	48	39
/ʔ/	'ʔosor	80	60 59	34	29 28	6	4 4	12	8 9	4	3 3	10	11 10	14	5 5	50	41 42	37	25 24	24	17 17	15	15 15	28	25 24	22 22	48 46	36 34
/ʔ/	ʔuʷm	72	61	33	29	6	7	4	2	3	2	11	12	15	9	52	42	34	8	21	15	13	12	21	21	23	44	36
/ʔ/	ʔa:t	79	63	34	30	6	5	10	7	4	2	11	11	14	8	53	44	42	37	25	21	17	18	27	25	24	48	40
pʔa	Average	76	62	33	30	6	5	8	8	3	2	11	11	15	8	51	43	39	28	23	19	14	16	24	24	24	47	38

FIGURE H 1.3 (p.1)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
C_1 /p/	'pwa:les	68	60	37	33	3	4	0	0	0	0	5	10	13	13	51	43	0	0	13	15	12	16	7	14	28	42	35
/p/	pfa'ta:t	73	59	38	32	5	5	0	0	4	0	6	11	20	11	53	44	0	0	17	15	15	14	16	15	28	43	36
/p/	'pʃorti	69	60	37	32	3	5	0	0	0	0	6	11	23	12	51	42	0	0	14	15	11	15	10	16	28	44	46
/b/	'bra:mel	68	60	37	32	2	5	0	0	0	0	7	11	22	12	54	42	0	0	13	15	12	15	10	15	29	44	37
/p/	'pli:hi	67	59	35	31	5	5	0	0	0	0	7	11	20	13	51	44	0	0	14	15	12	15	11	14	28	42	35
/b/	bjuʷt	71	59	35	32	5	5	0	0	0	0	9	11	22	11	51	43	0	0	14	16	12	16	13	16	27	43	36

FIGURE H 1.3 (p.2)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD$_1$		HD$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/p/	pʰkejt	70	60	36	33	4	5	0	0	0	0	10	10	20	12	51	45	0	0	15	16	13	16	14	14	29	43	36
/p/	'pʰa:li	70	59	36	32	3	4	0	0	0	0	9	11	22	12	49	44	0	0	14	15	12	15	13	14	28	42	36
/m/	im'ʔa:rep	67 73	60	39 41	33	6 4	4	0 0	0	0 0	0	9 6	10	18 22	13	50 51	42	0 0	0	14 18	15	12 15	16	13 8	14	30	44	38
ppa	Average	70	60	37	32	5	5	0	0	0	0	7	11	20	12	51	43	0	0	15	15	13	15	12	15	28	43	37
/w/	'kewba	87 68	63	37 36	32	8 3	6	0 0	1	3 0	0	11 8	15	19 21	9	47 52	39	0 0	4	17 16	16	10 12	14	18 10	22	25	47	37
/w/	'sewfu	74	62	33	32	9	6	2	1	5	0	11	12	14	11	40	41	6	4	17	17	11	15	23	19	26	45	37
/w/	mewʃ	73	66	32	33	9	6	2	1	5	2	12	13	13	11	39	40	7	3	17	16	10	14	22	20	26	46	37
/w/	iw'ri t:a	73	65	31	33	9	7	1	0	6	4	11	12	15	9	40	42	6	0	16	16	10	15	21	22	25	46	36
/w/	'ewda	72	64	30	32	9	7	1	0	5	4	11	12	16	9	41	42	6	0	16	16	10	16	21	22	27	48	37
/w/	'liwja	73	64	31	32	9	7	2	0	5	3	11	13	15	9	40	40	8	0	17	16	10	15	22	22	25	47	37
/w/	tawk	73 71	63	31 31	32	9 8	7	1 2	0	5 4	3	11 12	13	16 14	8	41 43	43	5 10	0	17 17	17	9 9	15	21 21	22	26	47	38
/w/	tawh	70	64	31	32	8	7	0	1	5	3	11	12	15	9	44	40	0	3	17	15	9	14	20	21	26	47	37
/w/	sew'ʔa:n	75	66	33	33	7	7	4	0	3	2	12	13	16	11	45	41	18	0	18	15	10	14	22	21	26	47	37
pwa	Average	73	64	32	32	8	7	2	0	5	2	11	13	15	10	41	41	8	2	17	16	10	15	22	21	26	47	37
/f/	fposti	71	60	30	30	8	5	2	0	4	3	11	11	16	11	43	44	12	0	17	17	10	12	21	17	24	41	36
/f/	fwi:t	68	60	32	30	4	4	1	2	0	0	7	12	14	11	48	43	18	16	17	16	8	12	13	17	24	41	36
/f/	fʃa:r	67	59	32	30	4	4	0	0	0	2	9	11	22	12	49	44	0	0	17	16	8	11	14	18	24	41	36

FIGURE H 1.3 (p.3)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/f/	fra:k		60		30		5		0		2		11		12		45		0		16		16		17	25	42	36
/f/	ftiˑt	67	59	32	30	4	5	0	0	0	0	9	12	22	12	49	44	0	0	19	17	10	13	14	18	25	42	36
/f/	vjalʧ:	69	57	32	30	5	4	4	0	2	2	11	10	15	11	53	45	32	0	19	18	15	12	20	18	23	41	36
/f/	'fki:ren	67	58	31	31	4	4	2	1	0	0	11	10	19	12	47	45	18	18	18	17	9	12	16	17	24	41	36
/f/	'fhalʔi	66	59	32	30	4	4	1	1	0	0	10	11	19	13	49	44	18	11	17	18	9	13	14	18	25	42	36
/f/	fʔa:r	67	58	30	29	4	6	1	0	2	0	11	11	19	12	49	46	10	0	18	18	8	12	16	19	24	43	36
of a	Average	68	59	31	30	5	5	1	0	1	1	10	11	18	12	48	44	14	5	18	17	10	12	16	18	24	42	36
/ʃ/	'ʃpak:a		62		29		4		7		3		9		10		44		22		18		15		24	23	46	35
/ʃ/	ʃwi:k	87	62	39	29	9	4	5	7	4	2	11	11	17	9	50	44	19	23	19	18	13	15	25	24	22	46	35
/ʃ/	ʃfa:r	76	60	33	29	7	4	16	6	5	2	10	11	11	8	54	43	30	25	16	16	15	15	23	23	23	45	34
/ʃ/	ʃri:f	76	62	34	29	5	4	5	9	1	3	11	10	19	7	55	42	24	29	17	17	10	15	17	24	22	46	34
/ʧ/	ʧra:ret	79	60	30	27	7	4	14	10	3	3	11	10	4	6	54	43	34	22	19	18	16	16	26	26	21	47	34
/ʃ/	ʃtajt	69	62	28	28	6	3	11	11	5	3	9	10	10	7	51	43	31	24	19	17	15	16	26	25	23	46	34
/ʃ/	ʃjuh	70	61	28	28	5	4	17	9	5	3	9	10	9	7	51	44	31	23	20	18	15	15	28	25	22	46	34
/ʃ/	ʃki:n	70	63	29	28	4	3	13	11	5	4	9	10	10	7	51	42	32	28	19	16	15	18	28	25	24	48	35
/ʃ/	ʃha	70	62	28	27	5	3	14	12	5	4	9	9	9	7	50	42	29	25	18	18	15	16	27	26	22	47	35
/ʃ/	ʃʔal	71	62	28	29	6	3	14	10	5	2	9	11	9	7	50	43	30	25	18	18	16	17	29	27	22	48	36

