WPLC

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The reader is advised that the articles appearing in the *Working Papers* vary in the degree to which they represent the authors' final views on the matters under discussion. With this in mind, comments and suggestions on ideas set forth in these papers would be welcomed.

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We hope that the response to volume 3 will be as encouraging as the response to volumes 1 and 2. We would also like to acknowledge the patient work of Ms. Gisèle Clément who managed to type this issue, in spite of everything, and who is responsible for the fine graphics.

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Simplifications in the babytalk register:

a look at Nootka examples

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The differences which separate adult language from the language of children are quite well documented, throughout the maturation process of the child, and much research and study has been devoted to the development of adult language by children. Of course, children learn their language from adults and older children and the language spoken by a child is very much influenced by the nature of language directed toward him, as well as developmental factors. Conversely, it may be possible that children are able to influence the speech of their elders by forcing adults to bend to the linguistic inabilities of the child. The mechanisms by which children influence the speech of adults is much less well-documented than the mechanisms by which adults influence children, although in recent years more research has been directed toward this phenomenon.

Many theories of phonology have been advanced to explain and describe the way in which children develop language sounds. Some theories are more adequate than others in the description and explanation of the many phenomena which are present in children's utterances.

Theorists such as Waterson (1970) have adopted a stance which places emphasis on the role of perceptual input and allows more individual flexibility in the development of speech sounds. This so-called 'prosodic theory' rejects a universal hierarchy of acquisition proposed earlier by Jakobson (1941/1968) in favour of an emphasis on the individual linguistic environment of the child and the perceptual saliency of the sounds presented to him. It is the position of the prosodic camp that syllables and supra-segmentals are most salient to children early in their development and that children perceive words holistically, without an undue awareness of how elements are arranged within the word.

According to the prosodic theory, children attend only to the high saliency portion of words. The differences which can be observed between a child's perceptual ability and productive capability are explained by recourse to childrens' motor development.

The sounds which children tend to produce first tend to be those sounds which do not require a high degree of fine motor skills. Individual variations in which sounds are acquired in what order are explained by environment and individual perceptual variability.

The prosodic theory's dependence on the linguistic environment of the language-learning child causes one to pose the question: What is the linguistic environment of a young child?

Snow (1972) disclosed some of the features of adult speech to children — notably shortened utterances with meaningful pauses and reduced grammatical complexity and greater repetition. There is also a tendency for adults to talk to children only about things that are inside a child's compass of world knowledge. Garnica (1977), Ferguson (1964) and other researchers have remarked on the special lexical items used by adults when speaking with children and have also noted such suprasegmental phenomena as higher and more variable pitch. It appears that adults alter their speech in an effort to make their utterances more simple to process and use pitch variation as a way of eliciting orienting behavior by the child.

Kaye (1980) found that mothers' speech to children of language-learning age is different than that directed to young infants. Infants cannot possibly understand the words directed to them, so no effort is made to use special babytalk lexical items until a child is about a year old. Babytalk lexical items are reserved for children who may be able to benefit from their simplicity in order to learn language more quickly. This tendency for mothers to adjust their speech in the presence of children with different linguistic capabilities is evidence that adults adjust language to suit children's verbal and cognitive abilities.

Since the babytalk register seems to depend on children's verbal ability, it is only natural that babytalk lexical items are similar in some respects to the speech which language-learning children produce.

Children's linguistic limitations result in the phonological shape of items directed toward them being similarly limited. This can result in simplifications, homonymy and reduplications in babytalk which are similar to those present in the speech of young children.

Reduplication has been given as a characteristic of the babytalk register by numerous scholars and the reduplication of phonological

elements in child forms can easily be seen in almost any language. English, for example, has babytalk forms such as wa-wa "water", din-din "dinner", etc.

Reduplication of phonological elements seems to be one of the abiding characteristics of babytalk throughout the world. What is the basis of this 'universal'?

Not all languages use reduplication for grammatical purposes, but almost all seem to employ phonological reduplication as a stylistic variant when speaking to young children. Perhaps the reason for the wide use of reduplication stems from the use of reduplication by language-learning children themselves. Schwartz, Leonard, Wilcox and Folger (1980) found that some children use reduplication as a means of producing disyllabic words when their phonological inventory is still small. This observation is concordant with the prosodic theory of language acquistion which holds that the number of syllables in a word is a highly salient feature of the word, whereas the actual phonological elements are less salient, and therefore less important to the child.

About half of language-learning children studied by Schwartz, Leonard, Wilcox and Folger (1980) exhibited reduplication as an abiding strategy in word formation. There were no sex differences or other social or environmental factors which influenced the children's ability to use the reduplication strategy — it appeared that some children are born with the propensity to use that method of word formation. It is possible that individual perception plays a role in determining if the reduplicating strategy is used, but this was not broached in the study. One may project from this study, however, that there is a high percentage of children who are inherent reduplicators and that it is possible that this tendency is present across cultures. Since we can acknowledge the possibility that babytalk is to some extent patterned after the speech of children, then it is equally possible that reduplication is a strategy which one might well expect to crop up in babytalk all over the world.

Not all languages confine reduplication to their babytalk registers; in fact, a large number of languages use reduplication productively as a grammatical element. One language which depends on reduplication for a number of grammatical functions is Nootka. Grammatical reduplications in Nootka are of two major types; the first type yields a meaning change. This change involves the meaning of the root, indicating that the entity,

action or state which is expressed by the root, is spread over time or space. In other words, reduplication of the root means to repeatedly do an action, or to have something exist here and there. A form from Ahousaht Nootka which uses this form of reduplication is the form which means "to clap hands", seen in example 1(a) below:

1. (a) ƛ̓uḥ ƛ̓uḥ (y)a

reduplicated morpheme	ROOT: "to hold hand flat against a surface"	continuation suffix

yielding: ƛ̓uḥƛ̓uḥa "to clap hands (continuously)"

The second type of reduplication adds no additional meaning to the root, but is obligatorily required by certain suffixes (Rose 1976). This non-meaning altering reduplication can be seen in the example below:

1. (b) ḥa ḥaw̓iɬ k̓uk

reduplicated morpheme	ROOT: "chief"	SUFFIX "resembling" (obligatory reduplication)

yielding: ḥaḥawiɬk̓uk "resembling a chief"

[taken from Rose (1976)]

In the babytalk register in Nootka, another type of reduplication may be seen which is unlike the grammatical reduplications given above. It is phonological reduplication which bears a striking resemblance to the phonological reduplications in English and other languages' babytalk forms. The reduplication in the Nootka babytalk register has the same appearance as forms which are generated by language-learning children, and are very different from their adult register counterparts. Seen below in example 2 are some of these reduplicative babytalk forms juxtaposed with their adult counterparts.

2.

GLOSS	ADULT FORM	BABYTALK FORM
mother	ʔumʔi (Ahousaht)	maːma (Ahousaht)
hurt or injury	ʔuːsuqʷ (Nitinaht)	naːna (Nitinaht)
let's eat!	haʔukeːʔidicx̌ (Nitinaht)	maːma (Nitinaht)

These phonologically reduplicated forms are quite different in form and complexity from the grammatically reduplicated forms seen above, and from the adult forms of the words in example 2. As can be seen on the previous page, the babytalk register demands drastic simplification of the phonology and of the length and complexity of the word. What happens in languages such as Nootka when a grammatically reduplicated word is directed to children? Since the babytalk register demands simplicity, are reduplicating morphemes dropped in order to simplify, even though reduplication seems 'natural' for children to produce and understand?

In some examples from Nootka it appears that the reduplicative morpheme is retained, while the suffix which conditions its presence may be lost. For example, ƛuḥƛuḥa (given in example 1 (a)) becomes ƛuḥƛuḥ when elicited as babytalk. While loss of such a small suffix is hardly a major simplification, it is indicative of a larger pattern of simplification by suffix deletion, as well as giving an indication that the reduplicative morpheme is regarded as simple enough to be retained in forms directed toward children, while suffixes are regarded as "excess baggage".

Clearly, most forms which we associate with babytalk are not those which are merely grammatically simpler, but those which are totally different from the adult forms. In Ahousaht, these suppletive forms exhibit exactly what one expects of suppletive babytalk forms. They are phonologically simple, with the phonemes restricted to sounds which might reasonably be produced by a language-learning child.

What is meant by <u>suppletive</u> forms is that the babytalk item bears no phonological relationship to the adult form and is not built from the same root.

An example of a suppletive babytalk form is the Ahousaht hu·š which obviously bears no correspondence to the adult form, wa?i?ču?i meaning "go to sleep". The adult form can be analysed as a root, we?ič-, plus (u), and the imperative suffix. This suffix is responsible for the glottalization before the /č/, or at least there is a strong probability that this is the case. The babytalk form, on the other hand, cannot be analysed further. This Ahousaht form is very similar to the form in Sapir and Swadesh (1939), ho·š glossed as "sleep, child form" (note that the orthography in Sapir and Swadesh employs /o/

in place of the current /u/). Also in Sapir and Swadesh is another form meaning much the same thing, which is ʔeˑhoˑš and may be related to their form meaning "be quiet", ʔahoˑ, seen later in the paper. Of these three forms given in the 1939 work, note that only one remains in the speech of the Ahousaht informant today.

Forms which universally crop up as babytalk items are words which name parents, food, water, and excretory products. Nootka is no exception, and suppletive forms for these meanings are present in the corpus (example 3, below).

3. AHOUSAHT

Gloss	Adult	Babytalk
"mother"	ʔumʔi	maˑma
"father"	nuʔẇi	taˑta
"drink"	naqšiƛ	maḥ (also means "water" in B.T.)
"defecate" (masc.)	ẇaẇik	p̓up̓
"eat"	haʔukʷin	paˑpaš

It is interesting to compare the Nitinaht forms for the same meanings. Nitinaht is related to Ahousaht, but the adult phonology has no nasal consonants whereas Ahousaht contains four nasals. The forms in Nitinaht are:

4. NITINAHT

Gloss	Adult	Babytalk
"mother"	ʔabeˑqs	ʔeˑb
"father"	duwiʔ	deˑt
"drink"	daqšiƛ	maḥ
"defecate"	šab	hum
"eat"	haʔukeˑʔidicx̌	maˑmaˑ

Interestingly enough, although nasals are not present in the adult phonology, they are present in the babytalk register. This inclusion of abnormal phonological elements is not totally unknown in the babytalk register in other languages. Quileute, which is a Chimakuan language spoken in Washington State, also

lacks nasals in its adult phonology, but contains nasals in its babytalk (Frachtenberg 1917). The similarity between the babytalk of Quileute and that of Nitinaht is quite striking in other respects. Compare the forms in example 5, which show nearly identical items for the two languages.

5. Gloss	Quileute Babytalk	Nitinaht Babytalk
"toy"	lā'la'	la·la·
"clothes"	di'di'	ni·ni
"food/eat"	bā'ba'	ma·ma

Although the Quileute forms here have not been constructed using nasal consonants, the consonants which are used correspond to the Nitinaht consonants in all features except nasality. Perhaps there could be some borrowing between Quileute and Nitinaht through Makah which has resulted in these forms being so similar, or simply a coincidence stemming from the limited inventory which is used in babytalk.[1]

It is interesting to review the forms given by Sapir and Swadesh (1939) as child forms in light of the forms listed in this paper. Comparing the forms given by them with the modern elicitations reveals a considerable amount of difference. This could indicate that babytalk forms in Nootka communities were of very restricted currency, so that the Ahousaht babytalk forms would be very unlike the Nitinaht, or could indicate that the babytalk register is one which is very susceptible to change. Forms in Sapir and Swadesh (1939) are given below, with their Nitinaht and Ahousaht counterparts.

From the comparison of the three sets of babytalk in example 6 one can observe that Ahousaht is much closer to the Sapir and Swadesh data than is Nitinaht, but that certain suppletive forms which existed in the early data are now replaced by diminutive forms based on adult roots. Of the Nitinaht forms in that example, only the forms meaning "go to sleep" and "drink" are a match for either the modern Ahousaht or the earlier data.

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[1]Thom Hess in a personal communication has noted that numerous forms in Nitinaht have been borrowed from Quileute through the geographically intervening Makah. Therefore it is not unlikely that some babytalk forms may have been passed along.

6. GLOSS	S&S 1939	AHOUSAHT	NITINAHT
"be quiet!"	ʔaho·	camakʔišʔi	
"go to sleep!"	ʔe·ho·š/ho·š	huš	huš
"no, don't!"	ʔoʔiš	wikiʔišxax	
"mother, suckle"	ma·ma	ma·ma	ʔe·b
"water, drink"	ma·ḥ	maḥ	maḥ
"father"	ta·ta	ta·ta	de·t
"eat"	pa·pa	pa·paš	ma·ma·
"sore, hurt"	kax	hixpiq	na·na
"affection" (interjection)	ʔo·ʔo·ʔo·		

There is quite a bit more work which remains to be done in Nootka communities, both on the babytalk register and on the language as a whole. I have found in my Nootka research that there is insufficient documentation on Nootka to provide an adequate source of reference in determining what a root may mean, or how it may combine with a suffix. Recent works, such as Rose's *Kyuquot Grammar* are helpful, but there is still a great deal which is not available on other varieties of Nootka, such as Nitinaht.

In conclusion, it can be said that the modern data which this paper employs indicate that the babytalk register in Nootka abides by the same rules which apply to babytalk the world over. The register uses special lexical items which refer to items and concepts which are within a child's world. These lexical items are presented in a modified and simplified phonological form. This phonological form depends heavily on sounds in a young child's early phonetic inventory. The use of an inventory which is restricted by the universal motor and cognitive limitations of young children results in languages producing babytalk forms which are similar, despite the genetic and geographic distances between them (as was suggested in the Nitinaht/Quileute example.) Reduplication, which is a meaningful grammatical element in Nootka, is retained in the language directed toward children, even in forms where the suffix which conditions the reduplication is deleted. The differences between modern and earlier data demonstrate a language decrement, and it is hoped that more research can be done on babytalk before further losses occur in these languages.

	AHOUSAHT		NITINAHT	
	ADULT	BABYTALK	ADULT	BABYTALK
'dirty'	ʔaššmis	ʔa·ʔa·tis	ʔaššabs	ʔiš
'lie down!'	čitkpiʔičiˀ	čitkpiʔičuˀ·cʔi		
'sit'	tiqpiƛˀ	tiqˀ	tiqpiƛˀ	
'clap hands'	ƛuḥƛuḥa	ƛuḥƛuḥ	ƛapxi·ɬkʷ	
'go to sleep!'	waʔiʔču?i	hu·š	weʔič	hu.š

	AHOUSAHT		NITINAHT	
	ADULT	BABYTALK	ADULT	BABYTALK
'mother'	ʔumʔi	ma•ma	ʔabe•qs	ʔe•b (voc.)
'father'	nuʔẃi	ta•ta	duwiʔ	de•t (voc.)
'eat/food'	haʔukʷin	pa•paš	haʔuke•ʔidicx̌	ma•ma•
'suckle'		k̓ʷink̓ʷina		k̓ʷink̓ʷina
'drink/water'	čaʔak	maḥ	daqšiƛ ca•ʔaksas	maḥ
'breast or bottle'				ma
'hurt/injury'	ʔusuqta	hix̌piq	ʔu•suqʷ	na•na~ʔa•na•
'smile!'	cimḥ	kakuku		
'boo!'	hu	ʔix̌		ʔuʔ

	AHOUSAHT		NITINAHT	
	ADULT	BABYTALK	ADULT	BABYTALK
'pass wind'	ƛ̓iɬkcuˑ	ƛ̓iɬkƛ̓iɬkiš		
'penis'	k̓imis	kux^{w}yak		
'vagina'	ḥičkun	ʔaʔaʔuck^{w}in		
'defecate'	w̓aw̓ik	p̓up̓	šab	hum
'give me!'	ʔiniʔis	ʔiniʔis(#)x̌ax̌	hacseˑʔb	teˑʔb
'urinate (fem)'	tiskin	tis		ʔisano
'urinate (masc)'	ʔuqck^{w}i	kux̌^{w}		

	AHOUSAHT		NITINAHT	
	ADULT	BABYTALK	ADULT	BABYTALK
'toy'	ka•kana			la•la•
'jump'	tux^{w}šiƛ	tux^{w}	ʔackatšiƛ̓	ʔack
'no!'	wik	wikiʔišˇ(#)x̌ax̌		
'walk'	čˇi•x̌a	čˇi•x̌		pe•pa
'monster'	čˇiɬ̓ʔik			ma•ʔa•
'grandparent'				nan
'put on clothes'				ni•ni•

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A Laryngographic Investigation of Phonation Type and Laryngeal Configurations*

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1.0 INTRODUCTION

Phonetic research into the instrumental characterization of phonation types (Fourcin and Abberton, 1971; Fourcin, 1974; Esling, 1976, 1977, 1978; Roach, 1977; Roach and Hardcastle, 1979) has indicated that the electrical impedance laryngograph provides a useful means of identifying and distinguishing contrasting phonation types. The form of the present investigation follows Esling (1977) in which phonation types are categorized auditorily according to the articulatory phonetic framework established by Laver (1968, 1975, 1976). This framework follows the tradition of the general phonetic theories described by Abercrombie (1967) and the systematic nomenclature for phonation types provided by Catford (1964). Several primary phonation types are analyzed and compared laryngographically to determine the characteristics of ther larynx waveforms. These comparisons suggest a set of relationships between laryngeal configuration and characteristics of the vocal fold vibratory cycle, expressed in terms of contrasting systems of stricture.

Phonation type has several phonetic functions. It may fluctuate rapidly in speech as a feature of segmental contrast, or vary over clausal-length utterances as a feature of voice dynamics denoting shifts in 'register'. More commonly, it constitutes the laryngeal component of voice quality — a speaker's or speakers' habitual,

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quasi-permanent vocal tract setting. It is the description of phonation type as a component of voice quality with which this research is most closely concerned, although the laryngographic characterization of phonation types is applicable to the description of phonatory mechanisms functioning in any linguistic context, whether a part of voice quality, voice dynamics or segmental phonology.

In order to re-examine and test the procedures, hypotheses and conclusions discussed specifically in Esling (1976, 1977), Roach (1977) and Roach and Hardcastle (1979), an analysis of a number of laryngographic waveforms of contrasting phonation types was undertaken. The procedural issues under consideration include (a) how to obtain a permanent, continuous record of the larynx waveform (Lx) in order to make measurements over relatively long stretches of speech and (b) how to measure the various aspects of the Lx waveform period in order to contrast waveforms from one phonation type to another. The hypotheses under examination are:

(1) that contrasting phonation types are distinguishable on the basis of Lx waveform shapes,

(2) that changes in Lx waveform shape are not the result of changes in pitch but the result of changes in phonatory mechanism associated with differing phonation type, and

(3) that characteristics of Lx waveform rise-time and fall-time (or of waveform rise-time and period-time) correspond to differences in mode of phonation.

2.0 PREVIOUS RESEARCH

A considerable amount of research using the electrical impedance laryngograph has been undertaken since its description by Fourcin and Abberton (1971) and Fourcin (1974). Applications have been found in the study of speech disorders (Fourcin and Abberton, 1976; Wechsler, 1976; Wirz and Anthony, 1979) and in the study of language varieties (Thelwall, 1975). A review of this research can be found in Esling (1978).

In Esling (1976, 1977), a number of correspondences are presented between auditorily identified differences in phonation type and quantitative differences in Lx waveform shape, frequency, amplitude,

and the relative durations of the rise-time and fall-time of the Lx signal. This signal reflects the changing electrical impedance across the larynx during phonation, by means of a pair of electrodes placed on the throat on either side of the Adam's apple (Fourcin and Abberton, 1971; Fourcin 1974). The rising part of the signal corresponds approximately to the closing of the vocal folds, and the falling part of the signal to the opening of the vocal folds. These relationships between Lx waveform and phonation type are summarized in Esling (1978: 216-272, 311-323), where Lx characteristics are used to describe phonation types in a socio-linguistic survey of speech in an urban community.

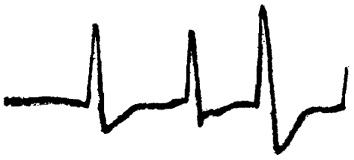
The phonation types under investigation include:

MV	modalvoice (neutral voice for the sensory modality of speech)
WV	whispery voice
BV	breathy voice
HV	harsh voice
VV	ventricular voice
CV	creaky voice
F	falsetto

In an early experiment, summarized in table 1, each distinct phonation type was repeated on the sustained vowel [i] while the Lx signal was photographed from the screen of an oscilloscope. The ratio of rise-time to fall-time was calculated by measuring the duration of the signal from the low point of the trace to the high point of the signal to give rise-time, and from the high point to the low point to give fall-time. This results in a relatively wide range of rise-time to fall-time (RT/FT) ratios, between approximately 3:10 for creaky voice at the one extreme, and 10:1 for breathy voice at the other. The Lx waveforms in question were very preliminary, exhibiting a sharp rise at the bottom of the curve instead of a flat base-line, due to the particular model of laryngograph used in this experiment. In table 1, approximately 40-50 msec. of each signal is represented, with frequency and RT/FT ratio listed for each example.

