A SYNTHETIC TEST OF INTONATION PATTERNS

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MAY 1991

DEDICATED TO MY
DEAR & NEAR ONES

CERTIFICATE

This is to certify that the Dissertation entitled " A SYNTHETIC TEST OF INTONATION PATTERNS" is the bonafide work on part fulfilment for the Degree of Master of Science (Speech & Hearing) of the student with Register NO.M8912.

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This is to certify that the Dissertation entitled:"A SYNTHETIC TEST OF INTONATION PATTERNS" has been prepared under my supervision and guidance.

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DECLARATION

I hereby declare that this Dissertation entitled:"A SYNTHETIC TEST OF INTONATION PATTERNS" is the result of my own study under the guidance of Dr.S.R.Savithri, Lecturer in the Department of Speech Science, All India Institute of Speech and Hearing, Mysore 570 006, and has not been submitted earlier at any University for any other Diploma or Degree.

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INTRODUCTION

Suprasegmentals are properties of speech that have a domain larger than a single element and include the following: stress, intonation, rhythm and quantity. Of these, the phenomemon displaying maximal linguistic contrastivity within the whole range of vocal effect has been labelled intonation. Intonation refers to variations in pitch as a function of time. The concept'intonation' is viewed not as a single system of contours but as a complex of features from different prosodic systems. These vary in their relevance, but the most central are tone, pitch range and loudness with rhythmicality and tempo closely related.

Crystal(1973) suggested that intonation is an important mediator in interaction situations. From an applied point of view, it has been suggested that intelligent use of information on intonation could improve speech recognition. Lieberman(1967), Kaplan & Kaplan(1970) report that intonation is the primary means of segmenting the relatively continuous speech signal to permit isolation of relevant syntactic/ semantic components. Linguists have been interested in characterising the types of intonation patterns that exist, the meanings they convey and are also in the pursuit of knowing how the temporal relationship of the fundamental frequency contour to the speech segments is governed by stress and syntax.

Psycholinguists, on the other hand have begun to examine intonation as an indirect source of evidence about what the units of planning are and how parsing is accomplished. Furthermore intonation plays an important role in the intelligibility and naturalness of synthetic speech (Olive & Nakatani(1974), Nooteboom et al(1976)). Attempts have been made in the past to study the aspects of intonation in various languages. In this regard studies by Crystal (1973),in English, Sandner(1981) in German, Rabson et al (1982) in Japanese, Thorsen(1978), Pierrehumbert(1980) in Danish, Williams(1985) in Welsh are worthy of mention. These researchers show evidence that infants develop various intonation patterns over a period of time and they respond to suprasegmental properties at an early age at the expense of other segmental aspects/linguistic features.

It is important that a speech-language pathologist know about the development of suprasegmental aspects of speech,as children with communication problems demonstrate unintelligible speech that is difficult to evaluate solely by segmental tests/segmental development norms. The above is necessary because in these patients errors of rhythm and intonation also affects the intelligibility of the child's speech (Hudgins(1946), John & Howrath(1965), Hood & Dixon(1969), Stevens, Nickerson & Rollins(1978), Bush(1979), Reilly(1979), Simon(1979), Stromberg & Levitt(1979)).

The term 'Dysprosodics' encompasses a range of individuals encountered with communication disorders exhibiting impairment in the suprasegmental features that could be a result of improper perception, production or speech programming. In these cases it would become the responsibility of the speech-language pathologist to gain knowledge about dysprosody and further correcting it. However, because of the difficulty in studying supra-segmentals "research into the nature and development of non-segmental phenomena in children is generally ignored or referred to haphazardly" (Crystal(1975)). The reasons he offers are:

1. The difficulty in obtaining natural and reliable samples
2. The large amount of time needed to process non-segmental data and
3. The absence of an acceptable system for classifying and transcribing the non-segmental data that exist.

No formal tests for intonation were developed until 1977 owing to the above reasons. It was all the more distressing since suprasegmental patterns were acquired earlier in the development of normal speech and language (Lewis(1951), Lenneberg{1967), Guberina(1971), Menyuk(1972), Crystal(1973), Tonkova-Yampol'skaya(1973), Kressin(1976)). Considering this, Koike & Asp(1977) attempted to design a test of intonation and rhythm(T-Trip), where they used twenty-five test items

uttered by a subject with extensive phonetic training.

However, T-Trip has several limitations, one being the inability to achieve an accurate control over frequency.

The use of synthetic stimuli can overcome this limitation. In this context, the present study is aimed at developing a synthetic test of intonation patterns. The study is further focused at understanding the performance of children aged four to eight years in imitating these intonation patterns synthesized. It is hoped that this test, if proven valid, can provide vital diagnostic information(for intonation patterns). It may also help in rehabilitating the dysprosodic patient in terms of suprasegmental features.

REVIEW OF LITERATURE

There exists a difference in opinion among researchers as to what the term 'suprasegmentals' actually refers to. Crystal & Quirk(1964) refer to tempo, prominence and pitch factors as suprasegmental features. However, Lehiste(1970) identifies suprasegmental parameters as intonation, stress and quantity (duration). She also provides acoustic and perceptual data to support this.

Among the suprasegmentals intonation seems to be an inclusive term that refers to variations in pitch as a function of time. Fairbanks(1940) used the term intonation to include both inflection and pitch shift. He used inflection to identify the pitch change within a single phonation and pitch shift to identify change in pitch from the end of one phonation to the beginning of the next phonation.

Lehiste(1970) uses the term intonation as the linguistically significant functioning of fundamental frequency at the sentence level. Contrastive function of fundamental frequency is called 'tone' at the word level. She distinguishes between lexical tone, grammatical tone and morphemic tone. Lexical tone is found in languages in which contrastive tone is associated with differences in the meanings of roots and stems (independently of stem formatives). Among such languages are Chinese and Slovene. The term 'grammatical tone' is applied to instances in which a difference in tone signals a

difference in grammatical function without changing the lexical meaning or overt morphological structure. The term 'morphemic tone' is used in instances in which the tone on a root is predictable from the presence of a suffix morpheme, which need not carry the tone overtly.

Most traditional perceptually based phonetic theories (Armstrong and Ward(1926), Pike(1945), Trager & Smith(1951) and many instrumental studies (Lieberman(1967), Hadding-Koch (1961), Vanderslice and Ladefoged(1972), Atkinson(1973), Tseng(1981), Landahl(1982) agree in so far as a falling of fundamental frequency and amplitude contour forms the terminal part of the breath group, that signals the end of a declarative sentence phrase in most human languages(Lieberman(1967). The falling of the frequency and amplitude contour reflects the biological and vegetative constraints of respiration.

INTONATION/TONE PATTERNS SUGGESTED BY VARIOUS AUTHORS

It has long been realised that within the prosodic contrasts of English, some features are more noticeable and seem to carry more semantic weight than others. This awareness is reflected very early in the development of prosodic studies though its formulation has been relatively recent.

Thus we find Butler in the 17th century seeing the importance of making a main distinction between rising and falling intonations.

Sweet(1878) distinguishes eight tones in all, some being more fundamental than others. They are: level, high rising, low rising, high falling, low falling, compound rising, compound falling and more emphatic. Sweet(1906) distinguishes three primary forms of nuclear tone - level, rising and falling.

Palmer(1922) distinguishes four basic types of tones- falling, high rising, falling rising and low rising which is almost invariably intensified and hence is considered normal. He also describes intensified falling tone and two kinds of tonal sequence -

1. Co-ordinating (\\,// ^v) where the tone groups are identical.
2. Subordinating (\/, ^, `, ´ and N) where the tone groups are dissimilar.