FIGURE H 1.3 (p.4)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD_1		HD_2		DD		ZD_1	ZD_2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
efa	Average	74	62	31	28	7	4	12	9	4	3	10	10	10	8	52	43	29	25	18	17	15	16	26	25	22	47	35
/r/	ir'bi'ɪt	72	60	32	29	5	4	10	4	4	2	9	11	13	9	50	43	38	21	21	17	16	16	25	22	24	45	36
/r/	er'wi:h	72	61	31	30	5	4	7	4	2	1	11	11	16	11	51	41	39	21	22	16	15	15	23	19	26	45	36
/r/	'erfa	73	62	31	30	5	4	11	3	2	2	10	11	14	12	51	42	42	19	22	18	16	17	25	20	25	45	37
/r/	'erdʒa	73	61	31	30	5	4	11	4	3	2	10	12	13	9	50	44	44	23	22	19	15	17	25	21	25	46	38
/r/	ir'ti'ɪr	72	61	30	30	6	4	9	5	3	2	10	11	14	9	50	43	37	23	20	17	17	16	23	21	25	45	37
/r/	ir'juʷs	71	59	30	30	5	3	8	3	3	1	11	12	14	10	50	42	37	21	21	16	15	15	25	19	24	43	35
/r/	ir'kej:en	71	60	31	30	5	3	8	5	4	2	10	11	13	9	50	42	39	21	22	18	16	16	25	21	24	45	35
/r/	er'hi'lu	73	61	31	29	5	4	10	6	3	3	10	10	14	9	49	43	40	22	23	18	16	16	26	22	23	45	35
/r/	'e:rʔu	72	61	30	30	5	5	9	4	3	2	11	11	14	9	49	42	39	22	23	17	16	17	25	21	25	45	36
pra	Average	72	61	31	30	5	4	9	4	3	2	10	11	14	10	50	42	39	21	22	17	16	16	25	21	25	43	36
/t/	'tpat:i	70	63	30	30	5	4	9	7	5	2	9	11	12	9	51	44	37	35	21	19	15	18	25	22	25	47	38
/t/	'twi:bet	71	59	31	30	5	4	10	4	4	2	11	11	10	8	52	43	35	20	20	17	15	18	26	21	24	45	36
/t/	tfejt	70	61	30	30	5	4	11	5	5	2	10	11	9	9	51	44	34	32	20	19	15	17	28	20	24	44	37
/t/	ma'mitʃ	72	63	32	31	4	4	11	7	5	2	9	11	11	8	51	44	41	35	21	20	15	19	26	22	25	47	39
/t/	tra:p	72	62	30	30	6	4	11	5	4	2	10	12	11	9	50	44	41	35	22	20	15	19	28	21	26	47	39
/d/	djuʷn	72	60	31	30	5	2	14	6	4	3	8	11	10	7	52	44	35	26	21	18	15	16	28	21	24	45	35

FIGURE H 1.3 (p.5)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		H D$_1$		H D$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/t/	'tkel:em	71	61	31	30	5	4	11	4	4	2	10	12	10	9	51	44	40	37	21	19	15	17	27	20	25	44	39
/t/	thalt	71	63	31	31	5	4	9	6	5	2	10	11	11	9	52	45	40	36	21	20	15	19	26	22	25	47	39
/t/	t?i:?	72	62	31	31	5	4	11	5	4	2	10	11	11	9	52	44	41	31	21	19	15	18	27	21	25	46	39
ota	Average	71	61	31	30	5	4	11	5	4	2	10	11	11	9	51	44	38	32	21	19	15	18	27	21	25	46	38
/j/	'tajba	79	64	31	31	5	4	17	6	5	3	9	11	12	9	50	46	42	37	23	20	17	18	32	22	26	48	40
/j/	taj'wa:n	79	65	31	31	5	4	18	7	4	3	10	11	11	9	50	46	42	38	23	21	17	19	33	24	25	49	40
/j/	daj'fi:n	77	64	31	31	5	4	17	7	3	2	10	11	11	9	50	45	43	36	22	21	17	19	30	24	25	49	40
/j/	aj'ʃi:n	79	64	31	31	5	5	17	6	4	2	10	11	12	9	51	45	41	39	22	21	18	18	31	23	26	48	40
/j/	'tajru	75	64	31	31	5	4	14	7	4	3	10	11	11	8	51	45	43	39	22	20	15	19	29	23	25	48	40
/j/	'tajtu	77	63	32	31	5	4	15	6	5	2	9	11	11	9	52	46	41	33	22	20	17	19	30	22	26	47	39
/j/	hdejk	81	65	31	31	5	5	21	8	5	2	9	11	10	8	50	46	40	36	24	21	18	19	34	24	26	49	40
/j/	hdejh	79	64	31	31	5	4	19	7	4	2	9	11	11	9	50	46	40	38	24	20	16	18	34	22	26	48	41
/j/	dej'?itu	82	65	31	30	5	5	22	7	4	3	10	12	10	8	49	45	41	38	25	22	19	19	36	24	25	49	40
pja	Average	79	64	31	31	5	4	18	7	4	2	10	11	11	9	50	46	41	37	23	21	17	19	32	23	26	48	40
/g/	'agbar	80	65	31	31	5	5	20	7	5	2	9	11	10	9	49	43	39	37	26	21	18	19	36	23	27	49	41
/k/	'kwi:kep	74	63	31	31	5	4	13	6	5	2	9	11	11	9	50	43	41	28	23	20	15	16	29	23	26	48	39
/k/	kfi:f	75	63	31	31	5	4	14	5	4	2	10	11	11	10	49	46	40	32	23	20	14	18	30	21	26	46	39

FIGURE H 1.3 (p.6)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		H D$_1$		H D$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/k/	ˈkʃaːʃen	74	64	31	31	5	3	13	8	5	2	10	11	10	9	51	44	42	36	24	21	15	19	30	24	25	49	39
/k/	ˈkraːfes	76	63	31	31	5	4	15	7	4	1	10	11	11	9	49	43	40	33	23	20	15	18	30	23	25	48	39
/k/	ktajːen	80	64	32	31	6	4	19	7	5	2	9	12	9	8	54	44	36	35	21	21	18	19	33	25	25	49	40
/k/	ˈikħal	82	64	31	31	7	4	21	7	6	3	7	11	10	8	54	44	37	36	22	21	18	20	34	24	26	50	40
/k/	ˈikʔal	91	65	35	31	5	3	24	8	5	2	10	12	12	9	55	45	49	37	27	22	21	20	37	25	27	51	42
oka	Average	79	64	32	31	5	4	17	7	5	2	9	11	11	9	51	44	41	34	24	21	17	19	32	24	26	49	40
/ħ/	ˈħbejtu	83	65	36	31	5	5	26	7	4	3	10	11	11	8	57	44	51	36	24	22	19	20	31	25	26	51	42
/ħ/	ˈħwaːwar	84 85	63	35 33	32	6 6	5	16 21	3	5 5	2	10 9	12	12 11	9	57 48	41	50 39	17	24 25	17	18 17	17	30 35	21	27	48	38
/ħ/	ˈħfirta	83	64	36	32	6	4	14	5	5	2	10	11	12	10	57	45	48	34	23	21	19	18	30	22	27	49	41
/ħ/	ˈħdʒejːelf	88	63	36	30	7	4	19	9	5	1	9	11	12	8	55	45	47	32	25	21	19	19	33	24	26	50	41
/ħ/	ˈħraːra	87	64	38	30	8	5	11	7	6	2	10	12	14	8	51	44	28	31	20	21	16	19	29	24	26	49	40
/ħ/	ˈħdaːna	83	66	37	31	6	4	9	9	3	2	11	11	17	9	56	45	37	36	23	20	14	19	25	26	25	51	40
/ħ/	ħjaːr	85	64	36	31	6	4	13	7	2	2	11	11	17	9	54	46	46	37	24	21	17	19	28	22	26	48	41
/ħ/	ˈaħkem	83	68	35	31	6	5	17	9	4	3	10	11	11	9	57	45	48	35	24	22	16	20	32	27	26	53	42
/ħ/	ˈaħʔar	87	67	36	31	6	4	19	10	5	2	10	12	11	8	55	44	46	32	25	23	19	21	33	26	27	52	42
oħa	Average	85	65	36	31	6	4	18	7	5	2	10	11	13	9	55	44	44	32	24	21	17	19	31	24	26	50	41
/ʔ/	ˈaʔbat	84	67	37	31	6	4	13	11	5	3	10	11	13	7	58	44	51	37	23	24	18	20	29	29	24	53	44