If we consider a frequency range for any one speaker, that range can be divided into four smaller ranges: low, low-mid, high-mid and high. The range of RT/FT ratios of the Lx signal can also

Table 1. Laryngographic waveforms - characteristic shapes for seven primary phonation types

RT/FT Ratio	Phonation type	Lx waveform
1.44	Modal voice 125 Hz.	
2.50	Whispery voice 100 Hz.	
9.66	Extremely whispery/ Breathy voice 85 Hz.	
0.61	Harsh voice 95 Hz.	
0.35	Ventricular voice 100 Hz.	
0.53	Creaky voice 60 Hz.	
2.00	Falsetto 305 Hz.	

40 msec.

be divided into four smaller ranges, in order to relate mode of phonation and frequency. For example, creaky voice and ventricular voice were found to have relatively low RT/FT ratios, while whispery voice and breathy voice demonstrated progressively higher RT/FT ratios. These relationships are illustrated in table 2(a), where the seven key or primary phonation types from table 1 are arranged according to increasing frequency, from top to bottom, and increasing RT/FT ratio from left to right. The top letter in each box refers to the shape of the peak of the Lx signal, and the middle letter refers to the shape of the base of Lx: 'p' for peaked, 'dp' for double-peaked, 'r' for rounded and 'f' for flat. The bottom letter in each box refers to the amplitude of the Lx signal: 'L' for low, 'N' for normal. Thus, creaky voice and ventricular voice have similar RT/FT ratios, but usually differ in frequency and the shape of the peak of Lx. Harsh voice has a higher RT/FT ratio than creaky or ventricular voice; the parameter which also distinguishes modal voice from whispery voice. Falsetto, besides its higher frequency, is lower in amplitude. Breathy voice, while in the same frequency range as ventricular and harsh voice, has the highest RT/FT ratio. Table 2(b) illustrates these relationships graphically, showing frequency and RT/FT ranges as target areas.

To summarize briefly:

(1) a relatively short permanent record of electrical impedance across the larynx was obtained by photographing the larynx waveform (Lx) from an oscilloscope screen;

(2) Lx periods were measured between the highest point and the lowest point of the signal to obtain rise-time (RT) and fall-time (FT) and a ratio of RT/FT;

(3) contrasting phonation types were differentiated according to characteristic Lx waveform shapes;

(4) contrasting phonation types were observed to correspond to differences in frequency as well as to other characteristics of Lx, but frequency was not controlled or examined separately;

(5) RT/FT was found to distinguish some phonation types within the same frequency range, but was not independent of frequency in all cases.

frequency range					
	4 high			Falsetto p or r p L	
	3 high-mid		Modal voice p p N	Whispery voice p p N	
	2 low-mid	Ventricular voice dp p or r L	Harsh voice dp r or f N		Breathy voice p p and f N
	1 low	Creaky voice p r L			
		1 low	2 low-mid	3 high-mid	4 high

RT/FT ratio range

Table 2(a). Lx characteristics of seven phonation types

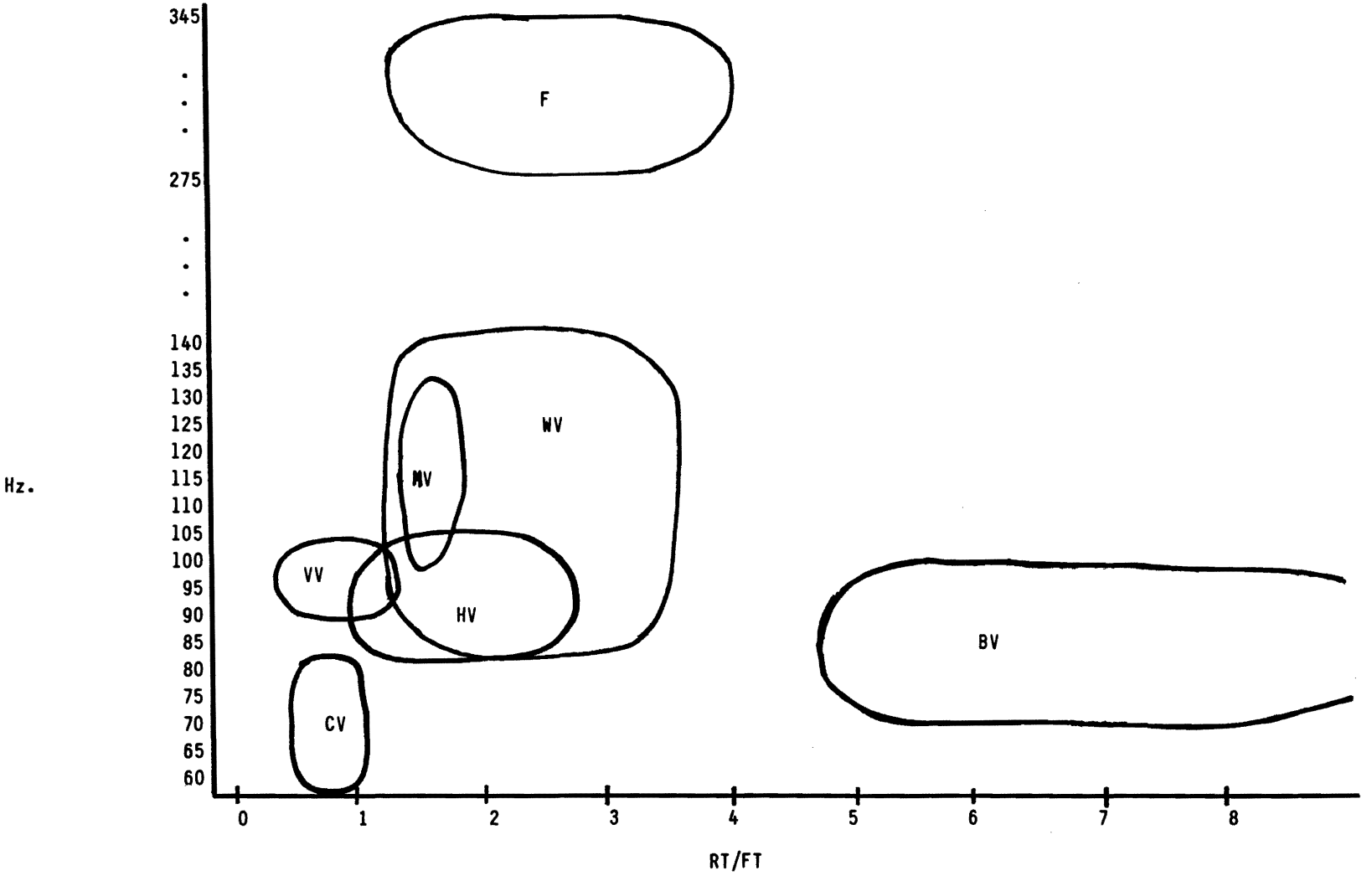


Table 2(b). Frequency and RT/FT ratio ranges for seven phonation types

3.0 PROCEDURE

In the present paper, a different technique of recording and measuring the Lx waveform from that described above is reported and evaluated. In this technique, samples of phonation are recorded on an FM data recorder and replayed at slow speed into an oscillograph running at a high paper speed, providing a permanent record of the Lx signal for longer samples of speech than in the earlier experiment. This resembles the technique employed by Roach (1977:51), although the ratios used here to characterize Lx waveforms are obtained by a slightly different method of measuring the periods of Lx.

In the first of two experiments, the subject (JE) produced each of the primary phonation types listed above on the steady-state vowel [a], not controlling specifically for pitch. In the second experiment, each phonation type was produced at four different pitch levels of roughly equal intervals, using the word 'bead' [bi:d]. The output of an electrical impedance laryngograph was recorded at 15 i.p.s. on an FM data recorder and then replayed at one-eighth of that speed into a Mingograf oscillograph running at a paper speed of 1000 mm./sec. The speech signal was recorded for subsequent evaluation of the accuracy and consistency of the subject's performance.

The procedure for measuring the Lx waveform differs from the procedure described above in three respects. First, instead of taking the lowest point of the signal as the base-line, the base-line is drawn to transect the point in each period (A, A_1, ...) at which the rapid rise begins, as shown in figure 1.

The base-line is drawn through point A for two reasons: to compensate for the effects of phase distortion, and because point A represents a reliable indication of the beginning of vocal fold closure. It is possible that the slightly rising slope of the base of the Lx signal may reflect a change in capacitance which is not the direct result of a change in impedance due to vocal fold adduction. The exaggerated slope of this part of the signal in the waveforms in table 1 is the result of a phase distortion introduced in the laryngograph itself as an anticipatory procedure to converting Lx to Fx, which is the running display of fundamental frequency (Fourcin, personal communication). This phase distortion may not necessarily invalidate comparisons between waveforms, as in table 1, if the distortion is uniformly present in all of them. However, excluding

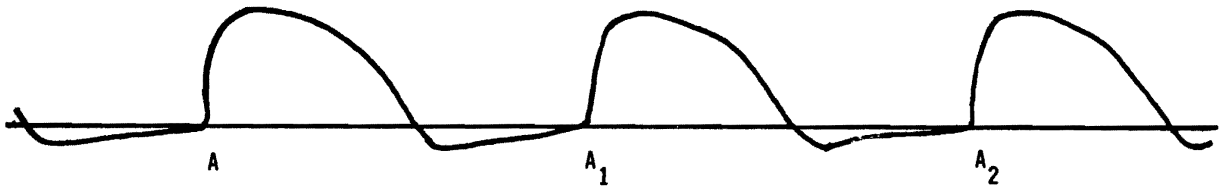


Figure 1. Lx waveform - Base-line

Phonation type	RT/FT	Frequency (Hz.)
Creaky voice (CV)	0.11	75
Modal voice (MV)	0.16	120
Ventricular voice (VV)	0.19	110
Harsh voice (HV)	0.24	100
Whispery voice (WV)	0.4	120
Breathy voice (BV)	0.47	150
Falsetto (F)	0.6	375

Table 3(a). RT/FT for short samples of 7 phonation types

it from our calculations may give a truer comparison of rise-time to fall-time (RT/FT) than before.

Furthermore, point A is more reliable because it signals the start of closure.

> Lx provides information about the nature of the closed phase of the vocal fold vibratory cycle. Lx is positive going for increasing closure and its positive peak corresponds to maximum vocal fold contact: *the leading edge of the waveform provides a precise indication of the beginning of the closure phase.* The Lx waveform gives no explicit information about glottal aperture size, however, and it is for this reason that the apparatus has been called a laryngograph rather than a glottograph (Fourcin and Abberton, 1976: 116, my italics).

Taking this point as the start of each cycle, therefore, gives a more reliable measure of the duration of 'closing', taken as roughly equivalent to rise-time (RT), and 'opening', taken as roughly equivalent to fall-time (FT).

The second difference in procedure is that only 80% of the signal is measured. In this procedure, measurements are made from 10% of total amplitude above the base-line, to 10% below the peak of the signal. This accounts for any slight build-up of capacitance or attenuation of the signal not related to the phenomenon being measured.

The third procedural difference in these experiments is that the length of time over which Lx is analyzed is longer than the samples measured in Esling (1977). Here, a minimum of 1250 msec. of Lx waveform traces for each phonation type are included in each calculation, instead of the 40 or 50 msec. obtained previously by photographing the Lx waveform trace. The RT and FT of every third period was measured, and a mean was calculated for each run of each phonation type.

4.0 RT/FT AND PHONATION TYPE

In the first revised experiment, the seven contrasting phonation types differed both in frequency and in RT/FT ratios. Their

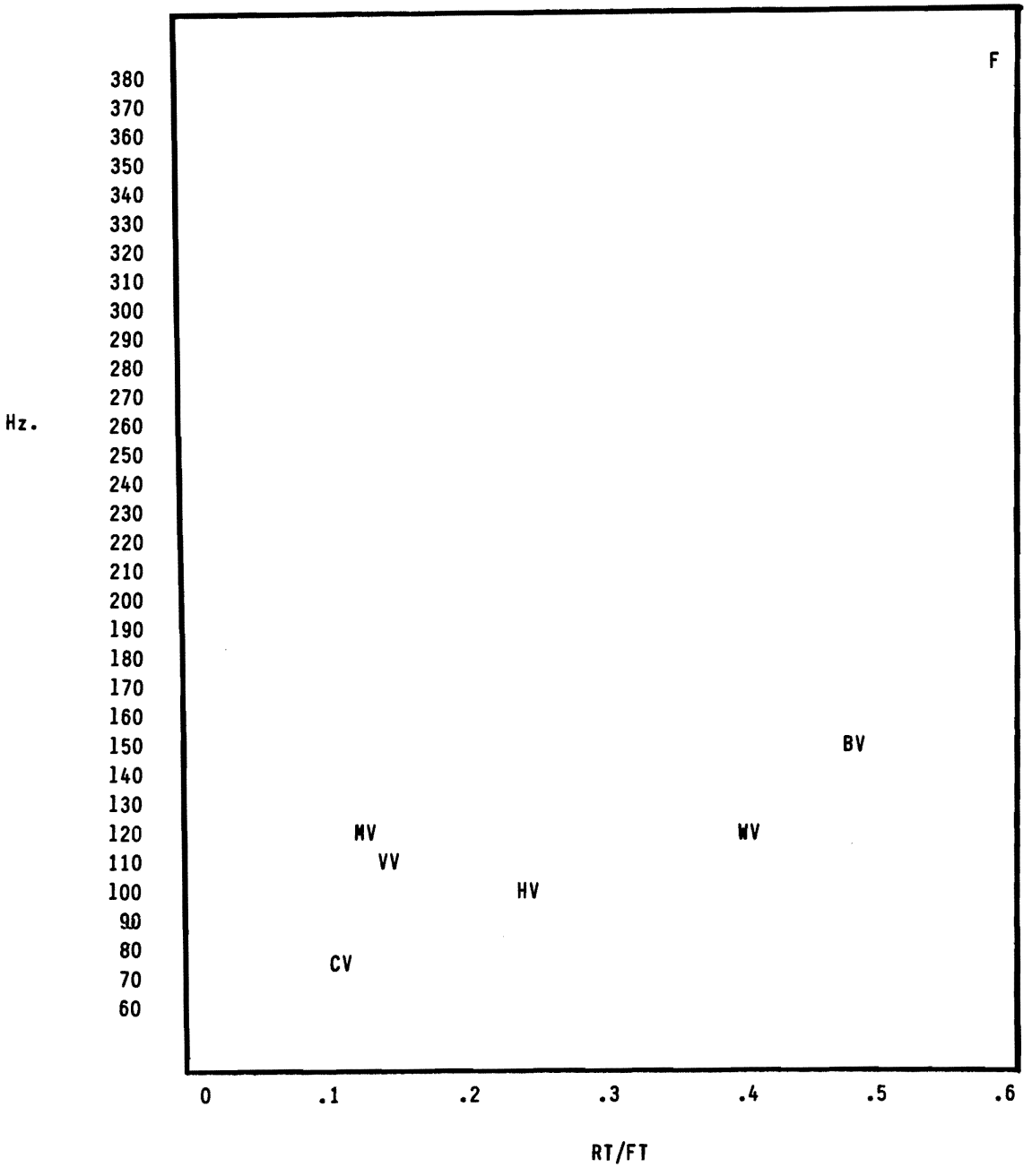


Table 3(b). RT/FT for short samples of 7 phonation types

distribution is listed in table 3(a), in order of increasing RT/FT ratio. This information is displayed graphically in table 3(b) to illustrate the relationship between RT/FT and frequency.

The data in table 3 differ in some respects from the data obtained in earlier experiments displayed in table 2, both methodologically and in results. The single tokens in table 3 represent measurements of Lx of up to 0.5 sec. of consecutive waveform periods for each phonation type, whereas the data in table 2 represent several tokens of 40-50 msec. for each phonation type. The figures in table 3 are based on measurements of 80% of total amplitude of the Lx signal, with a corrected base-line, while measurements in table 2 represent RT and FT between the minima and maxima of the Lx signal. For this reason, ratios in the earlier set of data are higher values, often greater than 1, than the ratios in the revised experiments. RT/FT ratios in table 3 are values between 0 and 1, which reflect more accurately the generally accepted model of vocal fold vibration where RT, the closing phase, is always faster than FT, the opening phase of the cycle. Thus, creaky voice, which involves the most antero-posterior laryngeal stricture, has an abrupt closing phase and RT, but a slow opening phase and FT. Ventricular voice, which involves the most transverse laryngeal stricture, also has rapid RT and slow FT. On the other hand, whispery voice and breathy voice, which involve progressively smaller degrees of laryngeal stricture, exhibit progressively slower RT, relative to FT. Reduced transverse stricture, and consequent increased glottal openness during this type of phonation, might explain the long, low rise of the Lx signal for breathy voice as shown in table 1, although the relatively long closing phase (and high RT/FT ratio) *after* base-line correction is the salient feature of whispery voice and breathy voice as shown in table 3.

There are two questions to consider in the light of these results. The first is whether RT/FT is independent of frequency. The results in table 2(b) suggest that RT/FT and frequency are independent, with five of the seven phonation types occurring within the same frequency range, 80 to 120 Hz., while exhibiting a somewhat linear relationship, except perhaps for MV, VV, HV, and WV, which are discriminated by RT/FT within the same frequency range of 100 to 120 Hz. In order to investigate this relationship more closely, it was necessary to conduct a second experiment, described below.

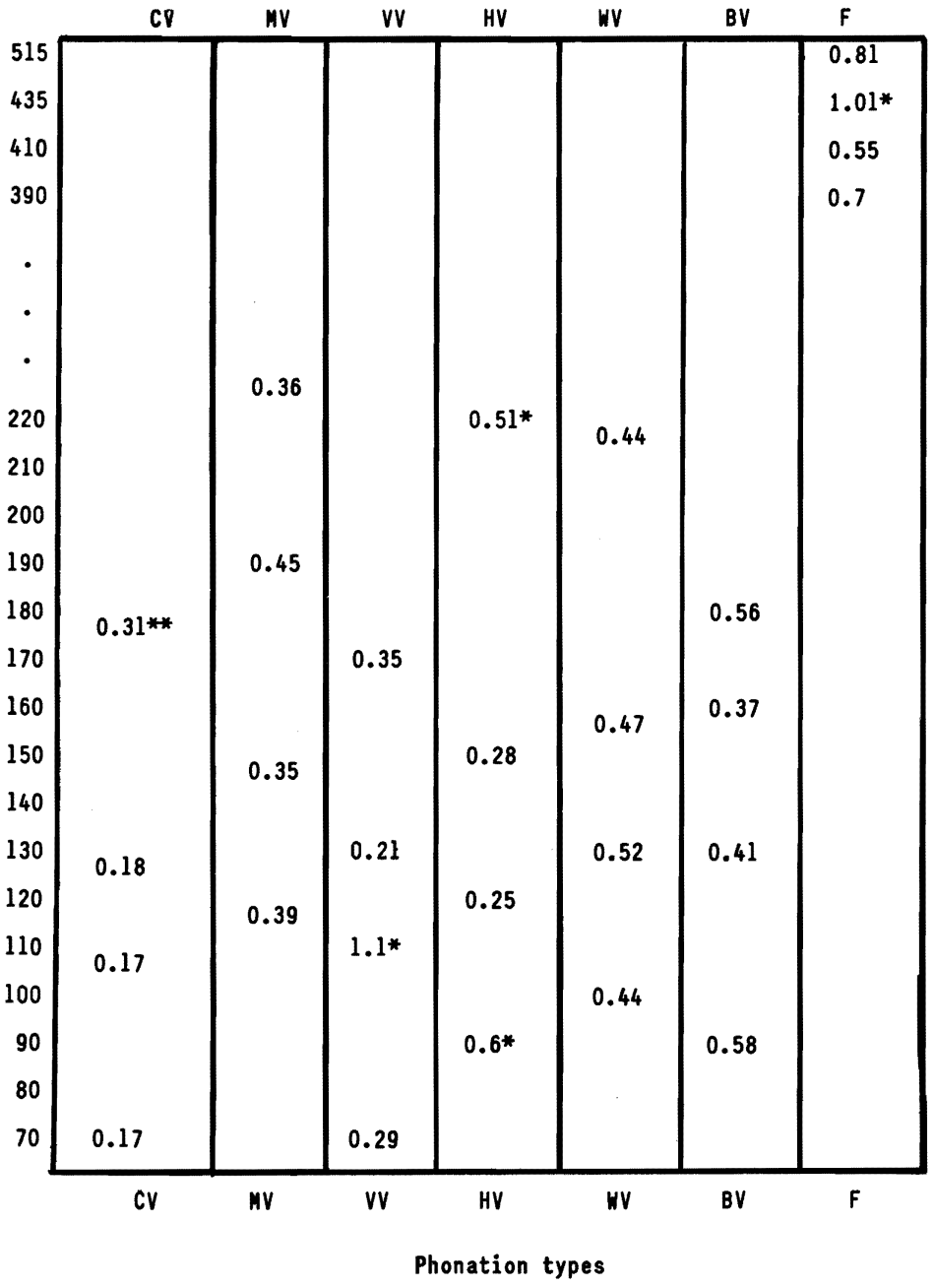


Table 4. RT/FT ratios at 4 frequencies for each phonation type

The second question to consider is whether another technique of measuring the Lx signal would produce similar results. Roach's (1977:54) calculation of rise-time over period-time (base-to-peak over time, BT/T) differs from the calculation of RT/FT used here, but results in low ratios for *creaky voice* and *tense voice* (around 0.3) with progressively higher ratios for *creak*, *normal voice*, *lax voice*, *murmur*, and *breathy voice* (approaching 0.7). If we suppose that tense voice corresponds auditorily to harsh voice or ventricular voice, and that lax voice is similar to whispery voice or breathy voice, then the distribution of RT/FT in tables 2 and 3 confirms Roach's findings for the measure BP/T. This supports the conclusion that RT, representing closing of the vocal folds, becomes slower as phonation becomes more whispery or breathy, and less creaky or harsh.