Armstrong and Ward(1926) based their dichotomy of falling and rising tones referring to the general shape of an intonation contour centered on a special nuclear type.

Heffner(1949) distinguishes between level, high rising, high falling, compound rising and compound falling as being tonal contrasts.

Nijland(1951) put forth five different intonation curves- Movetone - horizontal (—), Convexe - descendant (⌒), Concave - descendant (⌣), Concave - ascendant (⌒),&Convexe - ascendant (⌒)

Lee(1953) distinguishes between different types of tone sequences:

1. On pairs of Questions (\/)
2. On longer sequence of Questions (///\ or////) and
3. On two co-ordinated sentences varying in only one predicate word (/\ ).

Mc Carthy(1956) distinguishes between the following types of tones - Rise-fall, Fall-rise, Rise-fall-rise, fall-rise-fall with high and low varieties.of each.

Hultzen(1957, 1964) divides nuclei into two groups on whether they have a low (closed) ending or an open ending.

Mitchell(1957) specifies level, high rising, high falling and compound rising types of tones.

Kingdon(1958a) makes a distinction between high and low, normal and emphatic tones and then lists rising, falling, falling rising(divided and undivided types), rising falling (1,2 and 3 syllable types), rising falling rising (divided and undivided types) and level tone (though the latter is not nuclear).

'Schubiger(1958) identifies exocentric (subofdinate) and endocentric types of tone sequences. The specific sequences she mentions are - rising+falling(/+\, compound rising+falling (V+\), falling+falling(\+\), rising+rising(/+/), compound rislng+rising(V+/), and falling+rising(\+/). She also distinguishes between different types of tone sequences occuring on enumerations(///\), the more colloquial(\\\\ ), sequences which

are susceptible on continuation (////), patterns which lays emphasis on the penult (\\\/\), and on alternatives (/\and //).

Trim(1959) makes a major distinction between formally independent major tone groups and minor tone groups which are characterized as dependant and non-final. He places importance towards phonological criteria rather than a grammatical approach to define major tone groups.

O'Connor and Arnold(1961) recognize low and high falls and rises, rise-fall, fall-rise and a compound 'fall+rise' though the latter is considered a conflation of two simple tones. In total they distinguish six tone types and ten types of tone groups. Intonation is analysed by Halliday(1966) as a complex of three systemic variables:

1. tonality (the division of an utterance into tone groups and the placement of tone group boundaries)
2. tonicity (the placement of the tonic syllable and foot within the tone group and the consequent division of the group into tonic and pre-tonic elements of structure), and
3. tone (which is divided into primary and secondary tone).

He recognizes fall, rise, 'sharp' fall-rise, fall-rise, low-rise, rise-fall, fall+low rise, and rise-fall+low-rise as primary tones. He distinguishes between even (level, falling, rising), uneven (low spiky) and suspended (listing), high (level, falling, rising) and low (level, rising), mid (level) and low(level) sub types of secondary tone. He believes that

tonality, the division of an utterance into tone groups- not fusion of tones, is at present the first kind of choice important for Intonation. He, however believes that further research will demonstrate the existence of tone group sequences, which would require at least one intermediate stage between an utterance and a tone group.

In a study by Quirk and Crystal(1966), a major division of nuclear tones into two types was done -

1. Falling: Comprising simple, complex and compound tones, the final direction of the pitch movement being downward.
2. Rising : Comprising simple, complex and compound tones, the final direction of the pitch movement being upward.

Hirst(1977) believes that the level of tones or T segments in english can be defined by two binary features high and low.
+ low is defined so as to represent a lowering of pitch.
+ high defines to a slightly smaller rise in pitch.
A drop tone is a combination of (+High +Low).
A Mid tone refers to (-high -low), a High tone to (+high -low) and a Low tone to (-high +low). He also put forth possible representations for four different final feet (fig.l).

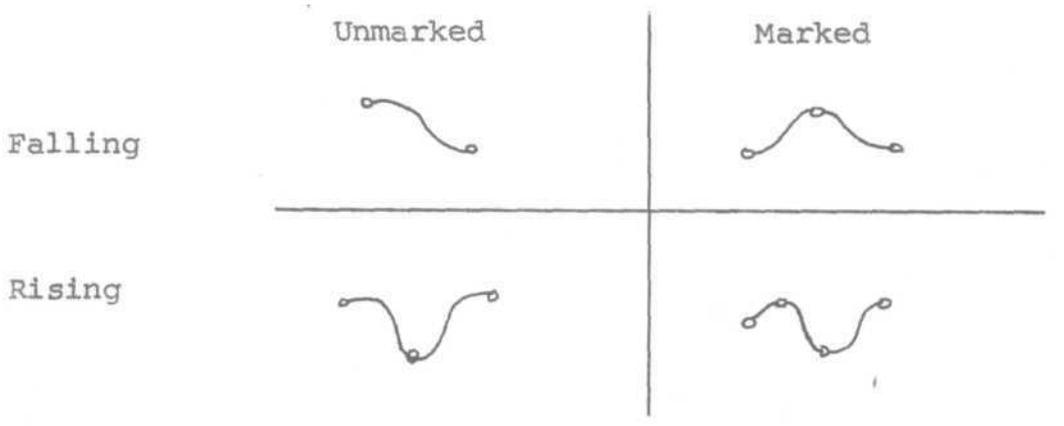


Fig.l: Representation of tones(Hirst-1977).

From all recent approaches to intonation, the most readily perceivable, recurrent, maximal unit to which linguistic meaning can be attached is the tone unit. All writers agree to this although the terminology of description differs.

A summary of the tone patterns suggested by various authors is depicted in Table 11-

PROPOSED TONE SYSTEMS.

INVESTIGATOR.	TOTAL-NUMBER.	LEVEL.	HIGH RISING.	LOW RISING.	HIGH FALLING.	LOW FALLING.	COMPOUND RISING.	COMPOUND FALLING.	MORE EMPHATIC	FALLING.	FALLING RISING.	MOVE TONE HORIZONTAL	CONVEXE DESCENDANT	CONCAVE DESCENDANT	CONCAVE ASCENDANT	CONVEXE ASCENDANT	(HIGH) FALL-RISE.	(LOW) FALL-RISE	(HIGH) RISE-FALL	(LOW) RISE-FALL	(LOW) RISE-FALL	(HIGH) RISE-FALL-RISE	FALLING-RISING (UNDEVIDED).	FALLING-RISING (DEVIDED).	RISE-FALL 2 SYLLABLE TYPE.	RISE-FALL 2 SYLLABLE TYPE	RISE-FALL 2 SYLLABLE TYPE.	RISE.	RISE-FALL-RISE (UNDIVIDED).	RISE-FALL-RISE (DIVIDED).	COMPOUND
SWEET (1878)	8	-	/	/	/	/	V	^	N			·																			
PALMER (1922)	4		/	/				-		\	↻																				
HEFFNER (1949)	5	-	/		\		V	^																							
NIJLAND (1951)												–	↓*	↘*	→*	↗*															
MacCARTHY (1956)	10		/	/	\	\											V	V	^	^	N	N									
MITCHELL (1957)	4	-	/		\		V																								
*KINGDON (1958a)	10	-								\													* V	* V	* ^	* M	* M	* /	* N	* N	
*O'CONNOR & ARNOLD (1961)	7		/	/	\	\					V						V														V

* Transcriptions are not provided but are written on the basis of description.

Table I :- represents the various tone systems proposed by various authors.