FIGURE H 1.3 (p.7)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD₁		HD₂		DD		ZD₁	ZD₂	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/ʔ/	'aʔwa	85	66	36	32	6	4	15	9	4	2	10	11	14	8	56	44	51	58	24	21	18	20	31	25	27	52	42
/ʔ/	'aʔfel	90		30		6		20		5		10		13		54		46		26		20		35				
/ʔ/	ʔʃuʷr	91	62	37	31	7	4	21	6	5	2	10	11	11	8	54	43	46	22	27	17	19	15	35	22	24	45	36
/ʔ/	ʔraːr		66		31		5		7		2		11		10		46		36		21		18		23	25	48	40
/ʔ/	dejːaʔtu	84	65	32	31	5	5	21	7	4	2	10	10	12	10	51	46	42	36	25	21	19	18	35	22	25	47	40
/ʔ/	aʔhel		69		41		5		11		3		11		8		45		36		29		20		27	25	52	43
/ʔ/	Average	87	66	34	33	6	5	18	9	5	2	10	11	13	9	55	45	47	34	25	21	19	19	33	25	25	50	41

FIGURE H 1.4 (p.1)

			EE		EA		AA		AX		XB		BB		BE		CC		YY		HD₁		HD₂		DD		ZD₁	ZD₂	ZH
			O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
C_2	/m/	'tewma	69	58	35	31	3	5	0	0	0	0	8	10	23	13	49	35	0	0	16	13	16	14	10	14	25	39	33
	/p/	'fposti	66	55	33	30	6	5	0	0	0	0	10	10	17	10	49	39	0	0	15	14	11	12	14	15	25	39	33
	/p/	'ʃpakːa	62	56	33	30	4	5	0	0	0	0	8	11	17	10	51	35	0	0	16	15	14	12	10	16	24	39	33
	/b/	ir'biːt	65	58	33	31	4	5	0	0	0	0	8	11	20	11	51	40	0	0	16	14	14	14	11	15	28	43	36
	/p/	'tpatːi	65	58	34	31	5	5	0	0	0	0	10	11	16	11	49	41	0	0	15	16	13	16	13	16	29	44	37
	/b/	'tajba	70	61	36	33	4	5	0	0	0	0	10	11	20	12	53	41	0	0	16	16	15	17	12	15	29	45	38
	/b/	'aqbar	69	59	35	32	5	5	0	0	0	0	10	10	19	12	53	42	0	0	17	16	15	16	13	16	27	44	37
	/b/	'hbejtu	70	61	37	33	4	5	0	0	0	0	9	12	20	11	53	40	0	0	14	15	14	14	11	16	29	44	38
	/b/	'aʔbal	70	62	38	34	3	6	0	0	0	0	8	10	21	12	52	43	0	0	16	14	15	14	11	15	29	43	37

FIGURE H 1.4 (p.2)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
ppa	Average	67	59	35	32	4	5	0	0	0	0	9	11	19	11	51	40	0	0	16	15	14	14	12	15	27	42	36
/w/	'pwa:les	76	59	33	30	10	7	3	0	6	4	11	11	13	7	42	39	9	0	18	15	12	12	24	21	23	44	34
/w/	fwi:t	67	56	31	30	7	6	1	0	4	0	10	11	14	9	43	39	3	0	16	24	10	12	20	19	23	41	32
/w/	ʃwi:t	65	57	28	28	9	8	1	0	6	0	10	13	11	8	39	38	6	0	16	14	10	12	21	19	23	42	33
/w/	er'wi:h	69	60	31	31	6	6	2	1	5	0	10	3	15	9	43	39	12	6	15	16	11	15	20	22	26	48	37
/w/	'twi:bet	66	60	29	31	9	8	1	0	6	0	10	13	11	8	38	39	3	0	15	16	11	14	22	21	26	46	35
/w/	taj'wa:n	74	63	33	32	7	6	2	1	4	2	11	13	17	9	44	38	6	5	16	16	9	16	19	22	28	50	38
/w/	'kwi:kep	74	60 62	35	32 31	8	7 7	2	0 1	5	3 3	11	11 12	15	7 8	42	38 38	10	0 7	16	15 15	10	14 13	21	22 23	27 27	49 48	37 37
/w/	'hwa:war	75	64	32	32	9	8	3	1	6	3	10	12	15	8	41	39	11	3	16	17	16	15	23	22	26	48	38
/w/	'a?wa	74	64	33	34	10	6	2	0	5	1	10	14	14	9	40	42	7	0	17	15	11	15	24	22	28	49	38
pwa	Average	71	61	31	31	8	7	2	0	5	2	10	11	14	8	41	39	7	2	16	16	11	14	22	21	26	47	36
/f/	pfa'ta:t	72	55	34	27	5	4	1	1	2	0	11	2	19	11	52	44	25	6	18	14	9	11	15	15	23	39	33
/f/	'sewfu	72	54	34	28	5	4	0	0	2	0	11	10	19	12	49	40	0	0	18	15	9	11	15	15	23	38	35
/f/	ʃfa:r	63	55 57	28	27 28	4	6 5	2	1 0	2	0 2	10	10 11	17	11 11	47	41 42	29	9 0	18	16 13	9	11 12	18	17 21	23 23	39 42	35 34
/f/	'erfa	65	56	30	28	5	5	0	0	0	0	9	11	21	11	50	42	0	0	19	19	12	11	14	17	24	40	36
/f/	tfejt	64	57	29	29	5	4	0	1	3	0	9	12	18	11	45	43	0	13	19	16	9	12	16	19	25	44	36
/f/	dajfi:n	69	57	32	29	6	4	0	1	0	2	9	9	22	12	52	44	0	5	18	19	10	14	14	18	26	43	38

FIGURE H 1.4 (p.3)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/k/	kfi:f	70	59	33	30	5	4	0	1	0	1	10	12	22	11	50	44	0	4	19	17	10	12	15	18	25	43	36
/k/	'hfirta	67	57	31	30	5	4	0	1	0	2	10	10	21	10	49	44	0	2	18	18	9	13	15	18	25	42	36
/k/	'aʔfel	68	58	32	30	5	4	0	1	0	1	9	10	22	12	51	42	0	6	19	17	11	12	15	17	25	41	36
ofa	Average	68	57	31	29	5	4	0	1	1	1	10	10	20	11	49	43	0/25	5	18	16	10	12	15	18	24	41	35
/ʃ/	'pʃorti	72	59	29	27	6	3	13	10	6	4	8	9	10	6	51	41	28	23	20	16	16	15	29	24	21	44	32
/ʒ/	mewlʃ	74	58	30	26	7.	4	14	9	5	5	8	7	10	7	50	41	26	20	25	17	15	15	29	23	20	43	32
/ʃ/	fʃa:r	67	57	27	26	5	3	13	8	5	3	8	10	9	7	41	43	31	22	19	17	15	15	28	23	21	44	32
/dʒ/	'erdʒa	70	59	28	28	4	3	15	9	5	3	8	10	10	6	50	42	33	28	19	19	18	16	29	25	24	47	35
/ʃ/	ma'milʃ	67	59	24	28	6	3	15	9	6	4	8	10	8	5	48	41	29	23	19	19	16	18	29	26	23	48	35
/ʃ/	ajʃi:n	73	61	27	28	6	2	16	12	5	4	9	10.	10	5	53	41	33	25	20	19	16	19	29	29	22	50	35
/ʃ/	'kʃa:ʃen	71	64	27	28	5.	3	16	14	7	3	7	10	9	6	50	43	31	24	21	19	15	18	31	29	22	50	35
/dʒ/	hdʒej:elʃ	73	61	28	28	5	4	18	11	5	3	8	10	9	5	51	44	34	23	21	18	17	17	31	26	22	48	35
/ʃ/	ʔʃu~r	69	60	25	28	6	4	16	8	6	3	9	10	7	7	47	44	25	21	21	16	16	15	33	24	23	46	33
ofa	Average	71	60	27	28	6	3	15	10	6	4	8	10	9	6	49	42	30	23	21	18	16	16	30	25	22	47	34
/r/	'bra:mel	78	59	34	27	6	3	10	8	4	3	11	9	13	9	52	41	40	24	25	17	16	15	26	21	22	43	34
/r/	iw'rejt	77	62 / 59	34	29 / 28	6	4 / 5	10	9 / 5	4	3 / 4	10	9 / 8	13	8 / 9	53	43 / 41	35	36 / 23	23	20 / 15	17	18 / 14	27	24 / 22	24 / 22	48 / 44	38 / 32
/r/	fra:k	68	57	30	28	4	3	9	5	4	3	9	9	12	9	48	43	34	18	22	15	15	13	25	19	22	41	33