5.0 RT/FT AND FREQUENCY

In the second experiment, the subject produced the same primary phonation types as before, but this time controlling for frequency by rendering each type four times, increasing pitch each time. Lx was recorded on the FM data recorder and replayed as before into the oscillograph. At least ¼ sec. of each token was measured from the paper trace to obtain RT/FT.

Table 4 lists the RT/FT ratios for each of the four tokens of each phonation type, in the same order as in table 3, with frequency increasing from bottom to top. If RT/FT increased as frequency increased, we would expect to see an increase in the value of RT/FT for each phonation type as pitch increases. This, however, is not the case. For this relatively small sample of 28 tokens, there does not appear to be any tendency for RT/FT to increase as frequency increases. For creaky voice, for example, the first three tokens are practically the same over a range of 55 Hz. The fourth token at 175 Hz.** was evaluated auditorily from the tape-recording as diplophonic, a combination of two competing regular vibratory patterns resulting in a secondary peak in the waveform. Auditorily, this token was described as harsh creaky voice, a combination of creaky voice and harshness. Laryngographically, this token has a higher RT/FT ratio as well as the double-peak associated above with harsh voice and ventricular voice. This type of waveform has been observed before for creaky voice (Fourcin, personal communication) and I suspect that the explanation is that the phonation type being observed was in fact a slightly harsh variety of creaky voice.

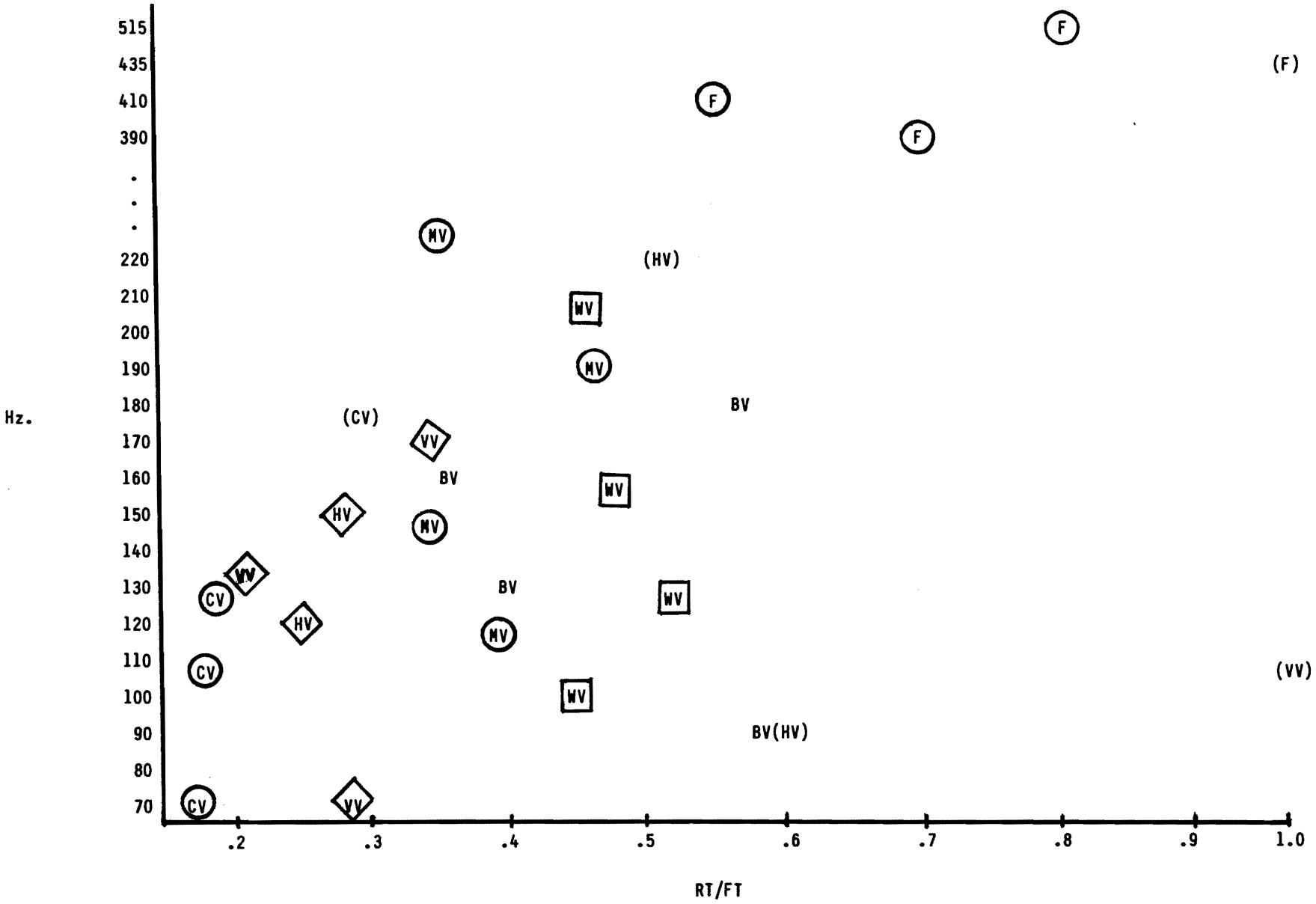


Table 5. RT/FT by frequency for 7 primary phonation types

The phase duration relationships for modal voice are also relatively constant over a 110 Hz. range. The single exceptional token of ventricular voice* exhibited a secondary peak *before* the principal peak of the waveform, which is not inconsistent with the shape expected for this signal but yields an inordinately long RT. The RT/FT ratios for harsh voice are almost the same as for ventricular voice, and the two exceptionally high values* also exhibit secondary peaks before the principal peak of the waveform. In any case, this phenomenon is clearly not due to frequency, because it occurred at both extremes of the frequency range for this phonation type. Whispery voice has consistent phase duration ratios over a 105 Hz. range. While breathy voice is less consistent, the RT/FT ratio at the bottom of the frequency range is practically the same as the ratio 90 Hz. higher. Falsetto, varying in frequency over 125 Hz., has a high RT/FT ratio at both ends of the frequency range; the exceptional token* having the pre-peak and exhibiting the auditory harshness characteristic of the abnormally high tokens of harsh voice and ventricular voice.

The consistency of RT/FT values up and down the vertical axis of table 4 presents a strong argument, therefore, that increasing frequency of vibration does not necessarily entail higher RT/FT ratios, that is, that the closing phase of the vibratory cycle does not necessarily become relatively longer. These results support hypothesis 1, that contrasting phonation types are distinguishable on the basis of laryngographic waveform shape, and support hypothesis 2, that changes in Lx waveform shape are not the result of changes in pitch.

6.0 RT/FT AND MODE OF PHONATION

Table 5 shows the distribution of phonation types in the second experiment, with frequency increasing vertically, and RT/FT increasing from left to right. The RT/FT values are those presented in table 4, with each token of each phonation type represented by an abbreviation, with exceptional values in parentheses. As in table 4, it is evident that tokens of the same phonation type fall within the same general range of RT/FT ratios, whether low-pitched or high-pitched. CV, MV, and F are circled for easy reference. VV and HV are enclosed in diagonals, and WV is boxed in. Creaky voice has a consistently low ratio up and down the frequency scale, 0.17 or 0.18, except for the single token of harsh creaky voice. Ventricular voice and harsh voice have slightly higher ratios, 0.2 to 0.35, with

three exceptions, distinguishable by their double-peaked waveform shape. Modal voice shows ratios between 0.35 and 0.45, overlapping somewhat with lower ratios of breathy voice or whispery voice. RT/FT ratios for breathy voice are split between near 0.4 and near 0.6, although results from earlier experiments, shown in table 2, suggest that the correct RT/FT relationship for this 'most open' type of phonation is the higher value, with a longer RT. Ratios for whispery voice are concentrated between 0.44 and 0.52, with little variation for frequency, and a fairly distinct target area especially at lower frequencies. Below 100 Hz., there is a clear distinction in RT/FT ratio between creaky voice, below 0.2; ventricular voice, near 0.3; whispery voice, near 0.45; and breathy voice, near 0.6. In the frequency range 115-130 Hz., near normal pitch for the subject in this case, creaky voice remains below 0.2; ventricular voice and harsh voice are both in the range between 0.2 and 0.3; modal voice is close to 0.4, as is breathy voice for this particular token; and whispery voice is near 0.5, higher than breathy voice at this frequency. Falsetto, always higher in frequency, ranges from near 0.6 to 0.8, higher than the RT/FT ratios of the other six primary phonation types.

7.0 CONCLUSIONS

Two separate systems of increasing laryngeal stricture are proposed to account for these results:

(A) a continuum of antero-posterior stricture for changing pitch, and

(B) a continuum of transverse stricture for glottal openness.

(A)	(B)
1. falsetto	1. breathy voice
	2. whispery voice
2. modal voice	3. modal voice
	4. harsh voice
3. creaky voice	5. ventricular voice

Because the laryngograph measures impedance and not glottal opening, these hierarchies describe laryngeal stricture or posture, not glottal aperture. Glottal aperture size, except as an effect of the laryngeal configuration in question, is not considered here.

The physiological basis for the laryngeal postures that characterize these phonation types is discussed in a fibre-optic study by Esling (1978:272-305).

Although RT/FT and frequency were shown not to be directly related for some phonation types, creaky voice, modal voice, and falsetto exhibit a linear relationship between RT/FT and frequency in a manner consistent with increasing antero-posterior stretching of the vocal folds for increasing pitch. Creaky voice is always lower in RT/FT ratio than any other phonation type, which suggests that fast RT, or rapid closing and slow opening of the vocal folds is associated with the antero-posterior shortening and slack vocal folds of creaky voice. Modal voice continues up the frequency scale where creaky voice stops, and the RT/FT ratio doubles, to about 1:3 or 1:2. Falsetto, high frequency, is highest in RT/FT, approaching a 1:1 ratio. The antero-posterior stretching and lengthening of the glottis for falsetto is assumed here to entail slow RT, or slower closing of the vocal folds, relative to FT. The thin, stretched vocal folds of falsetto open and shut in almost equal phases, where closing is only slightly faster than opening. Thus, in continuum A there is a relationship between frequency and RT/FT which conforms to a theory of three principal vocal 'registers' (Hollien, 1972) or phonation types. Table 6 shows the target areas in this linear relationship.

The second continuum of laryngeal stricture which accounts for the data reported here begins with breathy voice, with the least transverse laryngeal stricture, presumably equivalent to low medial compression, and consequently greatest glottal openness of vocal fold vibration. RT/FT ratios for breathy voice are nearly as high as for falsetto, while frequency is of course much lower, suggesting that frequency is not responsible for slow RT in this continuum. Instead, it may be that the antero-posterior length of the vocal folds during breathy voice is similar to their length for falsetto, keeping closing relatively slow (see Esling, 1978:286). For creaky voice, on the other hand, the antero-posterior bunching of the vocal folds may induce the rapid snapping shut indicated by the fast RT. This conforms with Catford's description of breathy voice where the vocal folds 'flap in the breeze' (1964:32), and with Roach's finding of a high BP/T ratio for breathy voice (1977:51-52). Whispery voice, the next step on the continuum, involves more stricture and slightly faster RT or closing. Modal (neutral) voice is in the middle of both continua, with the same ratio (0.4) found by Roach (1977:54)and Roach and Hardcastle (1979:207). If Roach's

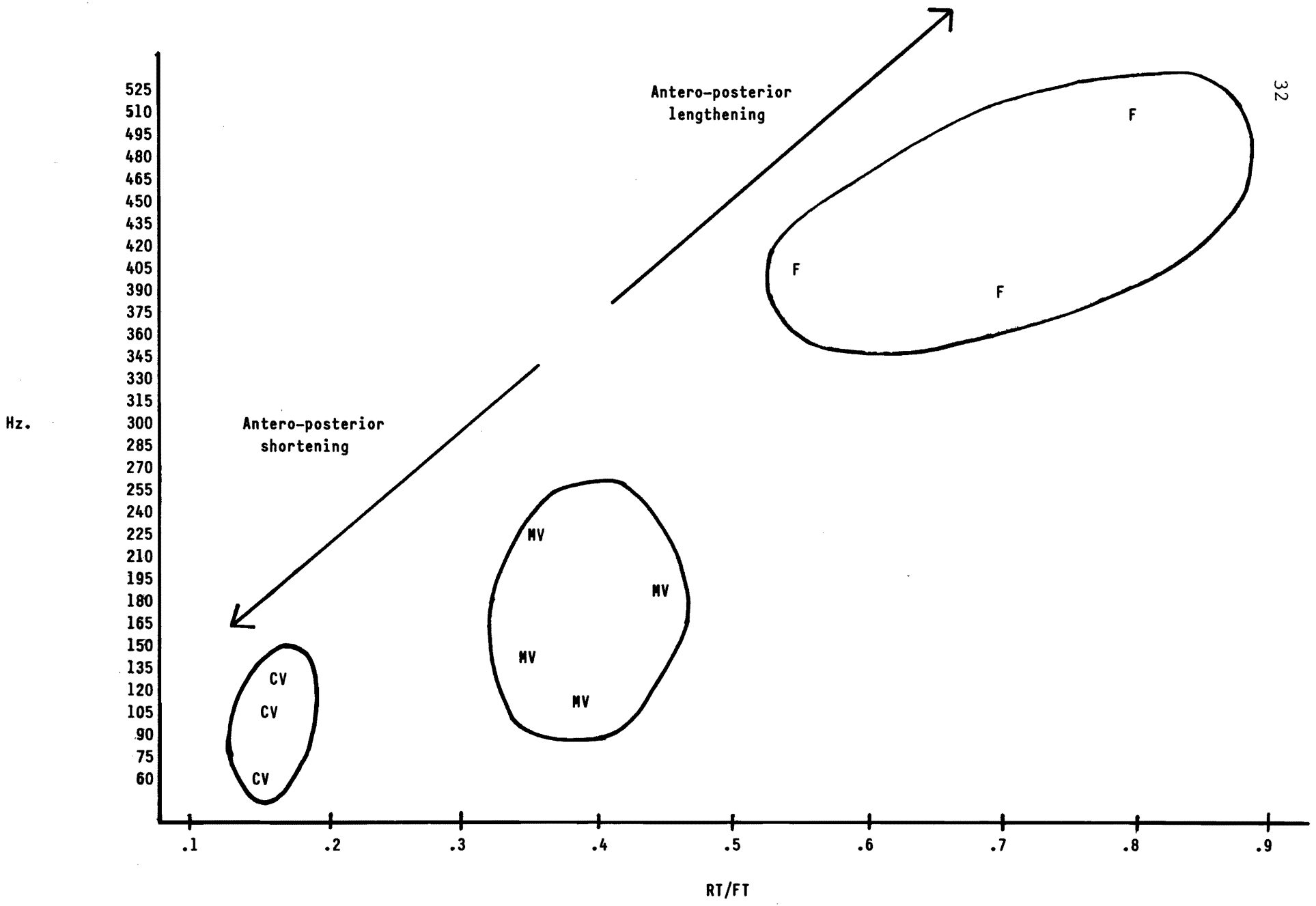


Table 6. Continuum A – Falsetto, Modal voice, Creaky voice

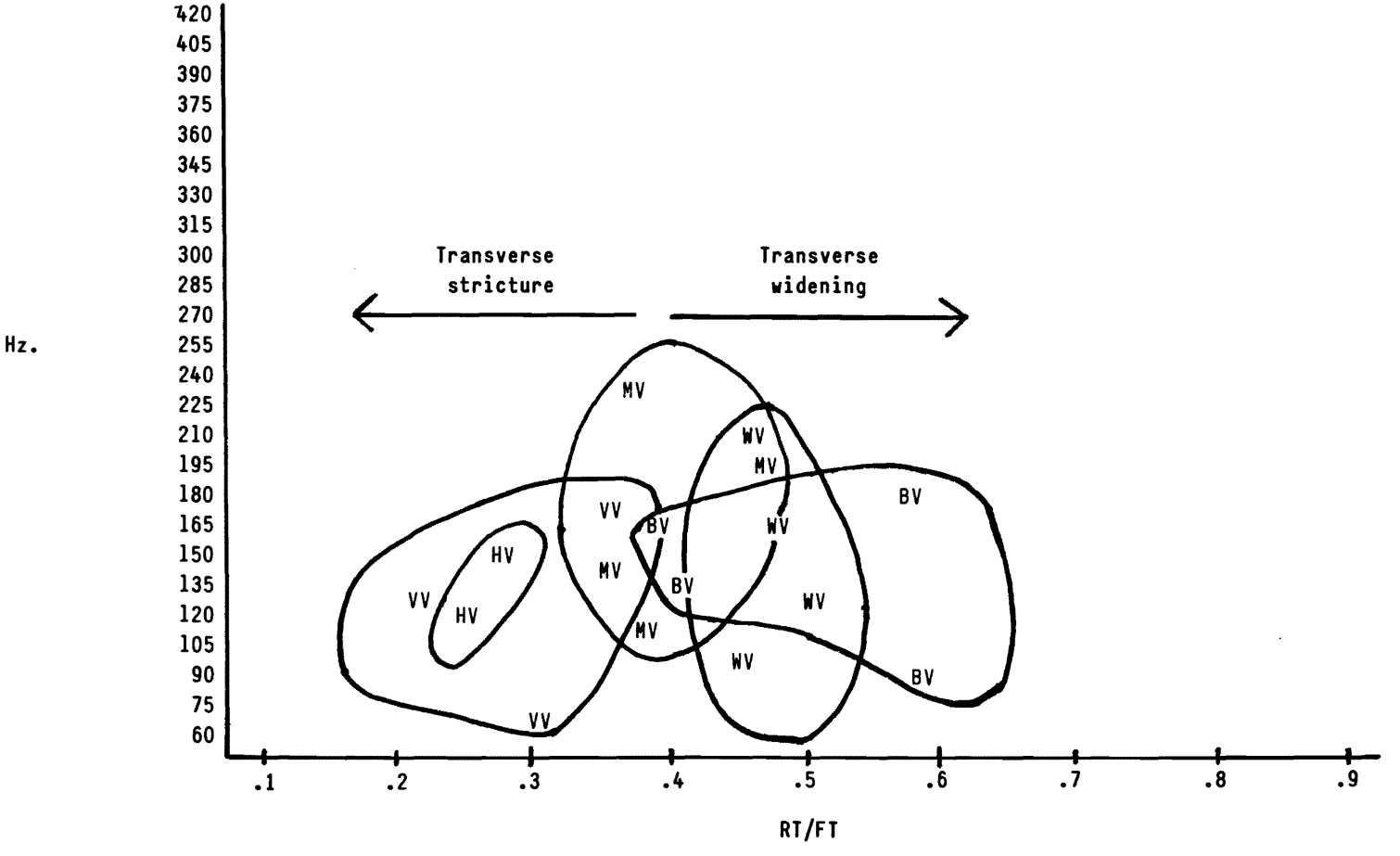


Table 7. Continuum B - Breathy voice, Whispery voice, Modal voice, Harsh voice, Ventricular voice

performance of breathy voice, murmur, lax voice, and normal voice reflect similar degrees of progressive laryngeal stricture to breathy voice, whispery voice, and modal voice as performed in this study, then these results corroborate Roach's findings.

Greater transverse laryngeal stricture along continuum B for harsh voice and ventricular voice tends to reduce RT almost to the speed of RT for creaky voice. This might be explained by the increased tension introduced over the glottis by the transverse stricture introduced in these phonation types, as described by Esling (1978:293-294). The direction of strictures is different from that which produces creaky voice, but the effect on vocal fold vibration seems to be similar, although never as profound as in the case of creaky voice. We are led to suspect similar muscular participation, such as the contraction of the vocalis, for both phonation types. Table 7 shows the horizontal, non-linear relationship of RT/FT ratios along the continuum of transverse narrowing and widening.