TONE/INTONATION SYSTEMS

Special consideration has been extended towards English as English tone/intonation systems have been the most widely studied.

ENGLISH: 'In English there seems to be regular definable phonological boundaries for tone units in normal speech which is indicated by two factors. First; There will be a perceivable change in pitch either stepping up/down depending on the direction of the nuclear tone movement. The second criterion is the presence of junctural features at the end of every tone unit. This usually takes the form ef a very slight pause, but there are frequently accompanying segmental phonetic modifications viz: variations in length, aspiration etc which reinforce this. The nuclear unit(tone system in English) can be categorized into 3 types viz: simple, compound and complex.

SIMPLE	COMPLEX	COMPOUND
Basic types \ / –	V ^	\+/ /+\
Secondary types	~ ∩	^+/ V+\ \+–
Simple pitch range ↑↑, ↑ ↑, → +tone ∅, ↓, ↓ representing 4 degrees of tone height	↑↑, ↑ ↑, → +tone ∅, ↓, ↓	↑↑, ↑ ↑, → +both elements ∅, ↓, ↓
complex pitch range	n+V, ^, ~, ∩ w+V, ^, ~, ∩ Vn, ^w, Vw	n/+\ etc w\+/etc \+n/ /+n\ w\+/ w/+\

Table 2 summarizes the English tone systems.

Notations used in the Table-2 refer to the following:

1. ω (wide) pitch range
2. (Ø) Normal pitch range (stands for unmarked terms occuring in simple and complex pitch range systems).
3. n (narrow) pitch range.
4. ↑↑,↑ refer to a relatively high tone height.
5. Medium tone height is represented by ↑, → and
6. relatively low tone height is represented by ↓, ↓ and ↓

There also exists a general agreement about the internal structure of the tone unit. Minimally a'tone unit must consist of a syllable and this syllable must carry a glide of a particular kind. This is referred to as the nucleas of a tone unit!
'Halliday(1966) uses the term"tonic syllable in place of this". Maximally a tone unit must consist of three other segments - Head, Prehead, and Tail^

'Head refers to the stretch of utterance fpom the first stressed and usually pitch prominent syllable upto but not including the nuclear tone. It consists of an unspecified number of stressed/unstressed syllables (at least one of the former). Heads are classified as - Falling heads, Rising heads, Falling-Rising-falling) heads, Rising-Falling-rising) heads.

' The prehead or the preonset refers to any utterance which precedes the onset syllable within the same tone unit. It consists of an unspecified number of unstressed syllables

(at least one) but occassionally under certain conditions: Syllables with some slight degree of stress (not equivalent to the stress of the onset syllable and never with pitch prominence). Marked levels of preheads are - High preheads, Extra high preheads, Mid preheads , and Extra low preheads. The nuclear tail consists of an unspecified number of stressed/ unstressed syllables (at least one of the either) following the nuclear syllable usually continuing the pitch movement unbrokenly till the end of the tone unit.

In a comparison between English, French, and German emotive intonation patterns by Fo'nagy and Magdics(1963) it was found that -

(a) Joy increases the pitch range in each of these three languages which is reflected in a higher pitch level in a melody ascending frequently at irregular intervals as well as in irregular stress distribution. In French, the voice rises at the end of phrases rather or as against the descrescend character of Hungarian sentences. The features of tenderness observed in Hungarian appear in these languages too. The pitch level is higher, though narrower than in neutral statements.

(b) Longing is characterized by a slightly rising, descending and gently ascending melody at the end of the sentence in all the three languages.

(c) There is an increase in the pitch range in the three western languages for the emotion 'surprise'. In German and English the voice falls a fifth or sixth interval from a high level. This sudden fall is found in French too and a sudden rise is similarly frequent. In Yes or No questions, surprise is reflected in an increase of the rising interval.

(d) The intonation of sudden fright differs also in the western languages from the melody of surprise in having a narrower pitch range in the checking of loudness and speed and also in its peculiar timbre.

In the case of surprise, astonishment, the melody of the phrase floats on a high level and in the last syllable, it falls to a lower one. In speech expressing fright the melody does not stay long on the high level, rather,the greater part of the phrase constitutes a straight melodic line on a low level.

(e) Anguish is characterized by an extremely narrow pitch range in all the three western languages.

(f) Scorn is characterized by a narrow pitch range and a compressed or grumbled voice production as seen in Hungarian.

(g) Anger in German and English appears in the 4th, 5th and 6th ascending intervals of the stressed syllables frequently interrupting the straight melodic line.

(h) Sarcasm is felt in the checked 'widely arched' stressed off glide, in a creaky voice as well as in nasal timbre. In English and French the arc is wider than in Hungarian.

"A more comprehensive investigation yet remains to be attempted of Japanese intonation patterns which are likely to sound un-English" This necessity stems after a comparison between intonation patterns of English and Japanese by Abe(1955). Both English and Japanese have been found to employ a gradually falling intonation pattern for questions of the information seeking type. An effect of curiosity/ cordiality has been found to be imparted if a slight rise instead of a fall is added to the sentence. Heightened tones have been found to be suggestive of intensified feelings as animation, anger, irony, exultation, etc. where as an inte-rrogative word pronounced with a rapid descrescendo of voice with a falling sentence-final intonation introduces a note of accusation. A conspicuous rise of pitch on the other hand at the end either introduces a touch of surpise (for the speaker) or indicates that the speaker is highly incredulous.

Trager & Smith(1951, 1957) found that American English intonation patterns consisted typically of three pitches and a terminal contour. The initial pitch was most often 'middle' but could be any of the others (low, high or extra high). They found that the central pitch accompanying the primary stress of a phrase/clause was most often high in cases of

statements/questions but was frequently extra high during emphasis or could often be low or middle. The final pitch was most often low at the end of statements, middle at the end of clauses that did not end sentences and high at the ends of certain kinds of questions, but could be others too. The final pitch was found to be modified by the terminal contour, being sustained /—/, rising /// or falling /\ /. 'Sustained' was found to occur most often in clauses that did not end sentences, falling occured in statements and interrogative word questions and rising occured in other questions and in many non-final clauses. It is however noteworthy that two most striking features of British English that distinguishes it from American English as well as from most European languages are a wide variation in pitch and a predominence of falling patterns. Though a falling pitch from relatively high to relatively low characterizes the end of a declarative sentence in both British and American English and also in questions beginning with an interrogative word exemplified by "where are you going?", (Palmer(1922), Jones(1964)) report that in questions not beginning with an interrogative word for example: 'Are you coming?", American English and most European languages use a sharply rising intonation, where as British English has the same falling pitch as in 'Where are you going?".

Another variant, the Hawaiian American English(pidgin) differs from general American English in terms of phonetic shape of the pitch accent, though pidgin statements-usually special or interrogative word questions-take a rise-fall intonation very much like general American English. Interrogative word questions (exclusive of reclamatory and echo questions) have basically the same pattern in both pidgin and general American English. The Pidgin pattern is conspicuous from the general American English pattern of rising or high pitch with rising terminal for general questions of the Yes-No type in a way that the pattern starts at or quickly rises to high pitch level which lasts until just before the accented ultima/penult, on which there is low pitch with terminal steadying or slight rise. Pidgin tag questions have a high pitch with terminal rise if sentence final, and adopt a low pitch in sentence non-final position followed either by the residue of inverted word order or by more or less redundant material. Pidgin vocatives tend to be like one of the common general American English patterns with a high pitch followed by a slight drop and terminal rise. However, mid rising and high falling call patterns of general American English seems not to occur.