FIGURE H 1.4 (p.4)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD₁		HD₂		DD		ZD₁	ZD₂	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/r/	ʃri:f	66	61	25	27	5	4	13	9	6	2	8	11	9	8	46	41	24	23	21	18	14	17	29	24	23	46	35
/r/	ʃri:f	72	57	27	28	6	3	16	5	3	3	10	11	10	7	54	40	44	19	25	17	18	15	30	22	23	43	33
/r/	tra:p	81	59	33	29	7	3	17	7	5	2	9	11	10	7	56	42	36	23	20	18	18	17	29	23	24	47	36
/r/	'tajru	71	58	31	30	8	3	5	3	5	2	10	12	12	8	42	41	12	16	18	17	11	16	23	19	25	44	36
/r/	kra:fes	78	61	31	30	5	3	13	6	3	2	10	11	16	9	50	44	41	22	24	17	16	17	27	21	24	45	35
/r/	'hra:ra	73	60	31	30	4	4	11	5	3	2	11	11	13	8	49	45	39	22	25	16	17	14	27	21	24	44	35
/r/	ʔra:r	75	60	32	30	5	4	12	4	4	2	9	11	13	9	50	43	41	20	25	17	16	15	28	19	24	44	36
pre	Average	73	59	31	29	5	4	10	6	4	3	10	10	13	8	49	42	33	22	23	17	15	16	27	21	23	44	35
/t/	'pti:hi	77	61	34	28	6	4	10	6	4	3	10	9	13	11	56	42	44	32	22	19	18	16	25	20	23	43	36
/d/	'ewda	75	60	30	28	8	5	8	6	7	3	10	10	12	8	45	41	20	31	17	19	13	15	23	22	22	44	37
/t/	ʃtajt	68	60	25	29	6	3	15	8	5	2	8	11	9	7	49	45	31	32	20	19	16	18	30	22	24	46	38
/t/	ir'ti:r	68	59	29	29	4	3	8	5	4	2	10	11	13	9	49	44	33	27	21	19	15	16	23	21	25	45	37
/t/	'tajtu	70	58	30	29	7	5	4	2	4	3	11	11	14	8	51	41	23	9	18	15	11	15	22	21	25	45	35
/t/	'klaj:en	73	65	31	31	5	4	11	7	4	3	9	10	13	10	51	46	42	34	22	20	16	18	27	23	26	49	40
/d/	'hda:na	75	64	31	32	5	4	14	7	5	1	9	11	11	9	51	45	41	32	23	20	15	18	30	21	25	46	39
/t/	ʔti:l	72	64	32	31	5	4	10	7	4	2	9	11	12	9	53	45	41	24	21	20	14	18	25	22	26	48	40
alv	Average	72	61	30	30	6	4	10	6	5	2	10	11	12	9	51	44	34	28	21	19	15	17	26	22	25	46	38

FIGURE H 1.4 (p.5)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	Y
/j/	bjuᵘt	77	58	32	28	7	4	13	6	5	4	9	8	11	8	54	42	34	22	21	16	16	14	29	21	22	42	33
/j/	'liwjə	68	64	30	29	5	4	6	9	4	3	10	10	13	9	50	43	31	36	22	19	14	18	22	25	23	48	38
/j/	vjəlʃ	70	58	29	28	5	4	12	7	4	3	9	9	11	7	49	44	38	27	21	18	16	16	27	22	22	44	35
/j/	ʃjuh	68	59	27	28	5	4	15	7	4	3	9	11	8	6	47	42	28	25	20	19	15	17	30	24	25	47	36
/j/	ir'juᵘs	69	57	28	28	5	3	14	6	5	2	8	11	9	7	48	43	29	23	20	17	16	16	30	20	25	44	35
/j/	djuᵘn	70	56	30	29	6	4	6	3	6	2	9	12	13	6	49	41	23	19	19	16	12	15	24	20	25	44	34
/j/	kjas:	80	65	32	31	5	4	17	7	4	3	10	11	12	9	51	46	42	35	24	21	18	19	32	24	25	48	40
/j/	hja:r	80	66	30	32	5	3	20	8	5	2	10	12	10	9	51	46	42	31	25	21	18	19	34	25	26	50	40
/j/	ʔja:r	74	65	31	31	5	4	12	8	4	2	10	11	12	9	51	46	41	35	22	22	15	19	28	24	25	48	40
ojə	Average	73	61	30	29	5	4	13	7	5	3	9	11.	11	8	50	44	41	28	22	19	16	17	28	23	24	46	37
/k/	pkejt	79	62	34	29	6	4	13	9	5	3	10	8	11	9	53	44	44	35	25	20	15	17	29	23	24	47	37
/k/	tawk	68 71	63	31 31	29	5 4	5	6 9	9	3 4	4	10 10	9	14 13	7	49 49	42	36 38	35	21 23	20	13 14	18	21 24	26	22	48	39
/k/	'fki:ren	70	61	30	29	5	3	11	9	4	3	8	9	12	8	49	42	38	31	22	19	15	16	27	24	23	46	36
/k/	ʃki:n	69	60	29	28	4	3	15	11	4	3	8	10	9	5	49	42	32	28	21	17	14	17	28	25	25	48	36
/k/	ir'kej:en	70	61	29	29	5	3	10	9	4	2	10	11	12	7	49	45	38	29	22	21	15	18	25	24	24	48	38
/k/	'tkel:em	74	61	32	30	5	4	11	6	4	2	10	11	12	8	52	46	42	37	22	22	15	19	27	23	26	49	41
/k/	hdejk	81	63	32	30	5	3	18	8	4	2	10	11	12	9	52	45	45	37	23	22	18	20	31	25	26	51	41

FIGURE H 1.4 (p.6)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/k/	'ahkem	79 83	66	31 31	32	5 5	4	18 22	9	5 5	2	9 9	11	11 11	8	50 49	44	39 42	37	24 26	23	17 17	20	35 36	25	27	52	42
pkd	Average	73	62	31	29	5	4	11	9	4	3	9	10	13	8	50	44	35	34	22	21	15	18	26	24	25	49	39
/ħ/	'pha:li	84	64	34	29	6	4	18	10	4	3	10	9	12	9	52	44	44	36	27	21	17	18	33	25	23	48	39
/ħ/	tawh	74	64	31	29	5	4	13	11	3	2	10	10	12	8	48	41	37	36	22	20	15	17	27	26	23	49	39
/ħ/	'fhal?i	73	62	30	29	5	3	13	11	4	2	9	10	12	7	47	43	38	37	23	20	17	17	28	25	22	48	38
/ħ/	ʃha	69	64	28	29	5	2	15	14	6	2	8	11	9	6	47	42	27	30	20	22	15	20	30	29	24	53	40
/ħ/	er'hi'lo	72	62	29	29	5	3	13	9	3	2	10	11	12	8	48	43	40	31	22	21	18	19	27	25	25	50	39
/ħ/	thall	78	63	32	30	5	3	14	9	4	2	11	11	12	8	52	45	43	37	23	22	17	20	29	26	25	51	42
/ħ/	hdejh	75	64	32	30	5	4	10	7	3	3	10	11	15	9	51	45	41	38	23	23	15	20	25	25	27	51	43
/ħ/	'ikhal	76	67	32	32	5	4	12	10	4	2	10	11.	13	8	52	44	43	37	23	21	16	19	28	26	26	52	42
/ħ/	'a?hel	81	66	31	32	4	4	22	8	5	2	9	10	10	10	49	48	42	36	26	22	18	20	36	24	27	51	42
pha	Average	76	64	31	30	5	3	15	10	5	2	9	10	12	8	49	44	39	35	23	21	17	19	30	26	25	50	40
/ʕ/	im'?a:rep	84	63	35	29	6	5	16	9	4	3	10	8	13	9	52	43	43	35	26	21	19	18	31	24	23	47	39
/ʕ/	sew'?a:n	71	63	31	28	5	5	9	9	3	4	10	10	14	7	48	41	35	34	21	22	15	19	23	26	22	48	40
/ʕ/	f?a:r	76	60	30	28	4	3	2	9	2	3	10	9	18	8	48	41	24	32	20	19	13	17	18	24	23	46	36
/ʕ/	ʃ?a:l	70	61	27	29	4	3	16	12	4	3	9	10	10	4	49	41	33	25	20	20	16	18	28	27	23	49	36
/ʕ/	'e:r?o	74	59	29	30	4	5	16	0	5	3	9	12	11	9	49	41	36	0	22	17	17	16	29	19	25	44	36