Despite the similarity of RT/FT ratios at the lower (most constricted) end of each continuum, the stricture appears to be of two different sorts, the product of different laryngeal configurations. Furthermore, creaky voice maintains consistently lower RT/FT values than harsh voice or ventricular voice, tending to confirm Roach's original hypothesis and hypothesis 3 of this study, that characteristics of Lx waveform rise-time and fall-time correspond to differences in mode of phonation, and that such a measure as RT/FT is useful in discriminating among phonation types produced with greater degrees of laryngeal stricture. The two configurational continua proposed here account for the data obtained using electrical impedance measurements, and demonstrate the usefulness of combining information on laryngeal structure with laryngographic information.

Equipment:

Electrical Impedance Laryngograph (University College, London)
T3000 Thermionic 4-channel FM tape-recorder
Siemens-Elema Mingograf 803
Oscilloscope

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The Effect of Downdrift on Major Phrase Intonation in Japanese

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Although the Japanese pitch accent system has been the subject of intense study over the years, the focus has been on the accentuation of what McCawley (1968) calls 'minor phrases'. These are relatively short phrases consisting typically of one content word and its encliticized postpositions, if any. Although certain types of minor phrases have resisted elegant analysis (notably those containing Sino-Japanese compounds), the accentuation of the majority is well known. A minor phrase contains at most one accent which is signalled by a precipitous fall in pitch after the first mora of the accented syllable. Only the location of the accent, if there is one, need be marked in the lexicon; the pitch pattern can then be derived by rule. (There are rules in the language which manipulate accents but by the time the pitch assignment rules apply there will be at most one accent per phrase.) The pitch assignment rules ensure that all moras up to and including the first mora of the accented syllable will be high pitched and all others will be low except that the first mora of the phrase will be low unless it is itself accented (McCawley 1968:137).

The focus on shorter constituents has meant that very little attention has been paid to the effect of intonation on the pitch patterns of minor phrases when they occur in longer utterances. Investigation of the interaction between accent and intonation profitably begins with longer utterances where variation in the actual pitch levels of concatenated minor phrases can be attributed to intonation. McCawley uses the term 'major phrase' to refer to phonological phrases which contain one or more minor phrases. McCawley found that, when a major phrase consists of more than one minor phrase, only the leftmost contains high pitch while the second and subsequent minor phrases 'only go up to mid pitch [138]'. McCawley chooses to account for this fall in pitch through the manipulation of accents prior to the application of the pitch assignment rules. The appearance of mid-pitch in non-initial minor phrases is, McCawley says, a consequence of an accent reduction rule which applies cyclically first to the minor phrases and then to the major phrases reducing all but the leftmost accent in each constituent.

Example 1 (McCawley 1968:173): *kabutte mitara*

'if (I) were to try putting on (a hat)'

	kabu'r	te	%	mi'	ta'ra
original accents	1		|	1	1
first pass through cycle:			|		
accent reduction	1		|	1	2
second pass through cycle:					
accent reduction	1			2	3

(' = accent; % = minor phrase boundary)

Later post-cyclic pitch assignment rules assign high pitch to all 1-accents, and mid pitch to all 2-accents. The 'tertiary accent' is not pronounced. No suggestion is made that the lowered pitch on the second minor phrase might be the result of phrase intonation and the handling of this phenomenon at the relatively high phonological level of accent manipulation rather than with a low level phonetic rule disguises the fact that it is intonation and not accent which is the reason for the decline in pitch. There are several things wrong with McCawley's analysis of the pitch patterns of major phrases, particularly to do with the erasure of minor phrase boundaries (see Shibatani 1972), but this paper will show that McCawley's analysis (and Shibatani's as well) makes the wrong predictions about the behaviour of pitch in some longer utterances. I believe that the phonetic facts suggest an intonational (phonetic) analysis rather than a phonological one. Such an analysis will account for these longer utterances as well as accounting for those which McCawley's accentual analysis handles adequately.

In major phrases consisting of only two minor phrases, such as Example 1, McCawley's analysis predicts the correct surface pitch pattern:

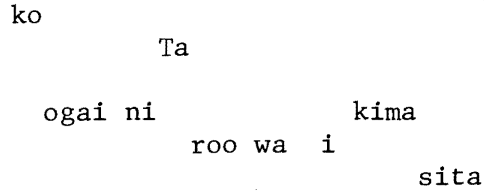
Example 1': bu
ta

ka tte mi ra

(McCawley's prediction as to the surface pitch pattern is correct in respect to the non-low pitches, he tells us nothing about the behaviour of the lows in such phrases.) The non-low pitch in the second minor phrase is lower than that in the first; this is McCawley's mid pitch. In major phrases consisting of more than two minor phrases McCawley's analysis cannot always predict the correct pitch pattern. McCawley explicitly states [138] that the mid pitch accent occurs on the second and subsequent minor phrases in a major phrase. Over the last two years I have subjected recordings of sentences obtained from native speakers of Japanese to an instrumental analysis which yields a trace of the fundamental frequency (F0) of the utterance. (Fundamental frequency is the primary acoustic correlate of pitch.) A careful examination of the F0 contours of longer utterances reveals that not only does pitch decline from the first to second minor phrase in a major phrase, it often declines over the length of the whole phrase. I suggest that this is the well-known pattern of F0 declination or downdrift which is found in many languages and which has even been suggested to have universal currency (Bolinger 1972). The effect of downdrift in Japanese can be seen from the examples below.

Example 2: *koogai ni Taroo wa ikimasita*

'Taroo went to the suburbs'



If we assume that this sentence consists of a single major phrase there is no way for McCawley to account for the fall in pitch from *Taroo wa* to *ikimasita*. Using McCawley's boundary symbols, @ for major and % for minor phrase boundaries, we can represent the above sentence as: *@koogai ni % Taroo wa % ikimasita@*. According to McCawley's accent rules there would be a 1-accent on the *ko* of *koogai ni* and 2-accents on *Taroo wa* and *ikimasita*. The pitch assignment rules would yield HMM since the pitch on the non-initial phrases should be the same, both at mid pitch. Another possibility is that there is no % between *Taroo wa* and *ikimasita* since these boundaries can be optionally deleted.

For *@koogai ni % Taroo wa ikimasita@* the accents would be 1-2-3 with the 3-accent not pronounced. The pitch on all the moras of *ikimasita* should then be interpreted as low since they follow the 2-accent on *Taroo wa*. The pitch rise from the first to second mora of *ikimasita* indicates that these moras are not all low and also indicates that the boundary must be there.

What if there is a major phrase boundary between *koogai ni* and *Taroo wa? @koogai ni @ Taroo wa % ikimasita@* would yield the correct pitch pattern on the second and third minor phrases, but it would not account for the fall in pitch from the first to the second; both *koogai ni* and *Taroo wa* should contain high pitches if there is a major phrase boundary between them. There is no placement of boundaries which results in the correct pitches being assigned to this sentence.

Example 3: *kyoo masaaki ga kusa o uma ni ataeru*

'Today Masaaki feeds hay to the horses.'

kyo sa

a sa

o ma o ma

ki (ku) u taeru

ga ni a

This is a slightly more complex example. While the fact that *kyoo* and *Masaaki ga* go up to the same pitch level suggests that there is a major phrase boundary between them, there is no placement of boundaries which will account from the steady decline in pitch from *Masaaki ga* to the end. The simplest explanation for the pitch contour of sentences like the above, and for McCawley's examples, is downdrift. Chew (1961:7ff) gives several examples that look much like Example 3 above and which also suggest that downdrift is the normal phrase intonation of Japanese. Of these he says,

> Within the same accent phrase each successive high pitch and low pitch is lower than the preceding one [7].

Chew puts no limit on the number of minor phrases which can occur in an accent phrase (=major phrase) — pitch declines

throughout the phrase. Chew uses this 'normal accent phrase' pattern as a tool for determining the location of major phrase boundaries and as an indication of their deletion in the case of his emphasis transforms (Chew 1961:Sec.14). If the pitches of a non-initial phrase are at the same height as they would be in utterance initial position then an accent phrase boundary must occur directly to the left of the non-initial phrase. This confirms the placement of the @ I proposed for Example 3. While Chew makes no specific mention of downdrift, it is clear from his discussion that downdrift would be a reasonable explanation for what he describes as the normal accent phrase.

Haraguchi (1977) does formulate a downdrift rule to account for the decline in pitch which characterizes major phrases, a very late rule which imposes a falling contour on the high and low pitches which are assigned to the moras of the utterance. Unfortunately, Haraguchi's downdrift rule cannot account for the pitch contours I have obtained in my research. While he admits that the example used by McCawley and Shibitani (Example 1 above) might have the surface pitch contour LHLLMLL in 'deliberate and relatively slow speech [30]', he claims that the most natural surface melody would be

bu

ka tte mi

tara

The high pitch on *mi* is lowered to the level of the low pitch of the preceding phrase and the low pitch on *tara* is lower still. In a major phrase in which the second minor phrase is medially accented, Haraguchi claims that a rise in pitch from the first to second mora of that phrase 'is crucially dependent on the presence of a pause in front of the initial mora [31]'. There is no evidence in my data that this pause is necessary. In fact, when one speaker, who spoke very deliberately, did insert pauses between phrases the resulting contour looked more like it was the result of the stringing together of major phrases with high sequences reaching the same level throughout the utterance. This could only be considered a very marked intonation contour which probably resulted from the recording situation. Normally people do not enunciate the words of a sentence so carefully with pauses in between each item. Most of my data consist of sentences

spoken at a careful but not especially slow rate. The non-initial highs do decline but not to the extent that they reach the level of immediately preceding lows and the non-initial minor phrases still retain a pitch rise from the first to second mora even without pause. It is possible that downdrift is a gradient phenomenon whose effect is determined to some extent by style and speed of speech but by insisting that highs downdrift to the level of immediately preceding lows, Haraguchi has put his case too strongly. The downdrift rule should simply state that each successive sequence of high and low pitches within a single major phrase will be realized at a lower pitch than the preceding one. In extreme cases this might result in highs being realized at the same pitch as immediately preceding lows.

It is worth saying something here about the function of downdrift in Japanese. The decline in pitch in major phrases knits together the elements of the phrase. A break in the line of declination indicates, as much as pause, the presence of a major phrase boundary. Example 4 exhibits just such a break in the intonation contour.

Example 4: *kyoo otoko wa kusa o uma ni ataeru*

'Today the men feed hay to the horses.'

kyo

sa

toko ma

o o u tae(ru)

o wa (kụ) ni a

The decline in pitch from *kyoo* to *otoko wa* and the abrupt rise in pitch from *otoko wa* to *kusa o*, even though it does not rise to the level of *kyoo*, suggests the following boundary placement *@kyoo % otoko wa @ kusa o % uma ni % ataeru@*. Downdrift applies to both major phrases and the break in the line of declination indicates the major phrase boundary.

There is some evidence to suggest that the decline in pitch which characterizes major phrases in Japanese may also be involved in the achievement of sentence prominence. Warkentyne (1978) claims that in Japanese, 'the pause group consists of a series of accent phrases, the last of which contains the primary

accent [219]'. Warkentyne's accent phrase corresponds to my major phrase and his pause group to some larger unit which can contain more than one major phrase. Speakers of Japanese can place major phrase boundaries, without resorting to pause, in such a way as to bring different sentence elements under the primary accent. If the line of pitch declination is reset this indicates that a major phrase boundary occurs at that point. Warkentyne believes that the initial minor phrase in the major phrase which contains the verb is the one with the most prominence. In Example 4 above *kusa o* would be prominent. Chew (1961) in his discussion of emphasis transforms in Japanese suggests something similar [89ff]. Since word order is relatively free in Japanese, this means that by manipulation of the order of minor phrases and the placement of major boundaries, prominence can be achieved without resorting to anything other than normal phrase intonation.

I have tried to show, based on acoustic phonetic data, that a phonetic rule of downdrift is preferable to McCawley's accent rules in accounting for the pitch patterns of major phrases in Japanese. My data also indicate that the downdrift rule proposed by Haraguchi is too strong, though it may account for some pitch patterns found in very rapid speech. Finally I suggest that downdrift will indicate where major phrase boundaries occur in longer utterances without the need for pause and also speculate that a normal phrase intonation characterized by downdrift, together with boundary placement, is sufficient to signal prominence in Japanese.

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The Effect of Bias on Ambiguity Detection in the Presence of Context*

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1.0 INTRODUCTION

The prime candidate for resolution of the multiple-reading/single-reading debate in the processing of sentential ambiguities would seem to be context (for a more complete discussion of the dimensions of the single-reading vs. multiple-reading question in ambiguity research, see Kess and Hoppe, 1981). However, to date the role of context has not been sufficiently explored so as to plumb the depths of its contribution, nor has much effort been made to grade the degrees of bias that contextual constraints might offer. This study offers one aspect of the answer to ambiguity resolution by inquiring whether the presence of preceding context so limits the reading options on an ambiguous sentence that one of the readings is automatically ruled out.

To date the experimental results from psycholinguistic experiments in ambiguity have often been equivocal, favoring now the single-reading hypothesis and then the multiple-reading hypothesis. Some attempts have been made to provide an overview resolution of the seeming discrepancy in the results by positing an in-sentence strategy that is dependent upon phrasal closure (see Bever, Garrett, and Hurtig, 1973), but those have been directed at explaining ambiguity results in single, and thus isolated, sentences. More recently, attention has been directed at providing contexts for ambiguous sentences in an attempt to see whether the presence of context does make for single-reading processing rather than multiple-reading processing of such ambiguous sentences.

The present study is directed at the role of context in resolving

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ambiguity with an eye to seeing whether readings are still processed in the presence of context. One might speculate that an answer to the ambiguity controversy might be provided by the definitive role of contextual constraints in removing the possibility of a second or multiple readings for ambiguous structures. Thus, if such contextual settings do provide for such severe contextual constraints, one might argue that many of the results supportive of the multiple reading interpretation are merely the result of dealing with isolated sentences or sentences in which the context was not sufficiently spelled out by more than a single preceding word. While this methodological approach of employing single sentences was largely congruent with the generativist-inspired approach to language analysis in linguistic research, it is not the most effective in dealing with natural language inferences which demand a larger discourse to replicate actual language settings. It is obvious that this is an area which must be more fully investigated before we can claim to understand sentence processing. Some understanding of the ambiguity results reported to date must take this fact into consideration. If ambiguity does prove to be highly sensitive to certain contexts, then previous experimental results may be interpreted in light of the type and extent of context provided.

Even so, the results of current experiments which inquire into ambiguity resolution in the presence of context are divided. Like the work with ambiguous sentences in isolation, some experiments are supportive of a single reading interpretation as a result of context, while others are still suggestive of a multiple reading interpretation despite the presence of context. For example, Foss and Jenkins (1973) still found differences with ambiguous sentences which were biased with a single context-bearing word embedded in the sentence itself. (It might be noted that the Foss and Jenkins study is an elaboration of the phoneme monitoring paradigm which was introduced into the study of ambiguity by Foss (1970) as a technique for measuring processual differences between ambiguous and unambiguous sentences. Two recent experiments (Newman and Dell, 1978, and Mehler, Segui, and Carey, 1978) have questioned the usefulness of the results of the phoneme monitoring technique in the study of ambiguity.) Lackner and Garrett's (1972) persuasive but operationally difficult dichotic listening experiment showed that subjects consistently paraphrased the ambiguous sentence in a manner consonant with a disambiguating sentence presented to the unattended ear. Mistler-Lachman's (1972) depth-of-comprehension tasks served to demonstrate that not all tasks need be ambiguity-sensitive, but her work also suggests that ambiguity does indeed

slow processing time when it does not have an effect. Thus, deciding whether a sentence follows from context does require a reading sufficient to make an interpretation of the foregoing context; so also does trying to make up a sentence to follow from context.

In investigating the role of context for lexically ambiguous sentences, Holmes, Arwas, and Garrett (1977) note two findings that show ambiguous words to be more difficult in processual terms, regardless of the presence of a single-word preceding lexical context. In general, ambiguous words were reported less often than unambiguous words, and ambiguous sentences were judged to be meaningful more slowly than their unambiguous counterparts. Work by others (for example, Conrad, 1974) also seems congruent with the multiple-reading hypothesis of how ambiguous sentences are dealt with, though their experimental design is somewhat less germane to the relationship between context and ambiguity resolution.

On the other hand, some experimental results do show support for a single-reading interpretation of ambiguity. Swinney and Hakes (1976) found that context did negate processing differences between ambiguous and unambiguous sentences. They also found, however, that lexically ambiguous words preceded by a neutral context showed significantly longer reaction times in monitoring for target phonemes in their phoneme monitoring task. Suls and Weisberg's (1970) experimental note on word association responses generated from ambiguous sentences with preceding paragraph context also show results compatible with a single-reading approach. Several other context-simulated experiments (for example, Perfetti and Goodman, 1970, and Tyler and Marslen-Wilson, 1977) show results which can also be taken as supportive of a single-reading approach.

It may not be, of course, that context automatically selects one reading exclusively over the other in all cases. Cairns (1973) has suggested that the bias of an ambiguity is what may lead to the processing of two meanings, if this takes place, instead of reprocessing effects. The more equal the two readings are in terms of their resolutional bias, the higher the probability that both readings will be considered at the time of processing. Such probability must be seen in the light of local biasing conditions within the sentence in Cairns' discussion, but one can expect that the same will be true of context and its relationship to the sentence in question as well. Thus, not all contexts, large or small, will automatically provide the

selection of a single-reading to the exclusion of a second reading. It may be that even a paragraph-long context will not provide sufficient key context to lead to a single-reading interpretation immediately, and thus a multiple-reading interpretation may still be considered. This interpretation is also congruent with hierarchy of sensibility and canonical ordering suggestions made elsewhere (see, for example, Oden, 1978, and Hogoboam and Perfetti, 1975), and may serve to modify the discussion to other than an all-or-none answer in resolving the single-reading/multiple-reading question.

Lastly, the multiple-reading interpretation seems to run counter to the idea of intersentential information and subsequent integration into a unified whole. Sentences are typically linked to some kind of meaningful context. They are then integrated with other information in a meaningful whole, so much so that if a meaningful theme is not present, it may even be invented. Moreover, sentences which are otherwise unrelated and thus meaningless may even by unified under a given semantic theme. There is a good deal of evidence from inference (Bransford and Franks, 1971; Bransford, Barclay, and Franks, 1972; Bransford and Johnson, 1973) and memory studies (Loftus and Loftus, 1976; Loftus, 1979) that what is thought to be seen or heard is as important as what was actually seen or heard in constructing scenarios for storage and subsequent retrieval. The rate of ambiguous sentences in such scenarios has not been addressed in terms of where they fit in more general terms of processing and inferential strategies.

Inference studies of this type clearly point to the fact that the information inferred by preceding input, pragmatic or sentential, is just as real in establishing expectations as is the information formally presented by the individual sentence itself. One cannot help but note that the multiple-reading interpretation seems at odds with this set of observations. Moreover, a view of context as providing constraints on possible interpretations is also more congruent with the given-new hypothesis (see Haviland and Clark, 1974). Here the listener or reader is characterized as actively seeking out the new information which is embedded in the immediate sentence given to him, presumably matching it up with what has transpired before in preceding input. The processing of such new information is actively matched against old information, with the latter serving as the referential backdrop against which the new information is measured. One expects that new information would be matched with preceding old information, at least along general

guidelines, rather than having the two or more readings of the ambiguous sentence tabulated for comparison each time. While such exhaustive tabulation may be the case for single sentences in isolation, it is another question whether it holds true for sentences embedded in context.

2.0 METHOD

2.1 Subjects

Sixty University of Victoria students participated in the study, 30 males and 30 females. Their names were selected from the Department of Psychology's subject pool of volunteers, and they chose to participate in the experiment when contacted by the experimenter.

2.2 Sentences and Contexts

The experiment involved the detection of two meanings of an ambiguous sentence under three different conditions. In two of the conditions the sentences were preceded by a context, and in the third condition the sentences were presented alone without any prior context.

The sentences were chosen from a collection of ambiguous sentences which had been used previously in the studies of ambiguity and which the evidence suggested were not strongly biased so that one meaning was much more likely to be seen than the other meaning. Also, the sentences chosen were similar in length, ranging from six to nine words. There were 21 sentences used in the main experiment; seven were lexically ambiguous, in seven the ambiguity was of the surface type, and in seven the ambiguity was in the underlying structure. There were also eight practice sentences where each kind of ambiguity was present at least once.

For the contexts approximately 70-word paragraphs were constructed. One context was written to dispose the subject to see one meaning of the sentence, arbitrarily labelled context A, and the other context was set for the other meaning of the sentence, context B. Attempts were made to devise meaningful neutral contexts which did not provide any bias one way or the other, but this was found to be impossible to do, and for this reason a neutral context condition was not included in the experimental design.