DANISH: Although a number of writers (Uldall(1960, 1961) , Von Essen(1956), Garding and Abramson(1965), Hadding-Koch and Studdert Kennedy(1963, 1964, 1965, 1974), Studdert-Kennedy and Hadding Koch(1972, 1973) have conceded that the

earlier parts of the course of fundamental frequency may play a role in the perception of intonation of sentences of differentiating function, They have all proceeded to test the significance of the 'terminal contour' which was emphasized by Danes(1960), Isacenko and Schadlich(1963), Isacenko(1965),

Thorsen(1978a) in her analysis of short sentences in Advanced Standard Copenhagen Danish found that intonation contours approached straight lines, slopes varying according to the sentence type in a trade off relationship with syntax. The more the syntactic information about the non-declarative function contained in the sentence, the more declarative was its intonation contour. Further, advanced standard Copenhagen speaking subjects could identify such utterances solely on the basis of the fundamental frequency course given no contextual or syntactic information. It was found that the less falling the intonation contour, the more interrogative an utterance was heard. The more steeply falling the contour was, the more declarative an utterance was heard and contours in the middle of the continuum were considered as non-final.

Thorsen(1979, 1980 a,b) considered the representation of sentence intonation in standard Danish to be in the form of simultaneous non-categorical components and suggested that the stress group and intonation components be viewed as invariant entities at a level in the speech production and perception process.

Pierrehumbert(1980) suggested that standard Danish be re-analysed in a fashion similar to her analysis of English in terms of a sequence of pitch accents, consisting either of monotonal (high or low accents) or bitonal combinations of the two (connected with a '+' in the transcription). In bitonal pitch accents either of the tones may be the stronger one, lining up with a stressed syllable, leading/lagging behind a weaker tone. Tones aligned with stressed syllables are denoted with a star. Pierrehumbert introduced a rule of downstep which lowered a H tone in the context H+L and HL+ , independently of the relative prominence (starring) of the tones. Overall downdrift is then a result of context-ually determined downsteps which are completely locally governed.

Confronted with the Danish data particularly the low plus high falling stress group pattern, Pierrehumbert faces an obstacle in her system: standard Danish has a bitonal L*+H accent. If tritonal accents are to be avoided, there is no room for a L after the H in pitch accents i.e. there is no context for the downsteps rule.

Pierrehumbert circumvents this problem by positing a downstep rule which applies in declaratives in Danish and which downsteps L* in relation to the preceding H. She bases this on an observation from Thorsen's model that L*+H interval is constant where as the HL* interval varies

(i.e. L* dissimilates from the preceding H to varying degrees in different types of utterances).

Thorsen(1980), however, negates it by saying that "with the rule which downsteps L* in relation to the preceding H by a factor K which varies according to the status of the sentence, all Danish sentence intonation contours are the product of locally determined pitch accent scaling(Pierre-humbert's first observation that L*+H interval is constant is not accurate where the actual physical scaling of the fundamental frequency is taking place). She says that it may be true at a more abstract level of production or perception."

CHENGTU DIALECT: (Szechuan, China)

In an analysis of an eight hour sample of a native speaker of the Chengtu dialect, Chang(1958) categorizes 10 principal allotones under four tonemes. They are:

Toneme I : 1. high rising
2. mid-level
Toneme II : 3. low falling
Toneme III : 4. high falling
5. high level
6. half-high falling
Toneme IV : 7. low-falling-rising
8. low-low-falling
9. low-level
10. neutral tone

Furthermore, he concludes that intonation does exist in the Chengtu dialect and that it is superimposed on the sentence as a whole. He adds that "it is this superimposed intonation that modifies the individual tones and not the tones themselves that decide the intonation of the sentence". His investigation also reveals that :

1. Toneme II always remains low falling.
2. Tonemes I & IV remain unchanged when they are in their initial position.
3. When Toneme I goes through pertubation, the naming tone is always replaced by a mid level tone.
4. Toneme III remains unchanged when it is in the final position.
5. The naming tone of Toneme III is replaced by a high level tone when it is initial in a three syllable group. It is replaced by a half-high falling tone when it is the middle syllable.
6. The naming tone of Toneme II is replaced by a low level tone when it is in the middle of a three syllable group. It is replaced by a low-low falling tone checked by a glottal stop when it is the final syllable.

HUNGARIAN: Emotive patterns in Hungarian were described by Fo'nagy and Magdics(1963). The following observations were made by them:

1. Pitch range was found to increase with joy.
2. Tenderness was expressed by a higher pitch level which did not fluctuate.

3. Longing was found to bring about a narrow pitch range.
4. The melody expressing a coquettish invitation was found to move on the mid level/even lower.
5. In the case of surpd.se the voice was found to suddenly glide up/ up and down to a high level within the stressed syllable, then according to the kind of surprise fell to a mid level(joyful surprise) or to a lower level(stupe-faction) leaving the sentence melody unclosed.
6. Fright had a typical intonation form as that of surprise.
7. Anguish was characterized by an extremely narrow pitch range, the melody of the stressed syllable rising about a semitone and returning to a much higher level where it became so to say paralysed.
8. Horror was found to be pronounced on a chest tone and 'complaint' was characterized by a 'musical' intonation i.e. floating on one level and ascending a semitone at regular intervals.
9. Scorn was almost always sounded in a chest tone and was reflected by a more/less even and finally descending melodic line intoned on a very low level.
10. Anger was generally expressed on a mid pitch level and was characterized by a straight, rigid melodic line which leapt up a 4th, 5th or 6th interval at the beginning of the phrases. Furthermore Sarcasm was characterized by a stressed syllable gliding to a low level in a wide arc.

ITALIAN: Chapellez(1964) made the following notes on 'Questions' in Italian:

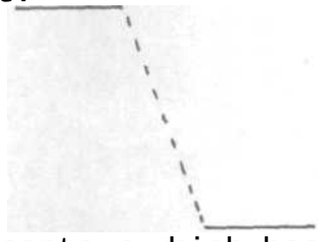
Short interrogative questions possessed one or the other of two basic intonation patterns of Italian viz. the falling and the falling rising. In his observation on intonation patterns during emphasis (for contrast), the pitch of the stressed syllable of the contrast word fell from a high to a low note. When emphasis was used(for intensity), the pitch range was widened and the stressed syllables were pronounced with increased stress.

KUNTMAIPA(NEWGUINEA): The minimum units of the intonation system in Kunimaipa are the three pitch levels, the intonemes: high, mid and low. These units combine to form sequences referred to as prenuclear contours and nuclear contours. Pence(1964) noted 4 types of prenuclear contours:

1. Stepping(Mid-high) prenuclear contour as seen in a declarative statement.

2. Rising(Low-high) prenuclear contour which carries a meaning of incompleteness.

3. Falling(High-low) prenuclear contour which seems to indicate exitement.



4. Level prenuclear contour which has a meaning of suspense.

He also noted ten types of nuclear contours. They are:

1. High nuclear contour: Which has a meaning of impending incompleteness or normal question.
2. Mid nuclear contour : The meaning of which is unknown.
3. Low nuclear contour : Which has a meaning of a normal or unemotional statement.
4. High-low nuclear contour: Which has the force of an announcement.
5. High-mid nuclear contour: Which has (tentatively) a meaning of a polite statement.
6. Mid-low nuclear contour : Which has a meaning of an emphatic statement.
7. Mid-high nuclear contour : Which has meanings of a polite request, polite question or non-emphatic call.
8. Mid-high-low nuclear contour : Which has a meaning of deep feeling such as intense sympathy or desire.
9. High-high-mid nuclear contour : Which is used as an intense or distant call.