FIGURE H 1.4 (p.7)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD$_1$		HD$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
/ʕ/	lʕiʔ	75	62	32	30	5	4	12	6	4	3	10	10	12	9	51	46	42	33	22	22	17	18	27	23	25	48	40
/ʕ/	'dejʕo		59		31		6		1		1		12		8		40		4		16		15		21	27	47	38
/ʕ/	'ikʕal	73	66	32	32	5	4	9	9	3	2	11	11	13	8	52	45	42	38	23	22	16	20	25	26	26	52	41
/ʔ/	ahʔar	83	69	30	32	5	4	24	12	5	2	8	11	11	8	47	41	40	36	29	24	19	20	40	27	26	52	44
ʕ	Average	76	62	31	30	5	4	13	7	5	3	10	10	13	8	50	42	37	26	23	20	19	18	28	24	24	48	39

<u>FIGURE H 2</u> (p.1)   Measurements (in mm.) along the parameters considered as deviating (plus or minus) from the "neutral" position. Average measurements.

	EE		EA		AA		AX		XB		BB		BE		CC		YY		H D_1		H D_2		DD		ZD_1	ZD_2	ZH
	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
"NEUTRAL" Rest-Position	73	57	39	31	6	5	0	0	1	0	11	11	16	10	60	44	0	0	22	18	18	15	17	15	25	40	37
▷i◁																											
Average	+5	+4	-5	-2	N	-1	+8	+8	+3	+2	N	N	-1	-2	-4	N	+43	+31	+1	+2	-1	+2	+8	+9	-2	+6	N
Lowest	N	N	-6	-6	-1	-3	+6	+5	+2	+1	-1	-2	-4	-6	-6	-3	+38	+26	-2	-1	-2	+1	+6	+5	-4	+4	-3
Highest	+6	+6	-4	+1	+7	N	+12	+11	+4	+4	N	+1	N	N	-2	+3	+46	+34	+2	+4	N	+3	+11	+14	N	+9	+3
▷ɛ◁																											
Average	+10	+6	-4	-1	N	-1	+12	+10	+3	+2	N	N	-1	-3	-5	N	+45	+33	+3	+4	+1	+4	+11	+11	N	+10	+4
Lowest	+8	+5	-5	-4	-1	-3	+9	+7	+2	+1	N	-1	-2	-7	-7	-3	+45	+27	+2	+2	N	+3	+9	+9	-2	+8	+1
Highest	+13	+8	-4	N	+1	-1	+15	+17	+3	+4	N	N	+1	-1	-4	+1	+46	+37	+4	+6	+2	+5	+13	+17	+1	+14	+6
▷a◁																											
Average	+8	+9	-5	-2	N	-1	+12	+12	+3	+3	-1	N	-1	-3	-5	-2	+44	+34	+3	+5	N	+5	+11	+14	-1	+13	+4
Lowest	+6	+4	-6	-5	-1	-2	+9	+9	+2	+2	-1	-1	-3	-7	-6	-7	+43	+28	+2	+3	-1	+4	+7	+11	-3	+12	+1
Highest	+11	+11	-4	N	+1	N	+17	+16	+4	+4	N	N	N	-1	-5	N	+46	+43	+3	+7	N	+6	+15	+16	N	+14	+5
▷o◁																											
Average	+6	+1	-7	-4	+1	N	+12	+6	+4	+4	N	N	-3	-4	-9	-4	+29	+21	N	N	-2	+1	+12	+9	-3	+5	-2
Lowest	+2	-2	-9	-6	N	-1	+6	+4	+2	+3	-2	-2	-4	-6	-14	-5	+25	+17	-1	-2	-4	-2	+6	+7	-4	+3	-5
Highest	+10	+4	-5	-2	+2	+1	+19	+9	+5	+4	+1	+1	-1	-3	-3	-2	+34	+24	+2	N	-1	+10	+17	+11	-1	+8	+1
▷u◁																											
Average	+2	N	-6	-4	+2	+1	+5	+2	+5	+3	-1	N	-4	-4	-9	-5	+19	+8	-3	-2	-5	-2	+8	+8	-3	+4	-3
Lowest	-2	-3	-8	-5	+2	-1	+2	N	+4	12	-2	N	-6	-5	-14	-7	+14	N	-4	-2	-7	-3	+4	+6	-5	+2	-6
Highest	+5	+3	-6	-2	+3	+2	+8	+4	17	+4	+1	12	-3	-2	-4	-3	+26	+17	-2	-1	-4	N	+12	19	-1	+5	-1

FIGURE H 2 (p.2)