Sentences which were ambiguous on the lexical, surface structure, and deep structure levels were tested for their susceptibility to domination by context. Lexical ambiguity is simply the result of words having more than one meaning, as for example, paper in He read the paper. Surface structure ambiguity, on the other hand, is the result of two distinct sets of hierarchical syntactic relationships being shown by the same surface linear arrangments, as in The tribal custom regarding old men and women was known to all. Finally, deep or underlying structure ambiguities are the result of two distinct sets of logical relationships being shown by the same sentence, as in Visiting relatives can be a nuisance.

2.3 Contextual paragraphs

Each ambiguous sentence was preceded by a full paragraph of context which attempted to limit the reading of the ambiguous sentence to only one reading. The ambiguous sentences were taken from previous experiments in the ambiguity literature. The context paragraphs were on the average 72 words in length and were provided for each of the three types of ambiguity. For example, for the lexically ambiguous sentence He wears a light suit in the summer, the following two paragraphs were provided. The first paragraph of context suggests the reading to be His suit is of a light weight in the summer, while the second paragraph of context instead suggests that the reading should be His suit is of a light color in the summer. The paragraphs are as follows:

He wears a light suit in summer = His suit is of a light weight in summer.

> Mr. Jones has many suits in his closet. Mainly, they are heavy, dark woolen suits that he feels are suitable for a man in his position. But as soon as the weather grows milder, Mr. Jones takes another look into his wardrobe to find something more comfortable. Something suitable, yet not too heavy and warm. He likes to wear linen suits when the weather permits. He wears a light suit in summer.

He wears a light suit in summer = His suit is of a light color in summer.

> Mr. Jones feels that heavy woolen suits should be of dark colors like black and brown and blue. He thinks that these colors set the mood of winter perfectly. But, as soon as warm weather comes, Mr. Jones looks like another person. His suits are always linen in light, bright hues. His favourite colors for spring and summer are light blue, beige, and white. He wears a light suit in summer.

Similarly, the ambiguous surface structure sentence The doctor saw the old Indian dance is provided with a context which limits the readings to either a sentence in which the meaning is clearly inclusive of the theme The dance was an old Indian one or The old Indian was dancing. The contextual paragraphs are as follows:

The doctor saw the old Indian dance = The dance was an old Indian one.

> As an anthropologist, Doctor Barnes' major area of research was the songs, dances, and music of the American Indians. Although he had seen and collected data on thousands of dances, there was a very old one which he had not seen. By chance, he found it was performed by a small Western tribe once every five years. He got to their camp just in time. The doctor saw the old Indian dance.

The doctor saw the old Indian dance = The old Indian was dancing.

> Although there was nothing really wrong with the old Indian, he had convinced himself that he had little time left to live. His doctor assured him that he was in fine physical condition, but the old Indian would not listen. The Indian remained in bed for many weeks until, one day, the doctor heard a phonograph playing. The doctor was astonished when he walked into the room. The doctor saw the old Indian dance.

Finally, the deep structure ambiguous sentence The mayor requested the police to stop drinking is limited to the two interpretations of The mayor wanted the police to enforce

anti-drinking regulations or The mayor thought the police drank too much by the appropriate contextual paragraph. The paragraphs are as follows:

The mayor requested the police to stop drinking. = The mayor wanted the police to enforce anti-drinking regulations.

Night after night, the city had been torn apart by drunken brawls. Drunken driving was such a problem that any driving was dangerous. The churches banded together to oppose the free beer being given away at all the local pubs. A committee of concerned citizens demanded a meeting with the mayor. Their appeal was favorably received. The police chief was called to city hall. The mayor requested the police to stop drinking.

The mayor requested the police to stop drinking. = The mayor thought the police drank too much.

The city council was adamant. The police force must do everything it could to win back the respect of the people. They had bought new, faster cars, dressed the men in impressive new uniforms. They even increased the policemen's salaries. But still the citizens jeered at them and refused to obey. Perhaps the police force would have a better image if they behaved better. The mayor requested the police to stop drinking.

2.4 Procedure

When the subjects arrived for the experiment, they were told that it was an experiment dealing with ambiguity and that they were to detect two meanings of an ambiguous sentence as quickly as possible.

There were two context conditions; in one the ambiguous sentence was preceded by context A, and in the other it was preceded by context B. The context was presented by having the subject pick up and read a paragraph card on which the context was typed. This was followed by the subject picking up a sentence card, turning it over, reading the sentence, and saying "Yes" when two meanings of the sentence were seen. The experimenter timed how long it took the subject to say "Yes" after turning the sentence card over. This was the detection time for the sentence

for that subject (even though the time involved both the reading time of the sentence as well as the time it took to detect two meanings). Immediately after saying "Yes", the subjects reported the two meanings of the sentence they saw, reporting first the meaning that was seen initially and then the meaning that was seen subsequently. Subjects were given 90 seconds to see two meanings. If they failed to see two meanings, their detection time was recorded as 90 seconds, and they gave the one meaning they saw and were told the second meaning of the sentence.

In the no context condition the subjects simply picked up a sentence card without any previous paragraph card, and the rest of the procedure was the same as that for the context conditions.

In both conditions the eight practice sentences were presented first — those in the context conditions were preceded by a context, and the subjects were given a chance to ask questions after which the 21 experimental sentences were presented. Following this the experiment was explained to the subjects before they left.

Twenty different subjects, 10 males and 10 females, participated in each of the three conditions. Each subject received all of the sentences, the lexically ambiguous, those ambiguous in surface structure, and those ambiguous in the underlying structure, presented in a random order, and each subject received a different random order. While each subject saw the same sentences, the difference between subjects was whether the sentences were preceded by context A, context B, or no context.

3.0 RESULTS

The essential datum collected from each subject was the time it took him or her to detect two meanings of each sentence. The number of instances where two meanings were not seen did not seem excessive: 46 of 1260 detections, or less than four per cent.

Median detection times for each subject for each type of ambiguity, lexical, surface, and underlying, were taken as the basic datum for the first analysis of the data. The data were submitted to a 3X2X3 ANOVA with repeated measures on the last factor. The first factor was context A, context B, or no context; the second factor was sex, and the third factor was type of ambiguity, lexical, surface, or underlying. The results indicated that the context was significant ($F = 6.88$, $df = 2, 414$, $p < .01$), sex

was marginally significant ($F = 5.20$, $df = 1,414$, $p = .023$), type was significant ($F = 11.30$, $df = 2, 828$, $p < .001$), and the interaction between context and type was also significant ($F = 6.35$, $df = 4, 828$ $p < .001$). An examination of the means (of the medians) indicated the following: Contexts A and B tended to produce faster recognition times than no context except for lexical ambiguity where context A showed faster recognition times than no context, but context B showed slower recognition times than no context. Females tended to show slightly faster recognition times than males. The underlying type of ambiguity was easiest to detect, lexical was the next easiest, and surface the most difficult to detect.

The differences between context A and B were puzzling since there was nothing systematic in choosing whether a context was labelled A or B, and the placement as context A or context B was arbitrary. It was believed that perhaps the initial bias of the ambiguous sentence without any context might interact with context in a way that would influence the detection time even though the sentences were chosen so that they should not be strongly biased toward one meaning or the other. Contributing to this belief was the fact that it was difficult, if not impossible, to select ambiguous sentences where one meaning was as equally likely to be seen as the other. We could only pick those that were relatively unbiased.

Therefore, all the sentences in the no context condition were examined to determine which meaning was given first — an indication of the bias of the sentence. Proportions of subjects who saw meaning A versus meaning B were calculated, and it was found that in no instance was one meaning given as the first meaning equally as often as the other meaning. In some cases meaning A or meaning B was seen first by over 80 per cent of the subjects. The data suggested that each sentence had some initial bias when presented without a context.

The second analysis examined the influence of the context, depending upon whether the context favored the bias of the sentence or was against it. That is, what was the effect when the meaning of the sentence that was cued by the context was the same or different from the meaning of the sentence that was given first by a majority of subjects in the no context condition? In order to accomplish this, means for each subject for each type of ambiguity — lexical, surface, and underlying — were calculated for those instances when the context favored the bias of the sentence. Means were also

calculated for each type for those that were against the bias of the sentence as well as when the sentences were presented without any context. There were essentially two types of sentences, those where a majority gave meaning A first and those where a majority gave meaning B first. These sentences were unsystematically distributed among the conditions that received context A, context B, or no context. Recall that subjects were tested with context A or context B or no context, and within these conditions each subject received three types of ambiguous sentences. This necessitated a 2X3X2X3 ANOVA with repeated measures on the last factor. The factors were: sentence bias, A or B; context biased in favor of, against, or no context; sex; and ambiguity type, lexical, surface or underlying.

The results indicated the following: Sentences biased in the A direction produced significantly faster detection times than sentences biased in the B direction ($F = 12.58$, $df = 1, 108$, $p < .001$). When the context was against the bias of the sentences, the detection times were significantly faster than when there was no context or the context favored the bias of the sentence ($F = 6.38$, $df = 2, 109$ $p < .01$). Females were not quite significantly superior to males ($F = 3.10$, $df = 1, 108$, $p = .08$). The differences in the type of ambiguity were similar to the first analysis where the fastest detection times were when the ambiguity was in the underlying structure, the next fastest were for lexical ambiguity, and the slowest was when the ambiguity was in the surface structure ($F = 11.91$, $df = 2, 216$, $p < .001$). The interaction between the type of ambiguity and bias of the sentence, A or B, was significant ($F = 6.81$, $df = 2, 216$, $p < .01$), indicating that while the above order of ease of detection was true for the A sentences, it was not so for the B sentences where the surface ambiguity was as easy to detect as the lexical ambiguity. The interaction between the type of ambiguity and whether the context was in favor of or against the bias, or no context was present, was also significant ($F = 11.8$, $df = 4, 216$, $p < .001$). This suggested that while detection times were faster when the context was against the bias of the sentence for lexical and underlying ambiguity, this was not the case for surface ambiguity. The nature of this interaction can be seen in Table 1. Table 1 presents the means when sex and sentences A and B are combined. An inspection of the table can illustrate some of the findings mentioned above regarding the significance of the main factors.

Table 1

Mean Detection Times

		Type of Ambiguity			
		Lexical	Surface	Underlying	Total means
Context	Favoring bias of sentence	19.20	11.93	9.62	13.58
	Against bias of sentence	6.54	13.62	5.92	8.71
	No context	9.27	20.72	13.36	14.45
Total means		11.67	15.42	9.65	

4.0 DISCUSSION AND CONCLUSIONS

Instead of context limiting the availability of two readings of ambiguous sentences, the evidence suggests the continuing presence of two readings. Subjects were typically able to retrieve two meanings for sentences despite the presence of context which specifically called for only one reading.

The results suggest that sentences have an inherent bias. A majority of subjects saw one meaning as opposed to the other meaning of the sentence in the absence of context. Furthermore, as a consequence of this, when the context is in line with the more common meaning of the sentence, then it takes longer to elicit the second reading of the ambiguous sentence. On the contrary, when the context is in line with the less common reading of the sentence, recognition of the other reading exhibits shorter detection times. It is as if the less common reading of the sentence was provided by the context while the more common reading is automatically provided by its a priori biased status. If the two readings of ambiguous sentences were roughly equal in terms of their bias, then one would not expect to see significant differentiation in the detection of one reading as opposed to the other reading in the presence of context.

These results are consistent with the canonical access modification of the multiple-reading approach to ambiguous sentence processing. Sentences are decoded in an ordered

access fashion with the inherent biased reading of the sentence playing a role as well as the context. Thus, for example, when the context provides for the second reading, the normal avenue of considering the first is bypassed. Hogaboam and Perfetti (1975) found similar support for a canonical access model when subjects were asked to decide whether an ambiguous word in a context had another possible meaning. When the context required a secondary sense of the word, decision times were faster than when the context required the primary sense. If sentences were roughly equal in terms of their biasing, one would also expect them to be roughly equal in their detection times. Moreover, the influence of context should stand in direct relationship to the reading of the sentence. A context should elicit the intended reading of the sentence first, as was the case here, and then the second reading would be detected within an average time span. One would not expect to find significant differences for second readings in that time range.

Generally, while one can say these results can be taken as consistent with the multiple reading hypothesis, the processing of ambiguous sentences is not as simple as just entertaining two readings for an ambiguity. A realistic explanation of what goes on will call for attention to the interaction between context and the inherent bias of the sentence.

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The Evolution of the Nisgha Counting System: A Window on Cultural Change*

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1.0 INTRODUCTION

The Tsimshianic[1] languages all have a complex system of numeration, with different sets of numerals depending on what is being counted. In most cases the forms clearly derive from a basic set used for abstract counting, but the forms of the latter are not immediately analyzable. They do, however, show evidence of being themselves complex forms, especially in Nisgha (N), and Gitksan (G). Many words which are opaque in Coast Tsimshian (CT) have more readily analyzable Nisgha and Gitksan cognates;[2] the numerals are no exception.

The similarities that exist between some of the Nisgha numerals, and between the numerals and other forms in the language, make it possible to reconstruct probable derivations for most of them, especially the set used for abstract counting. The literal meaning of the reconstructed forms throws light on the manner in which the number system must have developed, and on the diverse influences that helped shape it.

2.0 NISGHA NUMERALS AND THEIR MEANINGS

There are four sets of Nisgha numerals; the categories are: objects or abstract counting, animals and fish, people, and canoes,[3] as given in Table I.[4] Boas (1911) gives more categories of numerals, but some of these are actually measures, which are nouns, while numerals have their own syntactic properties, most of which are shared with adjectives and intransitive verbs.[5] Nisgha measures are given in Table II, which is probably not complete.

The four sets of numbers in Table I agree[6] with those in Boas' (1911:396-7), with one major exception: he gives the numerals in column I under the headings 'round objects' and 'long objects',

and the ones in column II under the heading 'flat objects, abstract counting'. No mention is made of animals and fish, even though column II numerals appear in Boas (1902) in connection with words designating animals and fish as well as flat objects.

It is likely that the numerals in column I were used not so much for living animals as for their skins, an item of trade long before European contact, and by extension objects with similar uses and characteristics, such as mats, blankets, and clothing. The original Nisgha distinction was probably between 'animals, skins and equivalents' and 'objects in general', rather than between flat and non-flat objects. Since skins must have been at one time the most frequently counted items, there may have been confusion in some speakers' minds as to whether abstract counting or counting of skins was taking place.[7]

One case where the confusion has not been resolved concerns the proper classification of the forms yuxʷtáɬt and qantóːɬt, both meaning 'eight'. In placing yuxʷtáɬt in column I and qantóːɬt in column II, in agreement with Boas and with the CT cognates (Dunn p. 38), I have been guided mostly by my own interpretation of the original meanings of these words. Many Nisgha speakers would agree with this placement, while others would place qantóːɬt in column I and yuxʷtáɬt in column II, the order given in the Gitksan Primer.

There are obviously some common elements within the numerals:

- except for 'two', all the 'human' numerals have some similarity to the column I forms; most of them end in -óːɬ;
- all forms for 'one' begin with kʸ-, and so does one of the 'ten' forms;
- all forms for 'three' begin with kʷiɬ-;
- the forms for 'five' and 'nine' all begin with kʷst-;
- the forms for 'seven' start like one of the 'two' forms and end like those for 'six'.

The following sections examine the numerals in more detail, though not necessarily in order.

	I Abstract counting, Objects	II Animals	III People	IV Canoes
1	kʸíl	kʸé:kʷ	kʸó:l	qaméʔet
2	kʸílpil	tipx̌á:t	paqatíl	qalpéltkʷs
3	kʷilál	kʷilán	kʷiló:n	kʷiláltkʷs
4	tx̌álpx̌		tx̌alpx̌tó:l	tx̌álpx̌kʷs
5	kʷstíns		kʷstinsó:l	kʷstínskʷs
6	qó:lt		qo:ltó:l	qó:ltkʷs
7	tipx̌ó:lt		tipx̌o:ltó:l	tipx̌ó:ltkʷs
8	yux̌ʷtáłt	qantó:lt	yuxʷtaltó:l	yuxʷtáltkʷs
9	kʷstimó:s		kʷstimo:só:l	kʷstimó:skʷs
10	xpíl	kʸáp	xpó:l	kʸápkʷs

Table I: Nisgha numerals

	Fathoms		Spans	Fingerwidths	Periods of Days	Bundles of ten skins (Boas)
	Boas	Aiyansh				
1		kʸilq̓á:x	kʸilsáq̓ans	kʸílsti:		kʷi:skʸiwá
2		kʸilp̓ilq̓á:x	kʸilp̓ilsáq̓ans	kʸílp̓ilsti:		kʸilpwá
3	kʷilalʔún	kʷilalq̓á:x	kʷilalsáq̓ans	kʷilálsti:		
4	tx̌alpx̌alún	tx̌alpx̌q̓á:x		wax̌ʔúnkʷs	tx̌alpx̌sá:ta	
5	kʷstinsilún	kʷstinsq̓á:x				
6	q̓o:l̓tilún					
7	t̓ipx̌o:l̓tilún					
8	y̓uxʷtal̓tilún					
9	kʷstimo:silún					
10	xpaʔúnti:	xpaʔún			xpisá:ta	

Table II: Nisgha measures (partial list)

2.1. One

In columns I, II and III all forms begin with ˈkʸ-:

I	ˈkʸíˈ	(object)
II	ˈkʸéːkʷ	(animal)
III	ˈkʸóːˈ	(person)

So do a number of other words all having to do with singularity, for instance

ˈkʸáːˈ	'to be one-eyed'
ˈkʸéːx̌kʷ	'to flee (sg)' (the plural is suppletive, hú:t)
ˈkʸéːq̓an	'to put one animal to flight'
ˈkʸóʔ	'backbone of a fish'
ˈkʸóːc	'yesterday (one day before today)'[9]

and the modifiers

ˈkʸaː	'most, the most (unique among others)'
ˈkʸaʔan or ˈkʸoʔon	'by oneself, separately'
ˈkʸax̌	'just this once, just for a minute'

It seems clear that the concept of singularity or oneness is expressed by the initial consonant ˈkʸ, or more probably, by a CV sequence ˈkʸə-, since CV is a common prefix shape.

The sequences after ˈkʸ occur elsewhere. The column I form ˈkʸíˈ ends in the suffix -ˈ which generally has the completive meaning of 'bringing something to its natural limit'.[10] The column III form ˈkʸóːˈ ends in -óːˈ like most of the other numerals in that column. The sequence -óːˈ does not seem to occur apart from the numerals, where it is restricted to the 'persons' category.[11]

The column II form ˈkʸéːkʷ ends in the derivative suffix -kʷ which is by far the most common in Nisgha and has a great variety of meanings.[12] Abstracting the suffix leaves ˈkʸéː-, a sequence that is always historically traceable to *ˈkʸáː-.[13] It is possible that this sequence was originally identical with the modifier ˈkʸaː 'most, the most', since there is a historical rule *á: > é: after palatals which applies only to stressed vowels, and modifiers are unstressed.

In column IV, ɬamé?et 'one (canoe)' probably has as its initial element the modifier ɬam 'simply, just', which is often used before kʸíɬ or kʸó:l (e.g. ɬam kʸíɬ 'just one'), and the final -t may be the suffix for 'passive of state', but the medial sequence -é?e is at present unidentifiable.

2.2. Ten

The words are:

Column I	xpíɬ	(objects)
Column II	kʸáp	(animals)
Column III	xpó:l	(persons)
Column IV	kʸápkʷs	(canoes)

The forms in columns I and III start with the sequence xp- before -íɬ and -ó:l respectively. Exchanging xp- for kʸ-, these formations are exactly the same as those for 'one' (2.1.).[14]

The sequence xp- or xpə- (with vowel quality adjustment depending on the following consonant) also occurs in the measures

xpa?ún 'ten fathoms' (?ún 'hand, arm, outstreched arms')

and

xpisá:ta 'period of ten days' (sá:, alternate form of sá 'day'; -ta collective suffix[15])

It does not seem to occur in any forms not meaning 'ten'.[16]

It is interesting that the column II form kʸáp begins with kʸ- like most of the 'one' forms. There is no reason to think that kʸ- has a meaning other than 'one' here: the column II forms are used for animals and fish, which were trade items as well as sources of food and clothing; ten skins or ten fish must have constituted a unit of trade well before the European fur trade, [17] hence the use of a base meaning 'one' is not surprising. The rest of the word is not identifiable at present.[18]

The form kʸáp, not xpíɬ, is the one used for multiples of ten:

kʸíɬpiɬ	wil	kʸáp	'twenty'
two	CONJ	ten	
kʷiláɬ	wil	kʸáp	'thirty'
three			

These phrases are probably of recent origin. Boas recorded a form for 'twenty', kʸiyítkʷ, also starting with kʸ-, and probably meaning 'one man' (that is, all the fingers and toes, as in many languages):

kʸ	-	(k)ʸít	-	kʷ
one		man		?

(-yít- < kʸít, alternate form of kʸát 'man, person').

2.3. Two

The numerals for 'two' are all different:

I	kʸiɬpiɬ	(objects)
II	ɬipx̌á:t	(animals)
III	paqatíɬ	(persons)
IV	qaɬpéɬtkʷs	(canoes)

This probably reflects both their extreme importance and the very diverse circumstances under which one might need to refer to two objects, animals or their skins or fish, persons, or canoes.