10. Mid-low-mid nuclear contour : Which is used as an excited sequence both in listing items and as a type of hesitation.

It is also noteworthy that 'Norwegian' has a second (tonal) stress accent where as the non-Scandinavian languages plus Icelandic, Farsese and Finnish, Swedish have only one. East Norwegian possessess a low tone with stress where as English and north German normally have a high tone.

WELSH: Uniqueness in the suprasegmental systems has been demonstrated acoustically in Welsh. Williams(1985) reports that in Welsh, pitch movement is not intimately connected with stress and such a connection belongs to rhythm. He emphasizes the need for different descriptive systems, intonational phenomena being quite different from stress phenomena . Ladd(1980), however, believes that this point may clarify some current puzzles if applied to stress and intonation in English. However, arguements that will ensue will be based on considerations of theoritical economy and generality, while in Welsh concrete acoustic evidence that stress is based on rhythm, which is essentially distinct from intonational phenomena exists.

With reference to the Indian context, the following studies have been conducted:

Some aspects of intonation in Kannada were studied by Manjula(1979). A total of nine emotions were studied out of which 4 were primary emotions, four were secondary and. one was neutral.

The four primary emotions included under the study were: anger, fear, grief and joy. The secondary emotions included: frustration, worry, surprise and jealousy. The term neutral (Rosenzweig(1964), Grey and Nicholson(1971) under the study meant that it did not carry any emotion. A total of 32 sentences were chosen, most of which were from spoken language which formed a part of daily conversation. Few sentences were also chosen from a well known Kannada grammer book. Four of the 32 sentences were neutral and the remaining 28 sentences were chosen so that each sentence could be expressed with any two emotions (of the eight emotions). Contexts were provided for these sentences. Four adult speakers, all native speakers of Kannada language were chosen for the study. A good stage actor, stage actress, a lay man and a woman were subjects for the study. A lay man and woman were included in order to rule out the variable that the good actor and actress might use stylised speech.

A new list for each speaker was constructed as alterations had to be made as a result of conducting a pilot study. The new list consisted of:

1. 18 test sentences without context where each emotion and neutral was represented twice.

2. 18 sentences with context and
3. One or Two practice sentences.

The lay people were finally excluded from the study due to lack of time and an adult male native speaker of Kannada with knowledge of linguistics was chosen as a judge. Marking of the intonation pattern for each sentence was done after as many trials as needed. The following patterns were observed:

1. Anger: Sentences representing the emotion anger ended in Rise-fall, Fall-rise(slight), gradual fall, gradual rise, fall-rise and sustain-fall.

2. Patterns representing the emotion fear varied from sentence to sentence. However, the terminal patterns of the sentences simulating fear demonstrated the following patterns: Rise fall, Sustain-fall, & Fall-rise.

3. Terminal patterns of the sentences spoken with the emotion frustration included sustain-fall, rise-fall, & sustain-fall-fall.

4. Terminal patterns representing the emotions jealousy included Rise-fall, Fall-slight rise, Fall-rise, Gradual fall, & Sustain-fall.

5. Terminal patterns representing the emotion 'worry' included Rise-fall, Sustain-fall & Gradual fall.

6. Terminal parts of four sentences in non-context situation were retained in the context situation for the emotion 'Surprise'. A rise-fall pattern was also indicated.

7. Terminal patterns of the emotion 'grief' included rise-fall, gradual-fall, and sustain-fall.

8. In the case of 'joy' patterns of all 4 sentences in the non-context situation were retained in the context situation. A higher and gradual rise and fall was observed for the emotion'joy' when compared to other emotional sentences. Rise-fall and gradual-fall terminal patterns were observed for this emotion.

9. Neutral sentences had terminal patterns of the rise-fall and gradual-fall type. It is important to note that patterns of a few sentences were retained and some were not in context or non-context situation for emotions where special mention has not been made.

In a study aimed at determining the intonation patterns used by Hindi speakers in expressing emotions like surprise, fear, frustation, jealousy, joy, worry, anger and grief by Chandrashekhar(1985), 36 sentences were constructed (four for each emotion), 4 others being neutral. The investigator and two judges finally selected 9 sentences representing a total of 8 emotions. Ten subjects, five males and five females ranging in age from 18 to 21 years who were Hindi speakers for more than ten years or whose mother tongue was Hindi were chosen as subjects.

Both frequency and intensity patterns between males and females were observed. No difference between intonation patterns used by males and females was noticed though habitual frequency was different for the two groups.

The following observations were made from the study:

1. A majority of subjects,(though slight individual variations existed), used a fall-flat-rise-fall curve to express 'surprise'.

2. Subjects used fall rise-fall rise and fall type of frequency curve and a gradual decrease in intensity to express the emotion fear.

3. Most subjects used a fall-rise-fall type of frequency variation to express the emotion frustation.

4. Though no consistent pattern was evident from the subjects to express jealousy, roughly a rise-flat-fall type of frequency curve and a rise-fall-flat-fall type of intensity curve were obtained.

5. Roughly a flat-fall-rise-fall type of frequency curve was found to be used by a majority of subjects to express the emotion joy though no consistent pattern was evident. Similarly an approximately flat-rise-fall type of intensity curve was noted among subjects though inconsistent.

6. Though different patterns of frequency variations were observed, most subjects roughly used a rise-fall-rise-fall type of frequency variation pattern to express grief. A majority of subjects demonstrated rise and gradual fall

type of intensity curve.

7. Most subjects demonstrated a rise-fall-rise-fall and rise type of curve to express anger, though total consistency among subjects was not present. Intensity variations showed a similar trend(Rise-fall-rise & fall) though there was a corresponding change in intensity with frequency.

8. A majority of subjects demonstrated a rise-fall-rise-fall-rise and fall type of frequency curve to express worry. A rise-fall-flat and fall type of intensity curve was noted in general.

9. Finally in the case of neutral sentence, most subjects used a rise fall-rise and fall type of frequency curve. It was also noted that no consistency existed in intensity variations, though generally there was a gradual decrease in intensity with time.

With a view towards finding out the kinds of intonation patterns used by speakers of the Kannada language in expressing various emotions, Nandini(1985) preferred samples of natural conversation recorded without the subjects knowledge. This, however being unavailable, sentences from audio recordings of popular films in Kannada used by the people were selected to overcome the drawbacks.

A total of thirty sentences from three film cassettes were selected randomly expressing various emotions. Perceptual and instrumental analysis was carried out for these sentences. Three judges, native speakers of Kannada with a knowledge of intonation listened and marked the sentences on a five point scale(1= too high, 5 = too low). The PM-100 pitch analyzer was used for instrumental analysis. The study indicated no differences between subjective and instrumental analysis particularly in the terminal part of the contour except for one sentence representing accusation. This sentence was identified as having a rising terminal contour by the judges, where as objective analysis indicated a fall type of terminal contour. This difference was attributed towards intensity and other factors.

It was concluded that intonation patterns seemed to depend more on frequency variations that on intensity and other factors and that it was possible to obtain valid and reliable information regarding pitch variations in sentences using trained judges. The analysis revealed the following intonation patterns used to express various emotions:

Type of sentence representing the emotion	Intonation pattern
1. Surprise	Rise-Slight-Rise/Fall(Gradual).
2. Anger	Rise-Slight-Fall/Rise.
3. Anger associated with a question	Slight-Fall(gradual)-Rise.
4. Jealousy	Rise(gradual)-Slight-Fall(gradual)-Rise gradual.
5. Frustation	Slight-Rise-Rise(gradual)-Slight-Fall-Rise.
6. Accusation	Rise(gradual)-FalKgradual)-Rise(gradual).