		EE		EA		AA		AX		XB		BB'		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
▷p◁ + Vowel	Average	+1	+1	N	-1	N	N	N	N	N	N	-2	N	+3	+1	-8	N	N	N	-5	-3	-4	-1	-3	-1	+1	+1	-1
	Lowest	-2	-1	-5	-2	-4	-1	N	N	-1	N	-6	-2	-5	-1	-16	-4	N	N	-5	-4	-7	-2	-11	-1	-1	N	-3
	Highest	+6	+2	+4	N	+4	+2	N	N	+3	N	+1	+2	+9	+3	-1	+2	N	N	-3	-2	-1	N	+5	+3	+2	+3	N
▷p◁ as C_1	Av	-3	+3	-2	+1	-1	N	N	N	-1	N	-3	N	+4	+2	-9	-1	N	N	-7	-3	-5	N	-5	N	+3	+3	N
	L	-6	+2	-5	N	-4	-1	N	N	-1	N	-6	-1	-3	+1	-11	-2	N	N	-9	-3	-7	-1	-10	-1	+2	+2	-2
	H	N	+3	+2	+2	N	N	N	N	-1	N	-1	N	+7	+3	-6	+1	N	N	-4	-2	-3	+1	-1	+1	+5	+4	+9
▷p◁ as C_2	Av	-6	+2	-4	+1	-2	N	N	N	-1	N	-2	N	+3	+1	-9	-4	N	N	-6	-3	-4	-1	-5	N	+2	+2	-1
	L	-11	-2	-6	-1	-3	-1	N	N	-1	N	-3	-1	N	N	-11	-7	N	N	-8	-5	-7	-3	-7	-1	-1	-1	-4
	H	-3	+5	-1	+3	N	+1	N	N	-1	N	-1	+1	+5	+3	-7	-1	N	N	-5	-2	-3	+2	-3	+1	+4	+5	+1
▷p◁ all contexts	Av	-3	+2	-2	+1	-1	N	N	N	-1	N	-2	N	+3	+1	-9	-2	N	N	-6	-3	-4	-1	-4	N	+2	+2	-1
	L	-11	-2	-6	-2	-4	-1	N	N	-1	N	-6	-2	-5	-1	-16	-7	N	N	-9	-5	-7	-3	-11	-1	-1	-1	-4
	H	+6	+5	+4	+3	+4	-2	N	N	+3	N	+1	+2	+9	+3	-1	+2	N	N	-3	-2	-1	+2	+5	+3	+5	+5	+9
▷w◁ + Vowel	Av	+4	+6	-5	N	+3	+3	+1	-1	+5	+4	N	+1	-3	-1	-17	-6	+3	+3	-3	-2	-7	-2	+8	+8	-2	+5	-1
	L	+1	+3	-6	-2	+3	+2	+1	N	+4	+2	N	-1	-4	-3	-19	-8	+2	N	-4	-4	-7	-3	+7	+5	-4	+3	-4
	H	+6	+7	-4	+1	+4	+3	+2	+3	+6	+7	+1	+3	N	N	-14	-3	+4	+7	-2	+1	-6	N	+10	+9	N	+7	+1
▷w◁ as C_1	Av	N	+7	-7	+1	+2	+2	+2	N	+4	+2	N	+2	-1	N	-19	-3	+8	+2	-5	-2	-8	N	+5	+6	+1	+7	N
	L	-3	+5	-9	+1	+1	+1	N	N	+2	N	N	+1	-3	-2	-21	-5	N	N	-6	-3	-9	-1	+3	+4	N	+5	-1
	H	+2	+9	-6	+2	+3	+2	+4	+1	+5	+4	+1	+4	N	+1	-15	-1	+18	+4	-4	-1	-7	+1	+6	+7	+2	+8	+1
▷w◁ as C_2	Av	-2	+4	-8	N	+2	+2	+2	N	+4		-1	N	-2	-2	-19	-5	+7	+2	-6	-2	-7	-1	+5	+6	+1	+7	-1
	L	-8	-1	-11	-3	N	+1	+1	N	+3		-1	-7	-5	-3	-21	-6	+3	N	-7	-4	-9	-3	+2	+4	-2	+1	-5
	H	+3	+7	-6	+3	+3	+3	+3	+1	+5		N	+4	+1	-1	-16	-2	+12	+6	-4	+8	-2	+1	+7	+8	+3	+10	+1
▷w◁ all contexts	Av	N	+6	-7	N	+2	+2	+2	N	+4		N	+1	-2	-1	-18	-5	+6	+2	-5	-2	-7	-1	+6	+7	N	+6	-1
	L	-8	-1	-11	-3	N	+1	N	N	+2		-1	-7	-5	-3	-21	-8	N	N	-7	-4	-9	-3	+2	+4	-4	+1	-5
	H	+6	+9	-4	+3	+4	+3	+4	+3	+6		+1	+4	+1	+1	-14	-1	+18	+7	-2	+8	-2	+1	+10	+9	+3	+10	+1

FIGURE H 2 (p.3)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
▷f◁ + Vowel	Av	+1	+2	-8	-4	+1	N	+3	+1	+2	+2	N	-2	+4	+2	-10	N	+18	+5	N	-2	-8	-3	+5	+3	-2	+1	-2
	L	-1	+1	-9	-3	-1	N	+1	N	-1	+1	N	-3	-2	+1	-11	-2	+12	N	-4	-2	-9	-4	+2	+2	-3	N	-3
	H	+3	+3	-6	+3	+3	+1	+4	+2	+5	+3	+1	-1	+7	+3	-9	+1	+23	+9	+1	-1	-6	-3	+6	+4	-1	+1	-2
▷f◁ as C_1	Av	-5	+2	-8	-1	-1	N	+1	N	N	N	-1	N	+2	+2	-12	N	+14	+5	-4	-1	-8	-3	-1	+3	-1	+2	-1
	L	-7	+1	-9	-2	-2	-1	N	N	-1	N	-4	-1	-2	+1	-17	-1	N	N	-5	-2	-10	-4	-4	+2	-2	+1	-1
	H	-2	+3	-7	N	+2	+1	+4	+2	+3	+3	N	+1	+4	+3	-7	+2	+32	+18	-3	N	-3	+1	+4	+4	N	+3	-1
▷f◁ as C_2	Av	-5	N	-8	-2	-1	-1	N	+1	N	+1	-1	-1	+4	+1	-11	-1	+5	+5	-4	-2	-8	-3	-2	+3	-1	+1	-2
	L	-10	-3	-11	-4	-2	-1	N	N	-1	N	-2	-9	+1	N	-13	-4	N	N	-4	-5	-9	-4	-3	N	-2	-2	-4
	H	-1	+2	-5	-1	N	+1	+2	+1	+3	+2	N	+1	+6	+2	-8	N	+24	+13	-3	+1	-6	-1	+1	+6	+1	+4	+1
▷f◁ all contexts	Av	-3	+1	-8	-2	N	N	+1	+1	+1	+1	-1	-1	+3	+2	-11	N	+12	+5	-3	-2	-8	-3	+1	+3	-1	+1	-2
	L	-10	-3	-11	-4	-2	-1	+1	N	-1	N	-4	-9	-2	N	-17	-4	N	N	-5	-5	-10	-4	-4	N	-3	-2	-4
	H	+3	+3	-5	+3	+3	+1	+1	+2	+5	+3	+1	+1	+7	+3	-7	+2	+32	+18	+1	+1	-3	+1	+6	+6	+1	+4	+1
▷ʃ◁ + Vowel	Av	+3	+5	-9	-4	+1	-1	+15	+11	+5	+3	-2	-1	-7	-3	-8	-3	+28	+23	N	N	-2	+1	+15	+11	-5	+5	-3
	L	+3	+3	-11	-5	N	-2	+13	+6	+4	+2	-4	-2	-7	-5	-12	-4	+22	+16	-1	-2	-3	-2	+14	+8	-5	+3	-4
	H	+5	+6	-8	-3	+2	N	+18	+14	+6	+4	-1	-1	-6	-2	-5	-3	+34	+26	+1	+3	-1	+4	+18	+14	-4	+8	-2
▷ʃ◁ as C_1	Av	-3	+5	-11	-3	-1	-1	+14	+9	+4	+3	-2	-1	-7	-2	-9	-1	+31	+25	-3	-1	-3	+1	+11	+10	-3	+7	-2
	L	-4	+3	-11	-4	-2	-2	+11	+6	+4	+2	-2	-2	-7	-4	-10	-2	+29	+22	-4	-2	-3	N	+9	+8	-4	+5	-3
	H	-2	+6	-10	-2	N	-1	+17	+12	+4	+4	-2	N	-6	N	-9	N	+32	+29	-2	N	-2	+3	+12	+12	-1	+8	-1
▷ʃ◁ as C_2	Av	-2	+3	-12	-4	N	-2	+15	+10	+5	+4	-3	-1	-7	-4	-11	-2	+30	+23	-1	N	-2	+1	+13	+10	-3	+7	-3
	L	-6	N	-14	-5	-2	-3	+13	+8	+4	+3	-4	-4	-9	-5	-19	-3	+25	+20	-3	-2	-3	N	+11	+8	-5	+3	-5
	H	+1	+7	-9	-3	+1	-1	+18	+14	+6	+5	-2	-1	-6	-3	-7	N	+34	+28	+3	+1	N	+4	+16	+14	-1	+10	-2
Pʃ◁ all contexts	Av	-1	+4	-11	-4	N	-1	+15	+10	+5	+3	-2	-1	-7	-3	-9	-2	+30	+24	-1	N	-2	+1	+13	+10	-4	+6	-3
	L	-6	N	-14	-5	-2	-3	+14	+6	+4	+2	-4	-4	-9	-5	-19	-4	+22	+16	-4	-2	-3	-2	+9	+8	-5	+3	-5
	H	+5	+7	-8	-2	+2	N	+18	+14	+6	+5	-1	N	-6	N	-5	N	+34	+28	+3	+3	N	+4	+18	+14	-1	+10	-1