Only one of these forms can be fully analyzed. In column I, kʸíɬpiɬ ends in the completive suffix -ɬ[19] like kʸíɬ, which can be abstracted, leaving the stem kʸíɬp- also found in kʸiɬpwá 'two bundles of ten skins' (Table II). Like a number of Nisgha stems which show a lexical í/á alternation (cf. analysis of kʸiyítkʷ above 2.2.), traceable to earlier *é, kʸíɬp has an alternate form in á, namely kʸáɬp 'testicles'; the common meaning must be 'pair'. Both kʸíɬp- and kʸáɬp derive from earlier *kʸéɬp, which is in turn analyzable into a prefix kʸə- and a root ɬVp, probably *ɬep; stress usually falls on the

root in present-day Nisgha, but there is evidence that stress often fell on prefixes at an earlier stage of the language. There are two kʸə- prefixes in Nisgha, one with locative meaning, the other with undetermined meaning, which could be involved here. There is also a root líp, evidenced in lípkʷ 'to sew something', lípis 'to sew': that is, to assemble or join skins or pieces of cloth, two at a time. The form kʸílpil then can be reconstructed as

kʸə	-	lep	-	-l
?		assembled		COMPL

The meaning 'two' then probably derives from the meaning 'assembled together, paired'.

The other words for 'two', unfortunately, are not so tractable, and only tentative observations can be made. In column II, ɬipx̌á:t 'two (animals)' starts with the proclitic ɬip '(motion) straight down'; the final -t may be the 'passive of state' suffix. The remaining sequence -x̌á:- may be derived historically from qaq 'open' (with q > x̌ after p; á: regularly derives historically from a sequence á + velar or uvular), thus

ɬip	-	qáq	-	-t
straight down		open		PASS. STATE

and the whole word may mean 'opened straight down', probably referring to a way of handling two skins (or possibly two fish or even birds) together.

In the derivation of the column III word paqatíl 'two (persons)', the root tíl may be identified with that in qalax̌tíl '(position) across from, facing', tílimx̌kʷ 'to answer', and tíltkʷ 'to revenge oneself', all referring to situations involving two participants; there is also an alternate root in á, tál, found in tál 'to have a fight', tálq 'to talk to someone', and lu:táltkʷ 'to meet someone', which also describe situations with two participants. It seems likely then that paqatíl originally had to do with a situation where two persons face each other, whether as partners or as adversaries. The initial sequence paqa- may be related to the proclitic paqayt 'in the middle'. A reconstruction *paqayt-tíl 'facing each other in the middle' (of a circle of onlookers perhaps) would seem to make sense as the origin of the word for 'two (persons)'.

As for the column IV word, qa|pél̓tkʷs 'two (canoes)', it has some recognizable parts, but the root is unidentified at present. The initial sequence qa|- is a prefix meaning either 'too (much)' or 'empty', or rather, 'capable of being filled'; at the end, -kʷs (preceded by epenthetic -t- caused by the preceding resonant), which may be decomposable into -kʷ and -s, is a common suffix with various meanings; the preceding -l̓ is the same completive suffix also found in kʸíl̓ and kʸíl̓pi|; but the root, pé-, probably originally followed by a velar, is unidentified, so that the total meaning cannot be guessed at, any more than for q̓amé?et̓ 'one (canoe)'.[20] But judging from the derivation of kʸíl̓pi| 'fully assembled', and the tentative meanings of t̓ipx̌á:t 'opened straight down' and paqatí| 'facing each other in the middle', it seems safe to assume that the original meaning of qa|pél̓tkʷs must also have originally been descriptive.

2.4. Four

All words for 'four' contain the sequence tx̌á|px̌:

Column I, II	tx̌á|px̌	(objects, animals)
Column III	tx̌á|px̌tó:|	(persons)
Column IV	tx̌á|px̌kʷs	(canoes)

We recognize in column IV the suffix -kʷs already found in other forms for canoes, and in column III the 'human' suffix -ó:|; the preceding t must have been inserted by analogy with the corresponding forms for 'six', 'seven' and 'eight', all of which, as we shall see, end in the sequence -tó:| as a result of adding -ó:| to a final suffix -t.

In the basic form tx̌á|px̌ we recognize the sequence -|p- found in kʸíl̓pi|[21] and traceable to a root *|ep 'assembled, joined' (2.3.), followed by a suffix or augment -x̌ found in a number of words but of yet undetermined meaning. The initial sequence tx̌á-, which carries the stress, is probably identifiable as the proclitic tx̌a: 'all, every': shortening of the long vowel would not be surprising in front of the cluster -|px̌.[22] Thus we reconstruct tx̌á|px̌ as

txá:	-	|ep	-	x̌
all		assembled		?

a designation which is appropriate for a square or rectangular structure such as a house or a kerfed box.

2.5. Three

All the forms for 'three':

Column I	kʷiɬáɬ	(objects)
Column II	kʷiɬán	(animals)
Column III	kʷiɬóːn	(persons)
Column IV	kʷiɬáɬtkʷs	(canoes)

have in common an initial sequence kʷiɬ- followed by what appear to be suffixes.

The column IV form kʷiɬáɬtkʷs is obviously derived from column I kʷiɬáɬ by addition of the suffix -(t)kʷs (of undetermined meaning) found in qaɬpéɬtkʷs (as well as all subsequent 'canoes' forms). The words in the remaining three columns need further analysis.

The initial sequence kʷiɬ- recalls the proclitic kʷiɬ 'fixedly, rigidly' and the word kʷáɬkʷ 'to be dry'. The primary meaning of the alternate roots kʷiɬ/kʷáɬ is probably 'stiff, rigid, unchanging', a description which applies to dried substances such as fish, wood and seaweed. This root is also recognizable in the phrase kʷàɬtim qóːt, literally 'stiffened heart',[23] meaning 'readiness, resoluteness (in front of danger, death, etc.)'.

One may wonder why a root meaning 'stiff, rigid, unchanging' would be used in the formation of words meaning 'three'. The most stable structure is a triangular one, as is well-known to the Nisghas, who construct their oolichan-drying frames with three vertical poles set in a triangular pattern, and held together by sets of three crosspieces, a fact which is not without significance in this discussion.

Turning now to the suffixes, in column III it is probable that the -óːn of kʷiɬóːn 'three (persons)' should be identified with the 'human' suffix -óːɬ found in the other column III forms. The change ɬ > n, which is fairly common though sporadic in Nisgha,[24] may have been triggered or encouraged by the presence of the earlier ɬ of kʷiɬ-.

In column I, kʷiláɬ, seems at first sight to end in the same completive suffix -ɬ, as kʸíɬ 'one' and kʸíɬpiɬ 'two', but a combination kʷíɬ + -i would yield ¢kʷíɬii or ¢kʷíɬ,[25] not kʷiláɬ. It seems more probable that kʷiláɬ is a former compound of the object-incorporating type, with the second member probably -ʔáɬ, thus

kʷáɬ	-	ʔáɬ
to stiffen		?

hence kʷiláɬ, after loss of glottal stop and unstressed vowel reduction, both common in compounds.

The element ʔáɬ postulated as the second member of this compound does not occur by itself, but is reconstructable from such forms as

kʸáːɬ	'to be one-eyed' (kʸ- 'one')
cáɬ	'eyes, face' (c- 'in')
ʔáɬaq	'to be quick-tempered, assertive, determined, brave, as shown by the expression in one's eyes' (-q suffix of undetermined meaning)

The literal meaning of kʷiláɬ then would be 'stiffening the eye'.

I would suggest that the word ʔáɬ meant not only 'eye', but also, metaphorically, 'triangular pattern'.[26] The meaning of kʷiláɬ then is 'stabilizing the triangle', a description which applies to the crosspieces that hold a triangular frame together, and which themselves form a triangle when in place, a set of three before; a phrase such as kʷiláɬit+ qanqán, meaning originally 'the pieces of wood that stabilize the triangle' could easily have come to mean only 'the three pieces of wood'.

In the remaining form kʷilán[27] 'three (animals)', in column II, we can assume that there has been dissimilation from earlier *kʷiláɬ, just as in kʷilóːn from *kʷilóːɬ. In many words ending in glottalized consonants, glottalization seems to have been originally a separate morpheme, and there are some related unglottalized forms. The form ʔáɬ- as a variant of ʔáɬ is evidenced in the proclitic ʔaɬuː 'plainly, visibly' (-uː modifying suffix)

2.6. Five and nine

The forms are:

Five:	Column I, II	kʷstíns	(objects, animals)
	Column III	kʷstinsó:l	(persons)
	Column IV	kʷstínskʷs	(canoes)
Nine:	Column I, II	kʷstimó:s	(objects, animals)
	Column III	kʷstimo:só:l	(persons)
	Column IV	kʷstimó:skʷs	(canoes)

Again, the suffixes -ó:l for persons and -kʷs for canoes are added to the basic forms. The latter are obviously related, as they both begin with the sequence kʷst- otherwise found only in the word kʷstáqs 'to leave or abandon something'. This transitive verb is built on the root *staq 'side', evidenced in the proclitic staX̌ or sta: 'on one side', preceded by the prefix kʷ- of undetermined meaning and followed by the (here) transitive suffix -s. The mó:s at the end of kʷstimó:s seems to be the word mó:s 'thumb'. If the upper limit of numeration is the number of fingers, it makes sense for the word for 'nine' to mean 'leaving out one thumb'. The form for 'five', then, most likely means 'leaving out one hand'. It is possible to derive the actual forms kʷstimó:s and kʷstíns by regular rules, from earlier, transparent forms.

These forms are object-incorporating compounds. Transitive suffixes such as the final -s of kʷstáqs are not used in object-incorporating compounds,[28] thus we reconstruct:

kʷstáq	-	mó:s
leave		thumb

A series of historical velar-weakening rules operating before consonant gives regularly

kʷstaX̌mó:s
kʷstahmó:s
kʷsta:mó:s

and the long vowel a: reduces in unstressed position, thus

kʷstamó:s

and eventually the modern

kʷstimó:s

Similarly, 'leaving out one hand' is a compound:

kʷstáq	-	ʔún	-	-s[29]
leave		hand		

yielding

kʷsta:ʔúns

and later

kʷstəúns
kʷstúns

But this form has the vowel ú, not í as in kʷstíns. Comparison of Nisgha with Gitksan and CT shows that many instances of Nisgha í derive from earlier ú, by an historical rule ú > í under certain conditions,[30] thus the present kʷstíns.

2.7. Six and seven

The forms are:

Six:	Column I, II	q̓ó:l̓t
	Column III	q̓o:l̓tó:l
	Column IV	q̓ó:l̓tkʷs
Seven:	Column I, II	t̓ipx̌ó:l̓t
	Column III	t̓ipx̌o:l̓tó:l
	Column IV	t̓ipx̌ó:l̓tkʷs

The column III and IV forms have the suffixes -ó:l and -kʷs regularly added to the column I and II forms. In both cases, these end in the cluster -lt, representing the two suffixes -l, 'completive' as in kʸíl̓ 'one', kʸíl̓pil̓ 'two', qalpél̓tkʷs 'two

(canoes)', and -t 'passive of state'. These two suffixes are often associated, and the meaning of the whole is 'brought to its natural completion, fully completed'.[31]

The first part of q̓ó:l̓t 'six' is probably a derivative of q̓óq 'to pull on something that is attached at one end (e.g., roots, hair)'; other derivatives are q̓óq+ 'cedarbark rope', q̓é:q+ 'to drag something', and probably also q̓ó: 'penis' and q̓ó:m 'to be desirous'. Long vowels generally result from an earlier sequence of short vowel plus a velar or uvular, thus q̓ó:l̓t can be reconstructed as

q̓óq	-	-l̓	-	-t
pull, extend		COMPL		PASS. STATE

The word for seven, t̓ipx̌ó:l̓t, is obviously related to q̓ó:l̓t. It starts with the proclitic t̓ip '(motion) straight down', and the following x̌ is the reflex of q̓ after the consonant p (cf. t̓ipx̌á:t above, 2.2.). The meaning is 'extended straight down'.

One may wonder why words for 'six' and 'seven' would have the common meaning 'fully extended'. I suggest that this expression refers to the position of the hand that is doing the counting. After counting up to five (by whatever method),[32] the hand would then be extended,[33] probably horizontally, for 'six', and then rotated into a vertical position with thumb up, for 'seven'.

2.8. Eight

The forms are:

Column I	qantó:l̓t
Column II	y̓uxʷtál̓t
Column III	y̓uxʷtal̓tó:l
Column IV	y̓uxʷtál̓tkʷs

As usual, the column III and IV numerals are formed by suffixation to a more basic form. The column I and II forms do not resemble each other except that they both end in the sequence -l̓t, also found in 'six' and 'seven'. As we saw earlier with 'three', however, the segment l̓ is not always a suffix.

The column I form qantó:ɬt is yet another case where interpretation must remain conjectural. The initial sequence qan- might be the proclitic qan 'leaning against something' or the prefix qan- which forms abstract nouns. The remainder, tó:ɬt, is probably analyzable in the same manner as qó:ɬt 'six', that is, as a root ending in a velar or uvular, followed by the suffixes -ɬ 'completive' and -t 'passive of state'. The root may be either tóq 'to take or grab something plural' or tóx̌ '(objects) to lie, to be put, laid'. The derivative -tó:ɬt means then either 'fully taken' or 'fully laid out' (in the plural), both of which are possible semantically, thus qantó:ɬt is reconstructable as

qan	-	tóq/tóx̌	-	-ɬ	-	-t
?		take/lay		COMPL		PASS. STATE

If qantó:ɬt was originally used for animals and fish, it may have to do with some practice in connection with the handling of animal skins, or fish. There is a word ɬú:kʷs meaning 'bundle of forty dried fish'. It is likely that four groups of ten were prepared, then bundled together, and qantó:ɬt would be an appropriate term to use.

In column II, the word ʔyuxʷtáɬt has a somewhat unusual shape: unstressed initial syllables rarely begin with glottalized resonants. It could be interpreted as an object-incorporating compound starting with the verb ʔyúxʷ 'to fish with line', but this verb is intransitive, and the rest of the word, táɬt, does not have a recognizable meaning. Instead, it is more probable that the phonological sequence yuxʷ is the common contraction of ʔi: huxʷ 'and again'.[34] Such a phrase would be suitable for the expression of a number considered as an addition to another number. The word huxʷ 'again' is often reinforced by the addition of the particle ti: 'indeed, too'; a reduced form of this particle, tə (with vowel quality adjustment) is used to form numbers above ten, as in

xpíɬ	ti	kʸíɬpil	'twelve'
ten		two	

In ʔyuxʷtáɬt, the t which follows ʔyuxʷ could be the reflex of this particle. There remains the sequence ʔáɬ, already found in the derivation of kʷiláɬ 'three' (2.5.), with the meanings 'eye', 'triangle', and therefore here, 'three'. The contraction ʔyuxʷtáɬ represents the original phrase

ʔi:	huxʷ	ti:	ʔáɬ
and	again	too	three

The final -t (which is not in the Gitksan Primer form) was probably added by analogy with the ending in qó:ɬt 'six', tɬpx̌o:ɬt 'seven' and qantó:ɬt 'eight', once the original meaning of yuxʷtáɬ had been forgotten.

One wonders again why a word for 'eight', coming after words for 'six' and 'seven' indicating hand movements, would mean 'and again three'. Movements of the whole hand are limited, and use must be made of the fingers again at some point: if nine is still indicated by leaving out the thumb, eight will mean also leaving out the adjacent finger, or, in additive rather than subtractive terms, using 'again three' fingers: probably by curling them into the palm, while leaving the hand in the same vertically oriented position as for seven.[35] For nine and ten, the remaining finger and the thumb join the three curled fingers.[36]

3.0 DEVELOPMENT OF THE NUMBER SYSTEM

It is possible to suggest a rough chronology of the development of the Nisgha number system as well as of the evolution of the method of counting.

Of the ten numerals for abstract counting, only kʸíɬ 'one' and xpíɬ 'ten' appear to contain a morpheme with actual numerical meaning. The morpheme kʸə- 'one' has especially wide distribution, and is used in the formation of words designating larger units, kʸáp 'ten (animals)', probably 'a set of ten skins or fish', and kʸiyítkʷ 'twenty' or 'one man'. The morpheme xpə- 'ten' is also used in compounds designating measures. It is likely that kʸə- is the most ancient, xpə- a later formation, but that together they designated the beginning and the end of a counting procedure of keeping track of numbers on the fingers of both hands, without, however, naming the intermediate steps.

The abstract forms for 'two' and 'four' both contain the sequence -ɬp- from the root *ɬep meaning 'assembled, joined'. The derivatives kʸiɬpiɬ 'two' (from kʸə - ɬep - ɬ 'fully assembled') and tx̌áɬpx̌ 'four' (from tx̌a: ~ ɬep - x̌ 'all assembled') then have their origin in the techniques of assembling objects, probably in garment-making and woodworking. The abstract form for 'three', kʷiɬáɬ (from kʷaɬ-ʔáɬ 'stabilizing the triangle') also has its origin in a technique, that of

constructing stable triangular frames. What are now numbers were then originally technical terms.

In contrast, the forms for 'five' and 'nine' refer to a manner of keeping track of numbers: if the goal is to assemble a set of tens, or two hands' worth, five and nine represent incomplete sets, readily identifiable on the hands: 'leaving out one hand', 'leaving out one thumb'. At some point, the descriptive words kʸíɬpiɬ, kʷiɬáɬ and tx̌áɬpx̌ started to be used for abstract counting, bridging the gap between one and five. It is probable that counting was done on the fingers of both hands, repeating the sequence one to five on each hand until all the fingers were used up. Nine was viewed as an incomplete ten, and for a time there was no need of other numerals between five and ten.

The remaining numerals q̓ó:ɬt 'six', ɬipx̌ó:ɬt 'seven' and yux̌ʷtáɬt or qantó:ɬt 'eight' bridge the terminological gap between five and nine, just like the originally technical words kʸíɬpiɬ 'two', kʷiɬáɬ 'three' and tx̌áɬpx 'four'. But these older forms originally had a meaning independent of counting. By contrast, the words for 'six' and 'seven' clearly refer to the act of counting, the specific hand gestures used in a counting procedure that goes beyond five, by extending, then rotating the hand. For 'eight', the meaning of yux̌ʷtáɬt 'and again three' only makes sense if the word is part of a set of counting instructions in which numeration starts from one and proceeds by successive additions, not, as for kʷstimó:s 'nine = leaving out one thumb' by subtraction from the complete set. The other word for 'eight', qantó:ɬt, which probably also has a technical origin, 'fully laid out' or 'fully taken up', must have been used in a different context, so that it was not part of the enumerative counting procedure.

These three numerals appear to be recent words, so clearly mnemonic that they suggest that the procedure in question was at one time new and strange, perhaps running counter to established habits. The forms for five and nine show that both hands were originally used in counting; but extending the hand in different directions for six and seven only makes sense if counting is being done on the fingers of one hand rather than two, a shift in procedure requiring new gestures associated with each number if ambiguity is to be avoided: extending and pivoting the hand ensures that six and seven cannot be confused with one and two. And if eight, nine and

ten are not to be confused with three, four and five, the hand position must be different: so the fingers now curl into the palm.

All the fingers are now together, and what is seen of the hand, besides the curled fingers, is the lower half of the palm, as well as the wrist: this area has a specific name in Nisgha, kʸɬ:ɬa?, a derivative of kʸɬɬ 'one' (with the detransitive suffix -a?); the literal meaning is approximately 'making up "one"'. This probably refers to the fact that a unit of ten has been achieved.

There would be little point in a procedure for counting to ten on one hand only, unless the other hand also played a role: that of keeping track of tens. Once one hand has 'made up a "one"', this 'one' can be transferred to the other hand. In this way, since each number from one to ten is associated with a specific gesture, it is possible to keep track of numbers up to ninety-nine,[37] without confusion.

There are, then, at least three discernible periods in this proposed development of the Nisgha number system:

1. At first, there was only a form for 'one', the base kʸə- which was attached to suitable words. 'Ten' and 'twenty' were expressed in terms of complete sets: kʸiyɬtkʷ 'twenty' was 'one man', kʸáp 'ten' was 'one set of ten skins or fish'. After a while the complex base xpə- also came to be associated with the number ten. Intermediate numbers were recognized as incomplete sets, but not named. Counting was done on the fingers of both hands, without specific words.

2. The incomplete sets 'five' and 'nine' started to be recognized formally by phrases indicating subtraction from the upper limit ten. Technical terms indicating typical patterns of two, three and four parts filled the gap between one and five. Counting to ten was still done on the fingers of both hands, probably by repeating the one to five sequence on both hands.

3. At a later date, a method was discovered or learned for counting to ten with just one hand, leaving the other hand free to count tens. In the absence of specific names for the intermediate numbers between five and nine,

> the gestures of this procedure were described, at first simply as an aid to its correct execution. Later, the meaning of the words were forgotten, and they acquired the purely numerical meanings they have today.