Hesitation demonstrated a Slight-Rise(gradual), Slight-Fall(gradual) type of pattern. Request had a Slight-Fall (gradual)pattern and question and answer had a slight rise and slight fall pattern respectively. 'Neutral' type of sentence demonstrated a rise-slight-fall(gradual) type of intonation pattern.

The terms slight and gradual were used to indicate the undermentioned:

1. Slight indicated a half rise and half fall, and
2. Gradual was used to indicate slower degree of rise or fall.

ACQUISITION OF INTONATION IN CHILDREN

There is some evidence that early communication is essentially suprasegmental in nature (Lewis(1951), Lenneberg (1967). 'The infant varies intonation patterns to express physiological and emotional needs. Although segmental development stabilizes at 8 years of age (Templin(1953), the age at which suprasegmental development reaches a similar level is not certain (Shadden et al(1980). At the age of six to seven months the child begins to imitate the intonation of the adults talking to him (Nakazima(1962). At about the same age most babbles of children are produced with a falling declarative intonation, but then the child begins producing both rising and falling, questioning intonation patterns (Tonkova Yompol'skaya(1969).'

Lieberman(1967) showed that the basic pitch of the babbling of two children at ten and thirteen months of age shifted towards the pitch of the adult speaking to them.' When the father was speaking with the child, the pitch of the babbling was lowered to nearer that of the father; when the mother spoke to the child, the babbling occured at a somewhat higher pitch, in keeping with the higher voice of the mother.

Speech perception studies have indicated clearly that both prosodic and segmental aspects develop as early as

six weeks in children(Morse(1972), Mehler et al (1978), Nooteboom(1978), Kessen, Levinex& Wendrich(1979), Horowitz (1983).

Infants have been found to discriminate between rising and falling patterns of intonation between 1.5 & 2 months (Morse(1972). By the age of eight months children could discriminate between a syllable pronounced with a rising intonation and the same syllable said with a falling intonation (Morse (1974).'

'Dore(1973), Von Raffler-Engel(1973), Peters(l974) have reported that children learn and produce intonation patterns of the input language during the first year of life.

Crystal(1973) suggests that infants respond to supra-segmentals at an early age, possibly at the expense of other linguistic features. He notes that 6-7 months is the most likely period for the emergence of non-segmental aspects of language.

'with increasing age, prosodic patterns become more influenced by factors as phoneme structure and vocabulary. By 18 months most normal children use intonation patterns typically produced by adult speakers in their language environment (Menyuk(1972) and by 2 years of age have less than 3% error in imitating simple rising and falling inflections (Kressin, Marquardt and Asp(1976). Koike(1977), Koike & Asp(1977) found that 5 year olds performed signifi-cantly better than 3 year olds on a more complex supra-segmental task.

Sandner (1981) demonstrated a three month old infant imitating his German speaking mother during a Five minute conversation. The infant in sandner's study appeared to regulate subglottic pressure and imitate intonation patterns as soon as his anatomy developed to the point where he could regulate subglottic pressure.

A more recent investigation on early imitation was done by Rabson et al (1982). Acoustic analysis of a conversation between a Japenese speaking mother and her Six week old son, showed the infant imitating the absolute fundamental frequency and the shape of the mother's intonation contour, the duration being lesser, however.

Landahl (1982) reported that the fundamental frequency contours of one word utterances in children are quite similar to those seen in adults.

Based on Menn's (1976 a) and Halliday's (1975) work on tonal contrasts a tentative analysis of tonal contrast development was put forth by Crystal (1986).

1. Initially the child uses only falling patterns.
2. The first contrast that is developed is between falling and level tones.

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3. The Second contrast is between falling and high rising tones.
4. The next contrast is between falling and high falling tones (as in contexts of surprise, recognition, insistence etc.,).
5. A contrast between rising and high rising tones follows.
6. The next contrast is between falling and high rising - falling tones; the latter being used in emphatic contexts.
7. Next appears a contrast between rising and falling - rising tones, the latter especially seen in warning contexts, presumably the ' be careful' pattern in adults.
8. Among later contrasts to a pear is hat between high and low rising - falling tones, especially in play contexts.

However Fernald (1978), Stern (1983) believes that mother's make adjustments to the prosody of their speech as soon as their babies are born. Stern studied maternal prosody to children at birth and aged Four, Twelve and Twentyfour months examining the variation in pitch (terminal contour change, transitional change between utterances, overall utterance range and highest utterance level timing and rhythm). They found that lengthened pauses

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were most noticeable at birth, exaggerated pitch contours and higher levels at Four months and longer utterance durations at Two years. They suggested the need to consider adult prosody to children in terms of a series of phases of development, arguing that during a particular phase of interaction, a mother increases the use of a subset of features and decreases her use of others.

With regard to the production of intonation contours, development of prosodic features of Two infants was studied by Sheppard and Lane (1968). Amplitude, frequency and temporal characteristics of the infants vocal behaviour were studied. The magnitude of increase of the fundamental frequency from One to Four months and subsequent stabilization was concordant with Fairbank's (1942) study which indicated that the mean fundamental frequency of experimentally induced ; hunger wails of one infant increased consistently from 373Hz (1 month) to 415Hz (2month) to 485Hz (3 months) to 585Hz at Four months of age which stabilized for the next Five months. The ability of preschool aged children to imitate sy nthetic sounds modelled on both English and non English vowels modeled by an adult male talker was studied by Kent (1978). The study revealed that .

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1. Preschool children in the Four to Five year old range could imitate both English and alien vowels with a generally successful preservation of the relative formant structures.

2. The variablity of reproduction tended to be larger for alien vowels than for English vowels atleast at the second formant frequency.!

TESTS OF INTONATION

Ideally for clinical and research purposes, systematic investigation of suprasegmental patterns requires a test that is both senstive and repeatable.' 'skills at the three levels of suprasegiental development i.e., perception, imitation and spontaneous production may not increase in a uniform manner since as Menyuk (1969) and Lahey (1974) suggest that the communicative value of prosody (atleast in linguistic processing) decreases with increasing age. Prosodic aspects of speach consequently may receive less attention!

Asp (1973) suggests that the level of suprasegmental development may be an important determinant of the intelligibility level achieved by hearing impaired children, children exhibiting misarticulations and a host of other communicative disorders. Till date T - TRIP is

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the only test of intonation. With a view towards systematic investigation of suprasegmental patterns Koike and Asp (1977) developed the Tennessee test of rhythm and intonation patterns, which is a three part suprasegmental test with 25 test items. Test items from 18 to 25 (8 items) were used to test intonation.'

The nonsense syllable /ma/ was spoken by a young adult male who had extensive phonetic training and had practiced the production of these patterns prior to recording on a song, model TC 800. A panel of three normal hearing listeners transcribed the rhythm and intonation patterns of each prerecorded test item. If atleast two listeners had the same transcription as the intended test item, the test item was considered to be produced correctly. All the items satisfied this criterion. Spectrographic analysis supported the judgements of the listeners.

Twenty children Ten children from 3.0 to 3 - 11 years of age and 10 subjects from 5.0 to 5 - 11 years of age having normal hearing were chosen for their study. All children were members in homes where only American English was spoken and these children passed (above the 25th percentile) the receptive portion of the Northwestern

syntax screening test. Each child had to imitate the prerecorded pattern presented and the child's response was recorded (Wollensak, model -1500).