FIGURE H 2 (p.4)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD_1		HD_2		DD		ZD_1	ZD_2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	Y
▷r◁ + vowel	Av	+3	+2	-6	-2	+1	-1	+9	+4	+4	+2	-1	-1	-3	N	-10	N	+31	+18	N	N	-4	-1	+10	+4	-2	+2	-3
	L	-2	N	-9	-5	N	-1	+3	+2	+2	+1	-2	-2	-6	-1	-17	-3	+12	+12	-4	-3	-7	-1	+7	+3	-4	N	-5
	H	+7	+3	-6	-1	+2	+1	+13	+6	+6	+3	N	N	-1	N	-6	+1	+41	+22	+2	+7	-1	N	+14	+6	-1	+3	-2
▷r◁ as C_1	Av	-1	+4	-8	-1	-1	-1	+9	+4	+2	+2	-1	N	-2	N	-10	-2	+39	+21	N	-1	-2	+1	+8	+6	N	+3	-1
	L	-2	+2	-9	-2	-1	-2	+7	+3	+1	+1	-2	-1	-3	-1	-11	-3	+37	+19	-2	-2	-3	N	+6	+4	-2	-15	-2
	H	N	+5	-7	-1	N	N	+11	+6	+3	+3	N	+1	N	+2	-9	N	+44	+23	+1	+1	-1	+2	+9	+7	+1	+6	+1
▷r◁ as C_2	Av	N	+2	-8	-2	-1	-1	+10	+6	+3	+3	-1	-1	-3	-2	-11	-2	+33	+22	+1	-1	-3	+1	+10	+6	-2	+4	-2
	L	-7	N	-14	-4	-2	-2	+5	+3	+2	+2	-3	-3	-7	-3	-18	-4	+12	+16	-4	-3	-7	-2	+6	+4	-3	+1	-5
	H	+5	+5	-5	-1	+2	N	+13	+9	+5	+4	N	+1	N	-1	-7	+1	+41	+36	+3	+2	-1	+3	+12	+9	N	+8	+1
▷r◁ all contexts	Av	+1	+3	-7	-2	N	-1	+9	+5	+3	+2	-1	-1	-3	-1	-10	-1	+34	+20	N	-1	-3	N	+9	+5	-1	+3	-2
	L	-7	N	-14	-5	-2	-2	+3	+2	+1	+1	-3	-3	-7	-3	-17	-4	+12	+12	-4	-3	-7	-2	+6	+5	-4	-15	-5
	H	+7	+5	-5	-1	+2	+1	+13	+9	+6	+4	N	+1	N	+2	-6	+1	+44	+36	+3	+7	-1	+3	+14	+9	+1	+8	+1
▷t◁ + vowel	Av	+2	+3	-5	-2	+1	N	+5	+5	+3	+2	N	N	-2	-1	-7	N	+28	+29	N	N	-3	+1	+6	+6	-1	+4	N
	L	+1	+1	-7	-3	N	-1	+2	+3	+2	+1	-1	N	-5	-3	-15	-2	+12	+12	-2	-1	-7	-1	+3	+4	-3	+2	-3
	H	+4	+6	-4	N	+2	N	+8	+7	+5	+2	+1	+1	N	N	-4	+1	+34	+38	+2	+2	-2	+3	+10	+7	N	+5	+1
▷t◁ as C_1	Av	-2	+4	-8	-1	-1	-1	+11	+5	+3	+2	-1	N	-5	-1	-9	N	+38	+32	-1	+1	-3	+3	+10	+6	N	+6	+1
	L	-3	+2	-9	-1	-2	-3	+9	+4	+3	+2	-3	N	-7	-3	-10	-1	+34	+20	-2	N	-3	+1	+8	+5	-1	+5	-2
	H	-1	+6	-7	N	N	-1	+14	+7	+4	+3	N	+1	-4	-1	-8	+1	+41	+37	N	+2	-3	+4	+11	+7	+1	+7	+2
▷t◁ as C_2	Av	-1	+4	-9	-1	N	-1	+10	+6	+4	+2	-1	N	-4	-1	-9	N	+34	+28	-1	+1	-3	+2	+9	+7	N	+6	+1
	L	-5	+1	-14	-3	-2	-2	+4	+2	+3	+1	-3	-2	-7	-3	-15	-3	+20	+9	-5	-3	-7	N	+5	+5	-3	+3	-1
	H	+4	+8	-5	+1	+2	N	+15	+8	+6	+3	N	N	-2	+1	-4	+2	+44	+39	+1	+2	N	+3	+13	+8	+1	+9	+3
▷t◁ all contexts	Av	N	+4	-7	-1	N	-1	+9	+5	+3	+2	-1	N	-4	-1	-8	N	+33	+30	-1	+1	-3	+2	+8	+6	N	+5	+1
	L	-5	+1	-14	-3	-2	-3	+2	+2	+2	+1	-3	-2	-7	-3	-15	-3	+12	+9	-5	-3	-7	-1	+3	+4	-3	+2	-3
	H	+4	+8	-4	+1	+2	N	+15	+8	+6	+3	+1	+1	N	+1	-4	+2	+44	+38	+2	+2	N	+4	+15	+8	+1	+9	+3

FIGURE H 2 (p.5)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		HD1		HD2		DD		ZD1	ZD2	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
▷j◁ + vowel	Av	+6	+6	-6	-1	N	-1	+13	+6	+4	+3	-1	N	-4	-1	-8	N	+38	+31	N	+1	-2	+1	+12	+8	-2	+6	N
	L	N	+2	-9	-4	N	-1	+9	+4	+3	+2	-1	-1	-6	-3	-10	-2	+28	+22	-3	-2	-5	-1	+9	+7	-4	+4	-3
	H	+11	+8	-4	N	+1	N	+16	+8	+5	+4	N	+1	-2	N	-5	+3	+44	+38	+3	+3	+4	+3	+14	+9	-1	+8	+3
▷j◁ as C_1	Av	+6	+7	-8	N	-1	-1	+18	+7	+3	+2	-1	N	-5	-1	-10	+2	+41	+37	+1	+3	-1	+4	+15	+8	+1	+8	+3
	L	+2	+6	-8	-1	-1	-1	+14	+6	+2	+2	-2	N	-5	-2	-11	+1	+40	+33	N	+2	-3	+3	+12	+7	N	+7	+2
	H	+9	+8	-7	N	-1	N	+22	+8	+4	+3	-1	+1	-4	-1	-8	+2	+43	+39	+3	+4	+1	+4	+19	+9	+1	+9	+4
▷j◁ as C_2	Av	N	+4	-9	-2	-1	-1	+13	+7	+4	+3	-2	N	-5	-2	-10	N	+41	+28	N	+1	-2	+2	+12	+8	-1	+6	N
	L	-5	-1	-12	-3	-1	-2	+6	+3	+3	+2	-3	-3	-8	-4	-13	-3	+23	+19	-3	-2	-6	-1	+5	+5	-3	+2	-4
	H	+7	+9	-7	+1	+1	-1	+20	+9	+5	+4	-1	+1	-3	-1	-6	+2	+41	+36	+3	+4	N	+4	+17	+10	+1	+10	+3
▷j◁ all contexts	Av	+4	+6	-8	-1	-1	-1	+15	+7	+4	+3	-1	N	-5	-1	-9	+1	+40	+32	N	+2	-2	+2	+13	+8	-1	+7	+1
	L	-5	-1	-12	-4	-1	-2	+6	+3	+2	+2	-3	-3	-8	-4	-13	-3	+23	+19	-3	-2	-6	-1	+5 +19	+5	-4	+2	-4
	H	+11	+9	-4	+1	+1	N	+22	+9	15	+4	N	+1	-2	N	-5	+3	+44	+39	+3	+4	+4	+4		+10	+1	+10	+4
▷k◁ + vowel	Av	+2	+3	-5	-2	+1	N	+7	+4	+4	+2	-1	N	-4	-2	-8	-1	+32	+26	+1	N	-2	N	+8	+6	-1	+5	+1
	L	+1	+1	-8	-2	N	-1	+4	+1	+2	+2	-1	N	-6	-3	-15	-4	+15	+7	-2	-3	-5	-3	+4	+5	-2	+3	-2
	H	+4	+4	-3	-1	+3	+1	+12	+8	+6	+3	N	+1	-1	N	-4	+3	+43	+39	+2	+3	N	+3	+15	+9	N	+8	+3
▷k◁ as C_1	Av	+6	+7	-7	N	-1	-1	+17	+7	+4	+2	-2	N	-5	-1	-9	N	+41	+34	+2	+3	-1	+4	+15	+9	+1	+9	+3
	L	+1	+6	-8	N	-1	-2	+13	+5	+3	+1	-4	N	-7	-2	-11	-1	+36	+28	-1	+2	-4	+1	+13	+6	N	+6	+2
	H	+8	+8	-4	N	+2	N	+24	+8	+5	+3	-1	+1	-4	N	-5	+1	+49	+37	+5	+4	+3	+5	+20	+10	+2	+11	+5
▷k◁ as C_2	Av	N	+5	-8	-2	-1	-1	+11	+9	+3	+3	-2	-1	-3	-2	-10	N	+35	+34	N	+3	-3	+3	+9	+9	N	+9	+2
	L	-5	+3	-10	-3	-2	-2	+1	+6	+1	+2	-3	-2	-7	-5	-13	-2	+6	+28	-7	-1	-6	+1	+2	+8	-3	+6	-1
	H	+1	+9	-5	+1	N	N	+22	+11	+4	+4	-1	N	+2	-1	-7	+2	+45	+37	+4	+5	N	+5	+19	+11	+2	+12	+5
▷k◁ all contexts	Av	+3	+5	-7	-1	N	-1	+12	+7	+4	+2	-2	N	-4	-2	-9	N	+36	+31	+1	+2	-2	+2	+12	+8	N	+8	+2
	L	-5	+1	-10	-3	-2	-2	+1	+1	+1	+1	-4	-2	-7	-5	-15	-4	+6	+7	-7	-3	-6	-3	+2	+5	-3	+3	-2
	H	+8	+9	-3	+1	+3	+1	+24	+11	+6	+1	N	+1	+2	N	-4	+3	+49	+39	+5	+5	+3	+5	+20	+11	+2	+12	+5