The shift in counting procedure can perhaps be roughly dated. It must have arisen in response to a need to count large numbers, and to name intermediate numbers rather than completing sets of ten, which must have been the ancient practice. These new conditions must have been those of the European fur trade, which created an economic situation in which much larger amounts of goods than before were changing hands; exchange rates were fluctuating according to supply and demand, and were often set by the Indians themselves.

It is impossible to establish on linguistic evidence alone whether the counting method evidenced by the Nisgha numerals, and their cognates in the other Tsimshianic languages, was developed independently in the Tsimshianic area, learned from some other group, or whether it is a case of stimulus diffusion: the idea of such a method may have been diffused, though not the actual details. It is remarkable that the new numbers were not borrowed from some other language: perhaps this type of counting was observed being done silently.[35] Areal research would be profitable in this connection.

Whatever the origin of the new counting procedure, its adoption must have given great impetus to counting and measurement, and to the formation of new words. Phrases were coined for numbers beyond ten, so that any number up to ninety-nine could be indicated. Paradigms such as those for persons and canoes, which only had a few entries, for one, two and perhaps ten, were filled in by the creation of new forms, derived by adding suffixes, or what appeared to be suffixes, to the abstract stems, or what appeared to be stems (e.g., -ó:l ('human' suffix) added to kʷil- considered as the stem of kʷilál 'three', -tó:l added to txálpx̌ 'four' on the analogy of qo:ltó:l 'six (persons)'). The abstract numbers themselves were used as prefixes to suitable words (e.g., kʸilqá:x 'one fathom' from kʸíl 'one' + qá:x 'wing, wingspan, armspan').[38]

4.0 CONCLUDING REMARKS

The morphological clarity of the Nisgha language gives us a rare window on the past life of the people and makes forgotten

aspects of a culture come alive. The Nisgha number system embodies a record of ancient cultural patterns and of cultural change precipitated by outside factors. It touches upon all aspects of life: it makes reference to crucial techniques, to social relations, to trading practices and their evolution; it preserves the beautiful metaphor of the eye for the triangle.

From a more general point of view, the evolution of the Nisgha number system may give clues to what probably happened in other parts of the world, where it is unlikely that decimal systems sprang up full-blown, and where unanalyzable numbers probably have a long but forgotten history of non-numerical meanings.[39]

NOTES

*The Nisgha (nɪsqáʔ, [nɪsg̊áʔə̥]) language is spoken in the Nass Valley of British Columbia. It is the 'Nass dialect' of Boas' (1902) *Tsimshian Texts* and of his 1911 *Tsimshian*.

The data presented here represent the speech of New Aiyansh, present home of the Gitlakdamix (kʸitlax̌ɬáːmiks) band. They were collected during the course of my employment with the Nisgha Bilingual/Bicultural Centre of B.C. School District no. 92 (Nisgha), in 1977-80 and again in the summer of 1982, during which times I resided on the reserve at New Aiyansh.

Among the numerous Nisgha speakers who helped me learn their language over the years, I am especially indebted to Mrs. Nita Morven, Mrs. Rose Robinson, and Mrs. Verna Williams, who were my first teachers of Nisgha, and whose patience and friendliness never failed; to the Rev. Hubert McMillan, a Nisgha hereditary chief of the Wolf tribe and priest of St. Peter's Anglican Church, New Aiyansh, as well as to Mr. Harold Wright, a hereditary chief of the Eagle tribe and Cultural Researcher for the Gitlakdamix band. Mr. Bert McKay, hereditary chief of the Frog/Raven tribe and Coordinator of the Nisgha Bilingual/Bicultural Centre, arranged for me to have access to these and other resource persons.

Bruce Rigsby provided me with a copy of the Gitksan Primer as well as many Gitksan data.

Neil Gallaiford made valuable suggestions about the counting procedure from eight to ten.

The reconstructions and interpretations presented here are my own, and I alone am responsible for any errors.

[1]I am coining this term on the analogy of German: Germanic. German is one of the Germanic, not German, languages. Similarly Tsimshian (c̓im 'in' + sán 'Skeena River'), now known among linguists as Coast Tsimshian, is only one of the Tsimshianic languages, which also comprise Southern Tsimshian, and in the interior, Nisgha and Gitksan. The latter two have been referred to as Nass-Gitksan (cf. Rigsby 1975, which gives Gitksan data).

[2]For instance N and G kʸɪ̓ɬp̓ɪɬ 'two', analyzed below as kʸə-ɬep - ɬ: CT gú?pɬ (Dunn 1970:38).

N cáẃaqs 'shoes', from cáxʷ - ?q - s: G cáẃaxs, CT có:xs (Dunn p. 35).

The relationship of CT to Nisgha and Gitksan can be compared to that of French to Spanish and Portuguese or Catalan: CT has a much more complex vocalism than the other languages, and there has been more extensive loss or change of consonants. Nisgha is on the whole the most conservative of the three. Little is known about Southern Tsimshian.

[3]The same categories, with almost identical forms, are given in the Gitksan Primer. CT also has a category for 'long objects', including a suffix -qan or -x̌an, probably from qán 'tree, log' (Boas 1911:396, Dunn 1970:39). The bases for 'one', 'two', and 'three' in this category do not seem to be related to other numerals, and I will not attempt to analyze them.

[4]The transcription is phonological. Nonglottalized stops are voiced prevocalically. The symbols e: and o: stand for long lower mid vowels.

[5]e.g., there is a difference between the noun-phrase

tx̌áɬpx̌+ sá 'four days' (-+ connective)

and the noun

tx̌aɬpx̌sá:ta 'a four-day period' (sá: alternate form of sá 'day'; -ta old (see note 15) collective suffix)

[6]Except in some phonological details. Boas' transcription, done before contrastive techniques were established, and based on limited data, is not always consistent, in particular in the differentiation of long and short vowels, and of glottalized and nonglottalized stops. He also fails to indicate the glottalization of resonants. For these reasons, my transcription may differ slightly from his.

[7]I was told on several occasions that Boas' informants were poor speakers of Nisgha. Boas himself thought that the tales he collected were 'only moderately well told' (1902). Boas collected his Nisgha data in 1894 in the then newly-formed Christian community of Kincolith, where his interest in 'pagan' customs was not particularly welcome, so that the only persons who would work with him were those on the fringes of society, some of whom were allegedly not native Nisgha speakers.

[8]a. Columns headed 'Boas' have not been verified. For unity of presentation and for comparability I transcribe Boas' and Dunn's forms phonologically.
b. In the first column (fathoms, from Boas), the -tí: on the last word is an intensive particle which is sometimes used after a measure.
c. Under the column 'fingerwidths', the term waẍ'únkʷs does not literally mean 'four fingerwidths', but its equivalent, 'one handwidth'. The root is ʔún 'hand or arm', also used for 'fathom'.

[9]Cf. also in Table II in the last column, kʷi:skʸiwá 'one bundle of ten skins'. The initial sequence is probably the prefix kʷi:s- used in a number of words designating garments:

e.g. kʷi:smála? 'button blanket' (mála? 'to fasten', qanmála? 'button')
kʷi:shaláyt 'Chilkat blanket' (haláyt 'shaman, shaman's dance')
kʷi:sháṯiks 'swimsuit' (hátiks 'to swim')

The form kʷi:skʸiwá then seems to mean 'garment made of ten skins' or perhaps 'ten skins, enough for a garment'.

[10]Like English *up* in *drink up*, *sum up*, etc.

[11]This -ó:l is different from the sequence -ó:lt found in the forms for 'six' and 'seven', analyzed in 2.6. below. Since -ó:l carries the stress in all cases, it is unlikely that it is a true suffix, as the overwhelming majority of true suffixes are unstressed. It is more likely to have been originally a noun, as is, for instance, qá:x 'wing, armspan' used as a suffix in the formation of measures for 'fathoms' (Table II). It might be a form of ʔúl 'bear', a form which in Nisgha has been replaced in most of its uses by smáx 'black bear', originally 'meat', also 'body, corpse', probably a borrowing from the Salish *səməy- (hence also CT sámi 'meat'). Identification of bears with people is common in most Northwest cultures.

[12]e.g., Passive, transitive, reflexive, 'like', 'having', etc. In many cases it seems that the only purpose of the suffix -kʷ is to differentiate the word it is added to from the original word.

[13]Justification for all rules used in these derivations is found in my unpublished paper *Nisgha plural-formation: an analysis of the morphophonemics*, which presents both synchronic and diachronic rules.

[14]The Gitksan Primer gives hixpíl, hixpó:l, which seem to involve a form of reduplication.

[15]This suffix, productive in Gitksan, is restricted in Nisgha to a few frozen forms.

[16](But there is the word xpá:ẇ 'jaws' which may ultimately provide a clue.) The sequence xp- should probably be further analyzed into a prefix x, otherwise attested but of undetermined meaning, and a base or root starting with p-, also undetermined, The original meaning of the xp- forms, then, was probably not numerical, although it must have become so fairly early, otherwise one would expect 'ten fathoms' to have been *xpil?ún, not xpa?ún (cf. kʸilqá:x from kʸil + qá:x).

[17]cf. Table II, last column, 'bundles of ten skins'.

[18]Boas (1911:398), observing the obvious relationship between the 'one' forms starting with kʸ, suggested that xpíl, kʸáp and xpó:l were similarly derived from a common root: evidently he saw in xp, which corresponds to CT kp, a reduced form of kʸáp. This is most unlikely, for the following reasons:

- initial preconsonantal x derives historically from unglottalized kʸ, not glottalized kʸ; the few instances of spirantization of glottalized velars and uvulars (as in t'ipx̌ó:lt, 2.6.) occur post-consonantally;
- the suffix -l, like most Nisgha suffixes, never changes the stress pattern of a word; a form kʸáp + l would be *kʸápil;
- even if by some exception the stress moved to the suffix, glottalization would be transferred to the final stop of kʸáp and the result would be something like *kʸipíl, or granting an unlikely spirantization of kʸ, xpíl, with glottalized p and unglottalized l, not the opposite as in xpíl.

Boas' hypothesis is therefore not tenable.

[19]Glottalization is transferred to the stem-final stop, and a vowel is inserted.

[20]Boas (1911:397) compares the sequence qalp- in qalpé'ltkʷs (older qalpé:'ltkʷs) and its CT cognate qalpé:ltk to the CT form for 'two (long objects)' q̓ó:psx̌an. There are many cases where a sequence Vl, before consonant, in N and G corresponds to a long vowel in CT, e.g., N, G wí'lp 'house', CT wá:p, but if this were the case here one would expect the stressed vowel of q̓ó:psx̌an to be á:, not ó:. Also, one would expect the stress pattern to be the same in N and in CT.

The initial glottalization in q̓ó:psx̌an is not an unsurmountable difficulty, as there are a number of cases where CT appears to have glottalized initial consonants, e.g., N, G kʷi'lá'l, CT kʷi'lí': 'three'; N, G qantó:'lt, CT q̓andó:lt 'eight'. But it is more probably that the CT forms for 'canoes' and 'long objects' are unrelated, and that the 'two' root of the 'long objects' category represents yet another aspect of the experience of twoness.

[21]The glottal element is transferred to p from the suffix -'l, (cf. above 2.3. and note 19).

[22]cf. CT tx̌á:lpx̌, Dunn p. 38. Usually Nisgha V́lC = CT V́:C (see note 20). That the l is preserved in CT shows that the long vowel must be original.

[23]cf. English 'to steel oneself'. The t in kʷaltim is the 'passive of state' suffix (-m attributive suffix).

[24]In general, these changes place n at the end of a word or closed syllable, l intervocalically, as in c̓ín 'to enter', c̓i'lim (proclitic) 'entering' (c̓ín + -m attributive).

[25]There is no attested sequence l + 'l that I know of in Nisgha: the closest parallel is

l'nx̌	+	-'n	>	*l'inn > li'n
(trees) to fall		CAUS		to cause (trees) to fall (naturally, e.g., storm)

[26]See also discussion of y̓uxʷtá'lt below 2.7.

The replacement of ?á'l 'eye' by c̓á'l 'eye(s), face' may have occurred as a result of a shift of meaning from 'eye' to 'triangle' or 'three'. The two forms ?á'l and c̓á'l may have coexisted for a while, cf. in present-day Nisgha ?á:q and c̓imá:q, both meaning 'mouth' (c̓im 'in', from c̓- 'in' (old base) and -m attributive).

[27]Both Boas and the Gitksan Primer give kʷiɬánt; the final t is probably the passive of state suffix, which is often added to instransitive stems such as the object-incorporating compound kʷiɬ-ʔáɬ or ʔáɬ.

[28]cf. kʸá+kʷ 'to pierce, stab, gaff something' but kʸá+hó:n 'to gaff (kʸá+-) fish (hó:n)'. The suffixes -kʷ and -s are allomorphs.

[29]Note that the suffix -s may have been part of the derivation of kʷstɬmó:s as well, where it would have been assimilated to the final s. Perhaps the meaning is reflexive or possessive (leaving out one's own hand, not someone else's). (cf. yó'oks-wé:ntkʷ 'to brush one's teeth': yóʔoks 'to wash something'; wé:n 'teeth'; -kʷ REFL)

[30]e.g., N qaɬís, G qaɬʔúst 'to let go of something'; N kʸíp, G kúp 'to eat something; N kʷstíns, G xʷstíns, CT kstü:ns 'five'.

[31]As in yánsaɬt '(month of) May' literally 'fully-leaved' (yans 'leaf').

[32]Although the numerals give no clue as to the original method of counting to five on the fingers, there may be other evidence: words related to counting are ɬícx̌ 'to count, to read something', ɬícx̌kʷ 'to count, to read', ɬíɬil 'to keep track of something, ɬíɬilskʷ 'to keep track of things', ɬíɬilskum-tá:la 'to keep track of money'. The root ɬíc , may be the original plural of yác 'to hit, strike something (e.g., a drum)'. The word ɬíckʷ designates a type of grouse that makes a loud drumming sound. It is likely that ɬíc meant originally 'to strike or beat rhythmically'. The use of this form to refer to counting suggests that each finger was struck in turn against some support.

[33]It is not clear in what way the hand is extended. It is probably not outstretched into a span, as a morpheme meaning 'span' is part of the measures kʸiɬsáqans 'one span', etc.; sáqan is a transitive verb meaning 'to lengthen, to extend something'. Perhaps qó:ɬt refers to a position in which the hand is held out horizontally with all the fingers straight together.

[34]The Gitksan Primer gives 'giukdal', which probably represents kʸuxʷtáɬ; kʸuxʷ is a contraction of kʸi: huxʷ, where kʸi: is the more formal variant of ʔi: (as also in Nisgha). Note the lack of -t at the end.

[35]I owe this suggestion to Neil Gallaiford.

[36]If the numbers from eight to ten are counted by curling the fingers back into the palm, one wonders why six and seven are not also indicated in this way, rather than by extending the hand in two different orientations. It could be because it is almost impossible to curl in the little finger without also curling in the fourth finger, and it is also difficult to curl in those two fingers without moving the middle finger. Thus there could easily be confusion between the gestures for six and seven, and perhaps even eight. But if six and seven are indicated in a different way, there is no ambiguity in the gesture for eight.

[37]Ninety-nine: kʷstimó:s wil kʸáp ti kʷstimó:s
nine ten nine
ninety

[38]There are also words referring to 'persons in canoes or boats', e.g., Nisgha kʷitá:t 'to be fishing alone in a boat', txalpxtá:t 'to be four in a canoe or boat'. This is another case where a sequence has been taken as a suffix but has a different origin. The ending -á:t is probably the word ʔá:t 'fishnet, to fish with a net'. In the word kʷitá:t the initial sequence kʷit- is probably the same as that in the modifier kʷitu: 'alone, by oneself', and it is probably the reduced form of *kʷó:t 'lost'. Where the modifier kʸo:lu: 'alone', built on kʸó:l 'one (person)' emphasizes singleness, kʷitu: and kʷitá:t emphasize the danger of being alone in a difficult environment.

The sequence tá:t was later taken as a separate morpheme and added to numerals (CT has a complete series, Dunn p. 39).

[39]I would appreciate receiving information from readers who may know of this and similar counting procedures.

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Gemination as a Syllable Structure Process in Modern Sinhala

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1.0 INTRODUCTION

Having evolved from a Middle Indic Prakrit, early Sinhala (Elu) shows the typical phonotactic processes of vowel reduction, de-aspiration and declustering through deletion and/or epenthesis. At that stage of evolution in the language, the phonotactic contraints worked towards maintaining the optimal - i.e., CV - Syllable Structure Principle.

1.1 a) Paṭ̂rə [$paṭ̂$ rə$] → paṭə̂ [$pa$ṭə̂$] 'leaf'
cvc cv cv cv

b) a + priyə [$a$pri$yə$] → apiriyə [$a$piriyə$]
v ccv cv v cv cv cv
'distasteful'

c) nil#upulə [nilupulə$] → nilupulə [$nilupu$lə$]
cvc v cv cv cv cv cv cv
'blue water lily'

The dominance of Sanskrit and Tamil in the Post-Chola Polonnaruwa period — 11th and 12th centuries A.D. — resulted in a proliferation of compounds, consonant clusters and geminates in the language that has subsequently come to be called mišra Sinhala (mixed Sinhala) as opposed to šuddha Sinhala (pure Sinhala or Elu). The spoken Sinhala of today, just like its literary (particularly prose) counterpart, is a variety of mišra Sinhala.

Considerable phonological differences distinguish the educated and uneducated modes of speech in modern Sri Lanka. For example, a constraint on syllable-internal consonant clusters which operates strongly (i.e., it allows no exceptions) at the uneducated level, operates only weakly at the educated level which tolerates clusters of a restricted nature. The standard for spoken Sinhala, taken in this paper, is the careful speech of the educated. The

Syllabification Rule (9.0) and the Syllable Structure Condition - SSC- (10.0) in this paper are not true generalizations in this respect.[1] However, the two processes of gemination discussed in this paper, which produce the characteristic or distinctive rhythmic quality in modern spoken Sinhala, are shared by both levels and the SSC and Syllabification Rule apply in their description.

The two processes of gemination investigated in this paper are (i) Reduplication and (ii) Assimilation — Progressive and Regressive. Both are syllable structure processes involving strengthening and weakening respectively.

Strengthening and weakening are preferred syllable structure processes which, generally speaking, operate to produce the optimal — CV — syllable structure. In Sinhala, however, these two processes, while preserving or creating the optimal syllable structure on the one hand, also violate the optimal syllable principle by preserving and/or creating CVC and CCV syllables. Yet both processes are extremely active and insuppressible in modern Sinhala and even colour the pronunciation of 'Ceylon English'. The dominance of the two processes, as well as their apparent contradictory behavior, demand and also merit further investigation and analysis. The examples in the following pages are intended to illustrate the processes, the environments that generate the processes and the resultant syllabic structure.

2.0 REDUPLICATION

The examples in 2.1 show consonant gemination in positions preceding syllable-initial vowels. The process operates at syllable boundaries which, in these examples, also coincide with word boundaries since this is essentially a process of compounding.

2.1 Reduplication I. C → CC/ — #$V

a)	pol#ulə	→	[pollulə]
	CVC ∀CV		CVCCVCV
	coconut # stake		'A stake for husking coconut'

b) mal # a:sənəyə → [malla:sənəyə]
CVC VCVCVCV CVCCVCVCVCV
flower # seat 'altar'

c) duk # a̍ḍo:na: → [dukka̍ḍo na]
CVC VCVCV$ CVCCVCVCV$
sorrow # wailing 'sorrowful wailing'

d) ko:ṭ # ekə → [ko:ṭ ṭekə]
CVC VCV CVC CVCV
coat # one (def) 'the coat'

e) bas # ekə → [bassekə]
CVC VCV CVCCVCV
bus # one (def) 'the bus'

In 2.2 reduplication results in the creation of C+LIQUID clusters within a syllable.

2.2 Reduplication II $C \rightarrow CC/\$ \_\_ C_{[+LIQUID]}$

a) a + priyə → [appriyə] ~ [appiriyə]
VCCVVC VCCCVCV VCCVCVCV$
un + pleasant 'unpleasant'

b) pa̍trə → [pa̍ṭṭrə] ~ [pa̍ṭṭərə]
CVCCV$ CVCCCV$ CVCCVCV
'paper/leaf' 'paper/leaf' 'newspaper'

c) wakrə → [wakkrə]
CVCCV$ → CVCCCV$
'crooked/curved'

d) wipləwə → [wippləwə]
CVCCVCV CVCCCVCV
'revolutions'

e) pa̍tlə → [pa̍ṭṭlə] ~ [pallə]
CVCCV$ CVCCCV$ CVCCV$
'bottom'

Reduplication in 2.3 below results in the creation of C+GLIDE clusters in educated speech. In uneducated speech Progressive

Assimilation consistently eliminates the clusters but causes gemination. It is noteworthy that there appears to be a growing tendency to do this even at the educated level.