One child from the three years old group and one from the Five year old group were chosen for each of the following item by item reliability measures. The intrajudge agreement for each panel member was 96% (Judge A), 94% (Judge B), 98% (Judge C) for judging a Three year old child and it was 90% (JudgeA), 94% (judges B & C) for judging a five year old child twice. In the entire panel, test - retest comparison showed 84% agreement for a 3 year old child and 92% for Five year old child. The agreement between the panel and the examiner was 100% for a three year old child and 96% for a Five year old child. The above results suggests that this test appears reliable and ideal for measuring a clinical population as it appears to be sentive to differences between groups of normal children of different ages (the Five year olds scoring significantly better than the Three year olds). The items used in the test to test intonation in the T - TRIP have been outlined below :-

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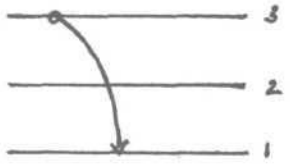

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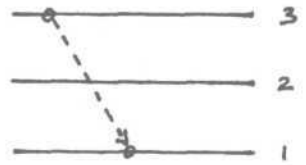

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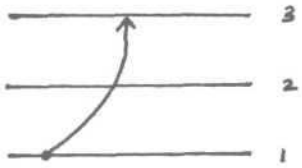

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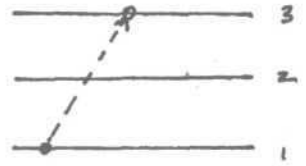

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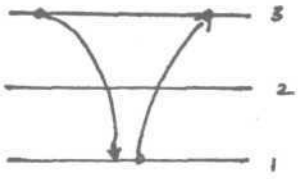

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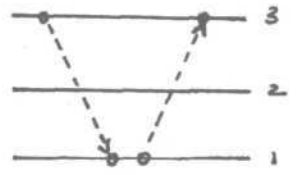

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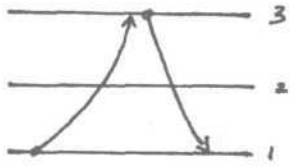

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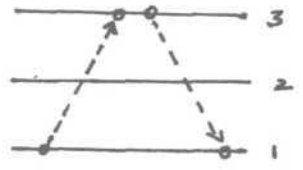

↘ = Fast fall. ⋱ = Gradual fall	PITCH
↗ = Fast rise ⋰ = Gradual rise	1 : Low
INTONATION.	2 : Mid
	3 : High

Numbers 18-25 in the T-TRIP represent items used to test intonation.

However, one of the major limitations of the T - TRIP is the lack of control over frequency. To overcome this limitation the present study was planned to construct a test of synthesized intonation patterns,where acoustic features were used to generate the syllable /ba/ based on spectrographic analysis (savithri - 1989). Further, this study is focussed at understanding the performance of Twenty children for these intonation patterns.

MEHODOLOGY

With a view towards studying developmental trends in intonation patterns, the syllable / ma / was preferred for a stimulus based on the premise that it was acquired relatively earlier than other syllables (Jacobson, 1971 and Halle - 1968, Menyuk - 1972, Tasneem - 1976).

However, due to technical shortcomings (non availability of a nasal shunt tube for synthesis), the syllable / ma / was replaced by its closest counterpart, the voiced bilabial stop / ba /.

The stimuli were synthesized using parameters based on the soft ware developed by ' Voice and speech systems ' (Anantpadmanabha et al - 1987). Silence was introduced in the First 500 msecs to avoid abruptness or bursts during recording of the stimuli.

The acoustic features used to generate the syllable / ba / have been represented in Table 3 (based on spectrographic analysis - (Savitri - 1989).

msecs -	500 - 580	580 - 600	600 till end
Fl	200 Hz	200 - 750 Hz	750 Hz
F2	900 Hz	900 -1250 Hz	1250 Hz
F3	2000 Hz	2000 Hz	2000 Hz
F4	3000 Hz	3000 Hz	3000 Hz
F5	4000 Hz	4000 Hz	4000 Hz
FO	214 Hz	214 Hz -230Hz	230-231-Hz
Amplitude	600	600	600 - 450

Table 3 :- Acoustic features used to generate the syllable / ba /.

The first formant was kept steady for 80 msecs at a frequency of 200 Hz and a smooth transition was introduced from 200 - 750 Hz for the next 20 msecs. The second formant frequency was kept constant at 900 Hz for 80 msecs and a smooth transition was made from 900 - 1250 Hz in the next 20 msecs duration. The third, fourth and fifth formant frequencies were kept constant at 2000 Hz, 3000 Hz, and 4000 Hz respectively.

The fundamental frequency of the stimulus was at 214 Hz for 80 msecs. It increased from 214 Hz to 230 Hz for the next 20 msecs and varied from 230 Hz for the time period from 600 msecs till the end of the stimulus.

A sampling frequency of 8000 Hz with a resolution of 10 msecs was used to generate the stimuli. A total of 4 levels of frequency were identified with 230 Hz being the base (based on personal communication with Manjula, clinical lecturer, Department of speech pathology with reference to her on - going research on intonation in Kannada). One level was identified as being below the base level (160 Hz) and two levels (300 Hz and 370 Hz) were identified as being above the base level. The stimuli were categorized under seven sets. Table 4 represents the aspects of intonation patterns considered in each set. A steep rise and fall was defined as having a duration of 100 msecs rise /fall and a gradual rise/fall was defined as having a duration of 240 msecs rise/fall. These durations were defined by perceptually analyzing the synthetic stimuli with varying durations by a

faculty in speech pathology well versed in the area of intonation and working in this area.

Initially, a time duration of 150 msecs was defined to assist in the perception of the steady component as in sets 6 and 7. However, as this could not give the percept of a steady component, 250 msecs was introduced for percieving the steady component.

Set Number	No. of synthetic stimuli	Aspects of intonation patterns
1	6	Gradual rise to level 3 and 4, steep rise to level 3 and 4, gradual fall to level 1 and steep fall to level 1 .
2	4	Gradual rise and fall steep rise - gradual fall, gradual rise + steep fall,steep rise + steep fall (all rises to level 3).
3	4	Same as in set 2 but rise is upto level 4.

Set Number	No.of synthetic stimuli	Aspects of intonation patterns
4	4	Gradual fall/ - gradual rise, gradual fall - steep rise, steep fall-gradual rise, steep fall - steep rise (rise only to level 3).
5	4	Same as set 4 but with rise upto level 4
6	4	Same as set 4 but with a steady component at the end.
7	4	Same as set 5 but with a steady component at the end.

Table 4 :- Represents various intonation patterns synthesized.

The various intonation patterns used in this study (based on personal communication with Manjula,clinical lecturer, Department of speech pathology with reference to her on - going research on intonation in Kannada) were superimposed on the syllable / ba /.

Table 5 shows Four levels of frequency (160 Hz, 230 Hz, 300 Hz and 370 Hz) represented by Four lines. The steady portion of the stimulus is represented by a straight line. All these patterns were synthesized using the acoustic features described in Table 1. These Synthetic stimuli were converted to analong signals which

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were audio recorded in a noise free environment on a cassette with an inter - stimulus interval of 5 seconds to allow time for imitation. A total of Thirty synthetic stimuli were generated and Five of these stimuli were re-recorded for test - retest reliability thereby constituting a total of Thirty Five synthetic stimuli which formed the material.