FIGURE H 2 (p.6)

		EE		EA		AA		AX		XB		BB		BE		CC		YY		H D$_1$		H D$_2$		DD		ZD$_1$	ZD$_2$	ZH
		O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	O	X	X	X	X
▷h◁ + Vowel	Av	+7	+6	-6	+1	+1	N	+15	+8	+4	+2	-1	N	-4	-2	-10	-1	+42	+28	+2	+1	-2	+1	+14	+10	-2	+8	+1
	L	N	+3	-8	-2	N	-2	+11	+3	+3	+2	-2	-1	-7	-4	-15	-5	+21	+10	-2	-2	-4	-2	+12	+6	-4	+5	-2
	H	+13	+8	-4	+10	+2	+1	+18	+10	+5	+4	N	N	-2	N	-5	+1	+44	+38	+4	+5	N	+3	+16	+11	N	+10	+5
▷h◁ as C$_1$	Av	+12	+7	-3	-1	N	-2	+17	+10	+4	+2	-1	-1	-3	-2	-5	N	+44	+35	+2	+3	-1	+4	+14	+11	+10	+10	+3
	L	+10	+5	-6	-2	-1	-3	+13	+7	+1	+2	-2	-2	-5	-4	-12	-3	+28	+30	-2	+2	-4	+2	+11	+9	+7	+8	+1
	H	+14	+10	-1	+1	+2	-1	+26	+14	+4	+3	N	N	+1	N	-3	+4	+51	+38	+3	+5	+1	+5	+18	+14	+12	+12	+6
▷h◁ as C$_2$	Av	+3	+8	-8	N	-1	-1	+15	+7	+4	+2	-2	N	-4	-1	-11	N	+39	+32	+1	+3	-1	+4	+13	+9	+1	+10	+4
	L	-4	+6	-13	-1	-2	-1	+10	+3	+2	+1	-4	N	-7	-2	-13	-3	+27	+17	-2	-1	-3	+2	+8	+6	N	+8	+2
	H	+11	+11	-5	+1	N	N	+22	+10	+5	+3	N	N	-1	N	-8	+2	+44	+37	+5	+5	N	+6	+19	+12	+2	+15	+5
▷h◁ all contexts	Av	+7	+7	-6	N	N	-1	+16	+8	+4	+2	-1	N	-4	-2	-8	N	+42	+32	+2	+2	-1	+3	+14	+10	+3	+9	+3
	L	-4	+3	-13	-2	-2	-3	+10	+3	+1	+1	-4	-2	-7	-4	-15	-5	+21	+10	-2	-2	-4	-2	+8	+6	-4	+5	-2
	H	+14	+11	-1	+10	+2	+1	+26	+14	+5	+4	N	+1	+1	N	-3	+4	+51	+38	+5	+5	+1	+6	+19	+14	+12	+15	+6
▷ʔ◁ + Vowel	Av	+3	+5	-6	-1	N	N	+8	+8	+2	+2	N	N	-1	-2	-9	-1	+39	+28	+1	+1	-4	+1	+7	+9	-1	+7	+1
	L	-1	+2	-6	-3	-1	-1	+4	+2	+2	+2	-1	-1	-2	-5	-10	-3	+34	+8	-1	-3	-5	-3	+4	+6	-3	+4	-3
	H	+7	+8	-5	N	N	+2	+12	+9	+3	+3	N	+1	+1	N	-8	+1	+44	+38	+2	+4	-3	+4	+11	+10	N	+10	+4
▷ʔ◁ as C$_1$	Av	+14	+9	-5	+2	N	N	+18	+9	+4	+2	-1	N	-3	-1	-5	+1	+47	+34	+3	+3	+1	+4	+16	+10	N	+10	+4
	L	+11	+5	-9	N	-1	-1	+13	+1	+3	+2	-1	-1	-5	-3	-9	-1	+42	+22	+1	-1	+1	N	+12	+7	-1	+5	-1
	H	+18	+12	-2	+10	+1	N	+21	+11	+4	+3	-1	N	-2	N	-2	+2	+51	+38	+5	+6	+2	+3	+18	+14	+2	+15	+6
▷ʔ◁ as C$_2$	Av	+3	+5	-8	-1	-1	-1	+13	N	+4	+3	-1	-1	-3	-2	-10	-2	+37	+26	+1	+2	-1	+3	+11	+9	-1	+8	+2
	L	-3	+2	-12	-3	-2	-2	+9	N	+1	+1	-3	-3	-6	-7	-13	-4	+29	N	-2	-2	-5	N	+1	+4	-3	+4	-1
	H	+11	+12	-4	+1	N	+1	+29	+12	+4	+4	N	+1	+2	-2	-8	+2	+42	+38	+7	+6	+1	+5	+23	+12	+2	+12	+7
▷ʔ◁ all contexts	Av	+7	+6	-6	N	N	N	+13	+6	+3	+2	-1	N	-2	-2	-8	-1	+41	+29	+2	+2	-1	+3	+11	+9	-1	+8	+2
	L	-1	+2	-12	-3	-2	-2	+4	N	+1	+1	-3	-3	-6	-7	-13	-4	+29	N	-2	-3	-5	-3	+1	+4	-3	+4	-3
	H	+18	+12	-2	+10	+1	+2	+29	+12	+4	+4	N	+1	+2	-2	-2	+2	+51	+38	+7	+6	+2	+5	+23	+19	+2	+13	+7

B I B L I O G R A P H Y

B I B L I O G R A P H Y

Abbreviations:

BSOAS - Bulletin of the School of Oriental and African Studies.
JASA - Journal of the Acoustical Society of America.
JSHR - Journal of Speech and Hearing Research.
W in P - Work in Progress, Linguistics Department, University of Edinburgh.

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Sample Visiogram (Schematic)