2.3 Reduplication III $C \rightarrow CC / \_\_ \$C_{[+GLIDE]}$

a) ḍakwa: → [ḍakkwa:] ~ [ḍakka:] 'show/drive (as cattle)'
CVCCV$ CVCCCV$ CVCCV$

b) ṭaṭwəyə → [ṭaṭṭwəyə] ~ [ṭaṭṭe+] 'status'
CVCCVCV CVCCCVCV CVCCV$

c) kap + wa: → [kappwa] ~ [kappa:] 'cause to cut'
CVCCV$ CVCCCV$ CVCCV$

d) saṭyə → [saṭṭyə] ~ [saṭṭə+] 'truth'
CVCCV$ CVCCCV$ CVCCV$

e) wa:kyə → [wa:kkyə] ~ [wa:kke+] 'sentence'
CVCCV$ CVCCCV$ CVCCV$

(+ marks forms which occur in uneducated speech only.)

2.4 Ceylon English pronunciation exhibiting the three processes of Reduplication given above (2.1 - 2.3)

a) 'not + at + all' [nɔṭṭæṭṭɔl]
CVCCVCCVC

b) 'up + above' [appəbav]
CVCVCVC

c) 'oppress' [oppres]
VCCCVC$

d) 'agree' [əggri:]
VCCCV$

e) 'igloo' [igglu:]
VCCCV$

f) 'supply' [səpplai]
CVCCCV$

g) 'Edward' [eḍḍwəḍ]
VCCCVC$

h) 'shipyard' [šippya:d]
CVCCCVC$

3.0 ASSIMILATION

Both Progressive and Regressive Assimilation occur in Sinhala. Regressive Assimilation is by far the most widespread. Progressive Assimilation is restricted and, although it operates at both levels, it appears to be more characteristic of uneducated speech (compare 3.1 with 2.3 above).

3.1 Progressive Assimilation I

$$C_{[+GLIDE]} \rightarrow C \begin{bmatrix} -GLIDE \\ \alpha FEATURE \end{bmatrix} \Big/ C \begin{bmatrix} -GLIDE \\ \alpha FEATURE \end{bmatrix} \quad \$ \ \_\_$$

a) ḍakwa: → [ḍakka] 'show/drive as cattle'
$ĈVC$CV:$ $ĈVC$CV$

b) penwa: → [penna] 'show'
CVCCV$ CVCCV$

c) saṭyə → [saṭṭə$^{+}$] 'truth'
$CVĈ$CV$ $CVĈĈ$CV$

d) aranyə → [aranne] 'woods/retreat'
VCVCCV VCVCCV

e) aḍwaka:t → [aḍḍəka:t^{+}] 'advocate'
$VĈ$CVCVC $VĈĈ$CVCVC

A comparison of 3.1 and 2.3 shows Progressive Assimilation to be a process still in evolution; a process which is not yet fully established, but which nevertheless shows the current drift of the language.

3.2 Progressive Assimilation II

The forms in Column II below also exemplify the Progressive

Assimilation rule in 3.1 above but are the optional or secondary forms of a possible two-way phonological derivation. Both forms are common at the educated and uneducated levels. However, forms in column II are again more characteristic of the uneducated mode. As can be seen, the forms in column I result from minimal C insertion between two contiguous vowels and preserve CV structure. The forms in column II, which are the forms relevant to gemination, result from Progressive Assimilation after the loss of a minimally distinctive vowel in the forms in column I, e.g.,

	kaṭu + ə	thorn + sing. def.
Minimal C insertion	[kaṭuwə]	Column I
Loss of minimally distinctive V	*kaṭwə	
Progressive Assimilation	[kaṭṭə]	Column II

3.2		Column I				Column II	
a)	kaṭu + ə CVCVV	→	[kaṭuwə] CVCVCV	→	(*kaṭwə)	→	[kaṭṭə] CVCCV$	'thorn/ shell'
b)	kolu + a CVCVV	→	[koluwa] CVCVCV	→	(*kolwa)	→	[kolla] CVCCV$	'boy'
c)	baḍu + ə CVCVV	→	[baḍuwə] CVCVCV	→	(*baḍwə)	→	[baḍḍə] CVCCV$	'thing/ article'
d)	gæṭi + ə CVCVV	→	[gæṭiyə] CVCVCV	→	(*gæṭyə)	→	[gæṭṭə] CVCCV$	'edge/ rims'
e)	pæṭi + a CVCVV	→	[pæṭiya] CVCVCV	→	(*pæṭya)	→	[pæṭṭa] CVCCV$	'young of animals'
f)	solə + wa CVCVCV	→	[soləwa] [holəwa] CVCVCV	→	[solwa] CVCCV$	→	[solla] [holla] CVCCV$	'shake' + causative
g)	kapə + wa CVCVCV	→	[kapəwa] CVCVCV	→	[kapwa] CVCCV$	→	[kappa] CVCCV$	'cut' + causative
h)	aḍə + wa VCVCV	→	[aḍəwa] VCVCV	→	[aḍwa] CVCV$	→	[aḍḍa] VCCV$	'drag' + causative

The examples in f), g) and e) above are somewhat different in that the minimal C — i.e., /w/ — is not inserted but is underlyingly present in the causative suffix. They also show the plausibility of the starred (unrealized) forms in a) to e) by the overt presence of similar forms after the loss of the minimal vowel. These forms, however, are restricted to the educated mode.

3.3 Regressive Assimilation $C \rightarrow C_{[\alpha FEATURE]} / \_\_ \$C_{[\alpha FEATURE]}$

a) lip # gala → [liggala] CVCCVCV 'hearth stone'

b) sabḍə → [saḍḍə] CVCCV$ 'noise'

c) aṭsənə → [assənə] VCCVCV 'signature'

d) ṭaṭpərə → [ṭappərə] CVCCVCV 'seconds'

e) aṭlas → [allas] VCCVC$ 'bribes'

f) haṭ # ḍawəsə → [haḍḍawəsə] CVCCVCVCV$ 'seven-day'

g) duk # paṭ → [duppaṭ] CVCCVC$ 'poor'
'grief' # 'befallen'

h) laksənə → [lassənə] CVCCVCV 'beautiful'

This process, like Reduplication, is extremely active at both the educated and uneducated levels, but causes no apparent alteration in the syllable shape.

4.0 EXAMPLES OF NON-ASSIMILATION/REDUPLICATION

The examples below document the failure of the processes of gemination to operate when the environment is altered by a reversal of the sequential order of segments on either side of $, thereby indicating that the processes of gemination are generated by certain constraints on the sequence structure of Sinhala.

4.1 V#$C Sequence [Reverse of 2.1]

a) kalu # pol → [kalupol] 'a kind of curry'
black coconut

b) me: # tænə → [metænə] 'here'
this place

c) ædə # kuda → [ædəkudə] 'faults/shortcomings'
crook hump

4.2 $\left\{\begin{matrix}\text{LIQUID}\\\text{GLIDE}\\\text{FRICATIVE}\end{matrix}\right\}$ $C Sequence (Reverse of 2.2 and 2.3)

a) tarkə → [tarkə] 'argument'

b) kalpə → [kalpə] 'eons'

c) asta:nə → [asta:nə] 'unfounded'

d) kalde:rəmə → [kalde:rəmə] 'cauldron'

e) awkənə → [awkənə] A place name.

f) æydə → [æydə] 'why'

g) kawdə → [kawdə] 'who'

To summarize, then, the two processes of gemination, Reduplication and Assimilation, occur across syllable boundaries and are controlled by the sequential order of segments on either side.

a) Reduplication occurs when the second segment is either a vowel, a glide or a liquid (V, GL or L), i.e.,

$$C \rightarrow CC/ \text{ — } \$\left\{\begin{matrix}V\\GL\\L\end{matrix}\right\}$$

b) Progressive Assimilation operates in some instances of the C$GL sequence; the exact constraints for this have not been worked out in this paper.

c) Regressive Assimilation, on the other hand, operates when the second agreement is not a V, GL, or L and when the first segment is not one of these or the fricative /s/.

If, however, the above sequences are reversed, i.e., when the preceding segment is a V, GL, or L and the following is any obstruents gemination is blocked (4.0).

In traditional Sinhala grammar, the processes of gemination illustrated above (2.0 - 3.0) have been viewed as processes of liaison or Sandhi. While using insights from such analyses, this paper will attempt to draw some significant generalizations, in relation to the observations above, in terms of the syllable structure proposed within the theory of Natural Generative Phonology (NGP) (Hopper 1972, 1976).

The syllable will be taken as the basic phonological unit or segment sequence. This was the case in traditional Sinhala phonology as well. Also following Hooper, consonantal strength (rather than distinctive features) will be used as a cover feature to classify the segments. Preliminary to the analysis, I shall give below (5.0) the intrinsic structure of the syllable from Hooper (1976:199).

5.0

MARGIN	NUCLEUS	MARGIN
Obstruents, Nasals, Liquids, Glides	Vowels, Glides, Liquids, Nasals,	Obstruents
Least V-like	Most V-like	Less V-like
STRONG	WEAKEST	WEAK

According to 5.0, the weakest position in the syllable is the vowel nucleus and the strongest position is the syllable initial position. The syllable final position is relatively weaker than the syllable initial position.

Based on this syllable structure and exemplifying the optimal syllable principle, the following hierarchy of suitability of segments for syllable initial and syllable final position has been presented (Hooper, 1976:224).

6.0 OPTIMAL SYLLABLE INITIAL: OBSTRUENTS
NASALS
LIQUIDS
GLIDES
VOWELS, OPTIMAL SYLLABLE FINAL

The representations in 5.0 and 6.0 embody the three universals of syllabic structure summarized as 7.0 below.

7.0 a) CV is the optimal syllable structure.

b) Syllable initial position is stronger than syllable final position.

c) Optimal choice for syllable initial position is obstruent and for syllable final position is vowel.

How do these principles of syllabification apply to Sinhala? The possible distribution of consonants in the Sinhala Syllable (8.0) and the Major Syllabification Rules (9.0) below are indeed consistent with these principles.

8.0 THE SINHALA SYLLABLE

$$\$ \quad C_m \quad C_n \quad V \quad C_p \quad \$$$

m_1 — p t͡ <ṭ>[2] k b d͡ <ḍ> g (s)

(m_1 = cluster initial position)

m — p t͡ ṭ č k b d͡ ḍ ǰ g m n s š h w y r l (ƀ d̪͡ ḍ͡ ğ)

n — y w r l
p t͡ <ṭ> k m n /s-

p — y w r b d̪͡ ḍ ǰ g (not word finally)
p t͡ ṭ č k s š m n ŋ

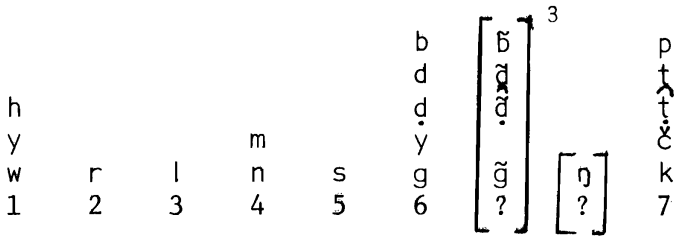
9.0 SYLLABIFICATION RULES

a) $\phi \rightarrow \$/C—C$ (Does not apply word initially)

b) $\phi \rightarrow \$/V—$ CV(C)

10.0 below gives a tentative strength scale for Sinhala consonants. In this scale the nasalized obstruents and the velar nasal are not assigned a numerical value because of their restricted distribution, which also makes them irrelevant to the discussion of gemination. y, ǰ, ṭ, ḍ may also be found to require adjustment of the strength assignments given below. Vowels are assigned zero (ϕ) value. The glides are the weakest C's and the voiceless stops are the strongest.

10.0 A TENTATIVE STRENGTH SCALE FOR SINHALA



The intrinsic structure of the syllable (5.0), however, shows that the syllable initial position is stronger than the syllable final position. It seems necessary therefore, on the basis of syllable position, to make a distinction between the strengths of adjacent syllable initial C's and syllable final C's; i.e., the strength of position affects and alters the strengths of identical C's. In other words, where C's of identical strengths are on either side of \$, the (syllable initial) C_m will be assigned greater strength value than the (syllable final) C_p (Hooper 1976).

11.0 gives the syllable structure conditions (SSC) for Sinhala. SSC's insert syllable boundaries and alter C's to required strengths. According to Hooper SSC's can explain syllable final weakening and syllable initial strengthening; they also generate the necessary feature changes.

11.0 SSC FOR SINHALA

$\$ \; C_m \; C_n \; V \; C_p \; \$$ where $n \leq 3$

If $n > 1$, then $m \geq 4$

$m > n$

If $XVC_p\$C_m$, and there is no pause then

$C_m > C_p$

Early in this paper, the two processes of gemination in Sinhala, (Reduplication and Assimilation) were claimed to be Syllable Structure processes involving strengthening and weakening respectively. The feature changes they generate are therefore to be taken as directly conditioned and described by the Syllable Structure Conditions given above (11.0); more specifically by the SSC that $C_m > C_p$ in a contiguous sequence $XVC_p\$C_m$, where there is no pause between C_p and C_m. Let us review the two processes in relation to this SSC.

12.0	REDUPLICATION	REGRESSIVE ASSIMILATION
	mal # atu	lip # galə
a)	SSC inserts $	
	$mal # $a$tu$	$lip # galə$
	CVC V CV	CVC CV CV
b)	A compounding or juncture rule eliminates the pause and brings together two segments violating the special condition that $C_m > C_p$ and/or the optimal syllable principle.[4]	
	malatu	lipga$lə$
	3 ø	7 6
c)	SSC generate a weakening or strengthening process as required — i.e., gemination — to adjust the strengths of segments on either side of $.	
	mallatu	ligga$lə$
	CVC CV CV	CVC CV CV
	3 3	6 6
	strengthened	weakened
	V → CV	No change

Reduplication also preserves the optimal syllable principle by inserting a C in syllable initial position. While no apparent change takes place in the shape (i.e., CV remains CV) of the syllable after Regressive Assimilation, the strength adjustments caused by it alter the structure of the syllable.

The rules for Reduplication and Regressive Assimilation are given as 13.0 and 14.0 below. The environments of the two rules, shown in terms of C strength, reveal the two processes to be mutually exclusive.

13.0 REDUPLICATION

$$\phi \rightarrow C\begin{bmatrix}\alpha\text{FEATURE}\\ \alpha\text{STRENGTH}\end{bmatrix} / C\begin{bmatrix}\alpha\text{FEATURE}\\ \alpha\text{STRENGTH}\end{bmatrix} \$ \_\_ \begin{Bmatrix}V\\ C\end{Bmatrix}_{[\leq 3\ \text{STRENGTH}]}$$

14.0 REGRESSIVE ASSIMILATION

$$C_{[>5\ \vec{\text{STRENGTH}}]}\ C\begin{bmatrix}\alpha\text{FEATURE}\\ \beta\text{STRENGTH}\end{bmatrix} / \_\_ \$C\begin{bmatrix}\alpha\text{FEATURE}\\ \beta\text{STRENGTH}\end{bmatrix}$$

Where β is > 3.

Gemination, then, occurs at a syllable boundary when a segment which occupies the C_p position has a higher strength value than the one in C_m. More specifically, however, Reduplication (and Progressive Assimilation, which has not been fully dealt with here) takes place when C_m is ≤ 3 in the strength scale and is weaker than C_p, Regressive Assimilation takes place when C_p is ≥ 5 on the strength scale and $C_m > 3$. In Regressive Assimilation the dominant factor is the strength of syllable position. It is the consonant in syllable initial, or stronger, position (C_m) which dictates the assimilation regardless of its inherent features or strength value relative to the weakly positioned C_p, as long as C_m meets the condition that it is > 3 on the strength scale. Total assimilation, of course, results in C_p having no non-redundant features — i.e., C_p becomes non-distinctive or weakened.

This paper has viewed gemination as a syllable structure process which is specifically aimed at meeting the SSC that if C_m and C_p are contiguous, with no pause in between, then $C_m > C_p$. Since the geminate consonants, whether generated by reduplication or assimilation, are identical in feature and strength, the question arises as to whether this condition has been met.

Hooper (1976) claims that total assimilation is a weakening process. The acquisition of feature values from surrounding

segments reduces the distinctive function of the assimilated C. Also, the weakening occurs in C_p whose position in the syllable is intrinsically weaker. Even when the result of the assimilation is, according to the strength hierarchy, stronger than the original C, the C remains weakened as all redundant features have been lost. In Sinhala, Regressive Assimilation is generated to reduce the strength of C_p if it is contiguous with a C_m of > 3 strength which is weaker than or equal to it. Reduplication (and progressive assimilation) is generated when, in the contiguous sequence, C_m < 3 strength and C_p > C_m by even one step on the scale. Again the reduplicated C is non-redundant in all its features but occupies a position of intrinsic strength in the syllable.

In the case of geminate pairs then, be they lexically present or generated by the SSC, the member occupying the C_p position is universally considered weak (Harris 1969). A rather loosely stated Redundancy Rule, 15.0 below, is adequate to make this generalization.

15.0 REDUNDANCY RULE

$$\text{STRENGTH}\left(C\begin{bmatrix}\alpha\text{FEATURE}\\ +\text{RELEASED}\end{bmatrix}\right) > \text{STRENGTH}\left(C\begin{bmatrix}\alpha\text{FEATURE}\\ -\text{RELEASED}\end{bmatrix}\right)$$

By this rule, a greater strength value (perhaps +1) is assigned to the released counterpart of a geminate pair. Thus the numerical value of the segments on the strength scale would be augmented by one (+1) where the feature [+ released] is present, which would necessarily be the segment in the C_m position, and the SSC that C_m > C_p will be met. For example, observe 16.0 below (from 12.0).

16.0 REDUPLICATION

$$\begin{array}{c} \$ma|\$la\$tu\$ \\ C_p\ C_m \\ 3\ \ 3 \end{array}$$

REGRESSIVE ASSIMILATION

$$\begin{array}{c} \$|ig\$ga\$|ə\$ \\ C_p\ C_m \\ 6\ \ 6 \end{array}$$

d) C_m augmented by the Redundancy Rule (15.0)

$$\begin{array}{c} C_p\ \$C_m \\ 3\ \ 3+1 \end{array}$$

$$\begin{array}{c} C_p\ \$C_m \\ 6\ \ 6+1 \end{array}$$

It would appear, therefore, that these preliminary observations support the tenability of the hypothesis that gemination in Sinhala is a syllable structure process. However, the primary function of this process seems to be to meet the SSC in Sinhala that, in a contiguous sequence unbroken by a pause, $C_m > C_p$ rather than to preserve the optimal (CV) syllable structure. While the latter is also achieved in a marginal sort of way, the evidence in the preceding pages shows that gemination operates strongly to meet this special SSC, often even violating the Optimal Syllable Principle by creating or preserving CVC or CCV syllables.

NOTES

[1]Educated speech allows syllable initial clusters of a restricted nature:

Educated Speech		Uneducated Speech
[priyə]	'beloved'	[piriyə]
[prəka:sə]	'public'	[pareka:sə]
[wastrə]	'clothing'	[wastərə]
[swa:mi]	'master'	[suwa:mi]
[nya:yə]	'law'	[niya:yə]
[bre:k]	'break'	[berek]
[træ:m]	'tram'	[ṭæræŋ]
[kri:m]	'cream'	[kiriŋ]

In uneducated speech, however, the SSC requires the insertion of $ without exception between consonants. When a single consonant is left over by this rule, epenthesis takes place by a vowel insertion rule which usually copies the following vowel, except when the second C is a glide — w/y. In this case u/i respectively are inserted. This was a productive process in early Sinhala and remains so in uneducated speech today.

A further constraint exists on clusters with initial /s/ in uneducated speech. In educated speech /p, t, k, m, n/ also occur following /s/. In uneducated speech an epenthetic rule operates to break up the cluster. However, epenthesis occurs in initial positions preceding /s/ and the inserted vowel is the minimal vowel realized as /ɨ/ in this position of word initial stress: e.g.:

Educated Speech		Uneducated Speech
[stá:nə]	'places'	[ísta:nə]
[sn̂á:yu]	'sinews'	[ísn̂a:yu]
[str̂í:]	'woman'	[ístr̂iri]
[st̂ó:ruwə]	'store'	[ístô:ruwə]
[st̤é:səmə]	'(railway) station'	[íst̤e:səmə]

[2]<> indicate these are restricted to English loan words.

[3]These are the prenasalized stops in Sinhala. They have a restricted distribution occurring only in syllable initial inter-vocalic positions, e.g.,

[aᵬə]	'mango'
[aḍə]	'blind'
[aᶁə]	'sound'
[aᶄə]	'horn/antler'

[4]It is noteworthy that early Sinhala exhibits a rule (active today in the language of poetry) that shifted the syllable boundaries in such cases to preserve the CV syllable structure.

$ma|$atu → ma|atu
CVC V CV CV CV CV

Reduplication also creates a CV syllable but while doing so it retains the CVC syllable as well.

$ma|$atu → $ma|$|atu
CVC V CV CVC CV CV

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