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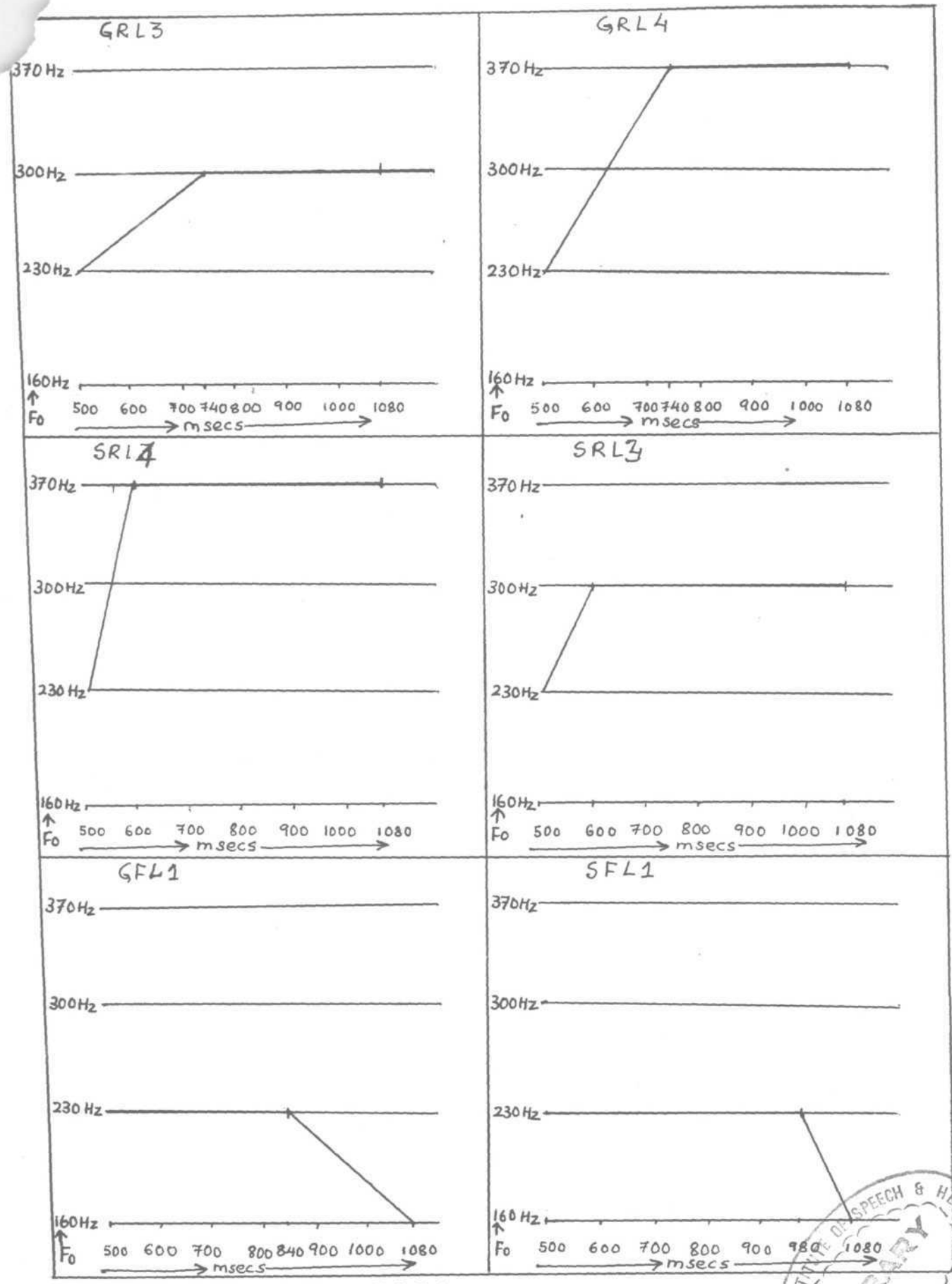
SET-I



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* SCALE 1cm = 100msecs [x-axis]
0-500msecs indicates silence
Total stimulus duration = 1080msecs.

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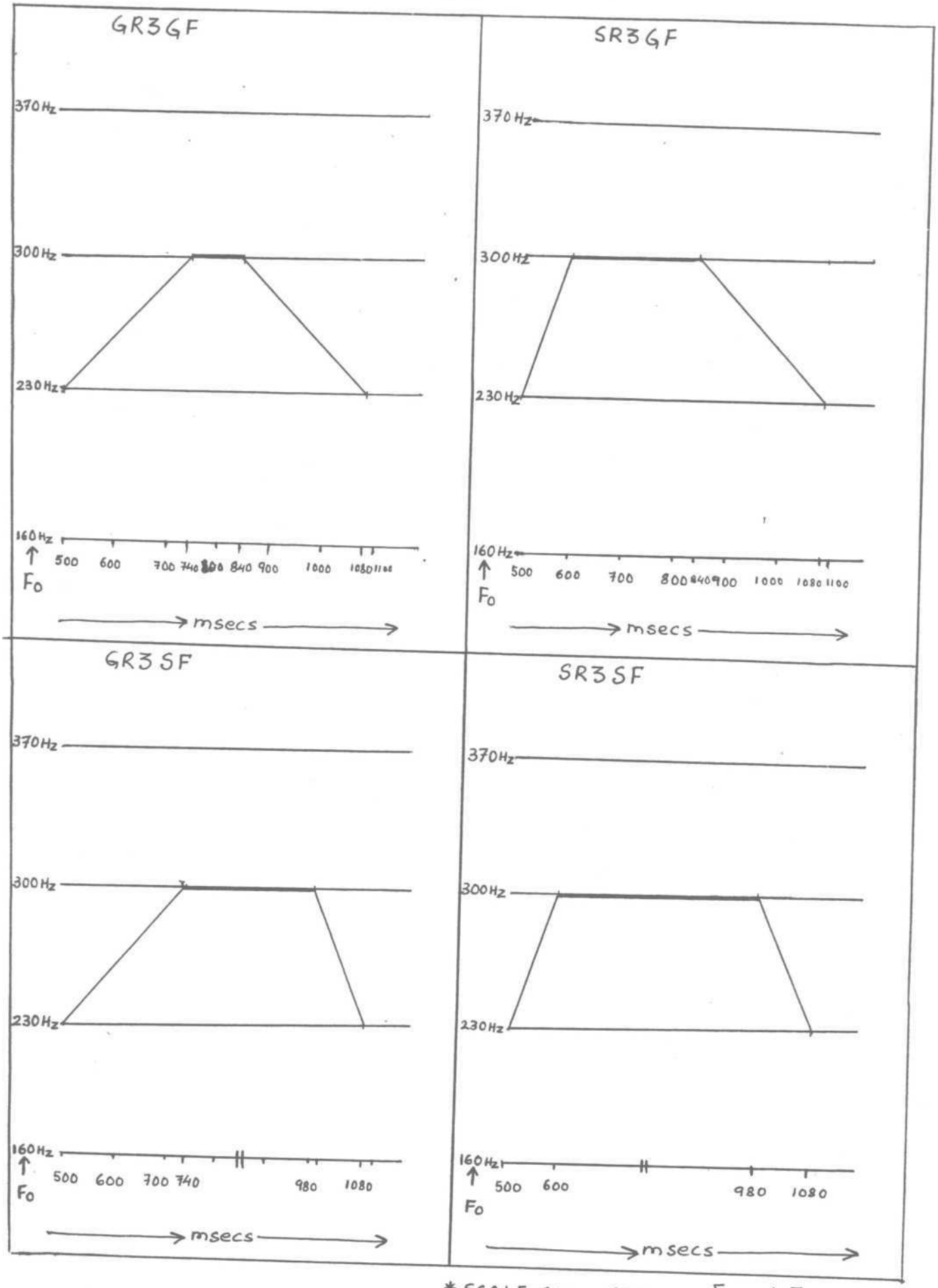
SET-II



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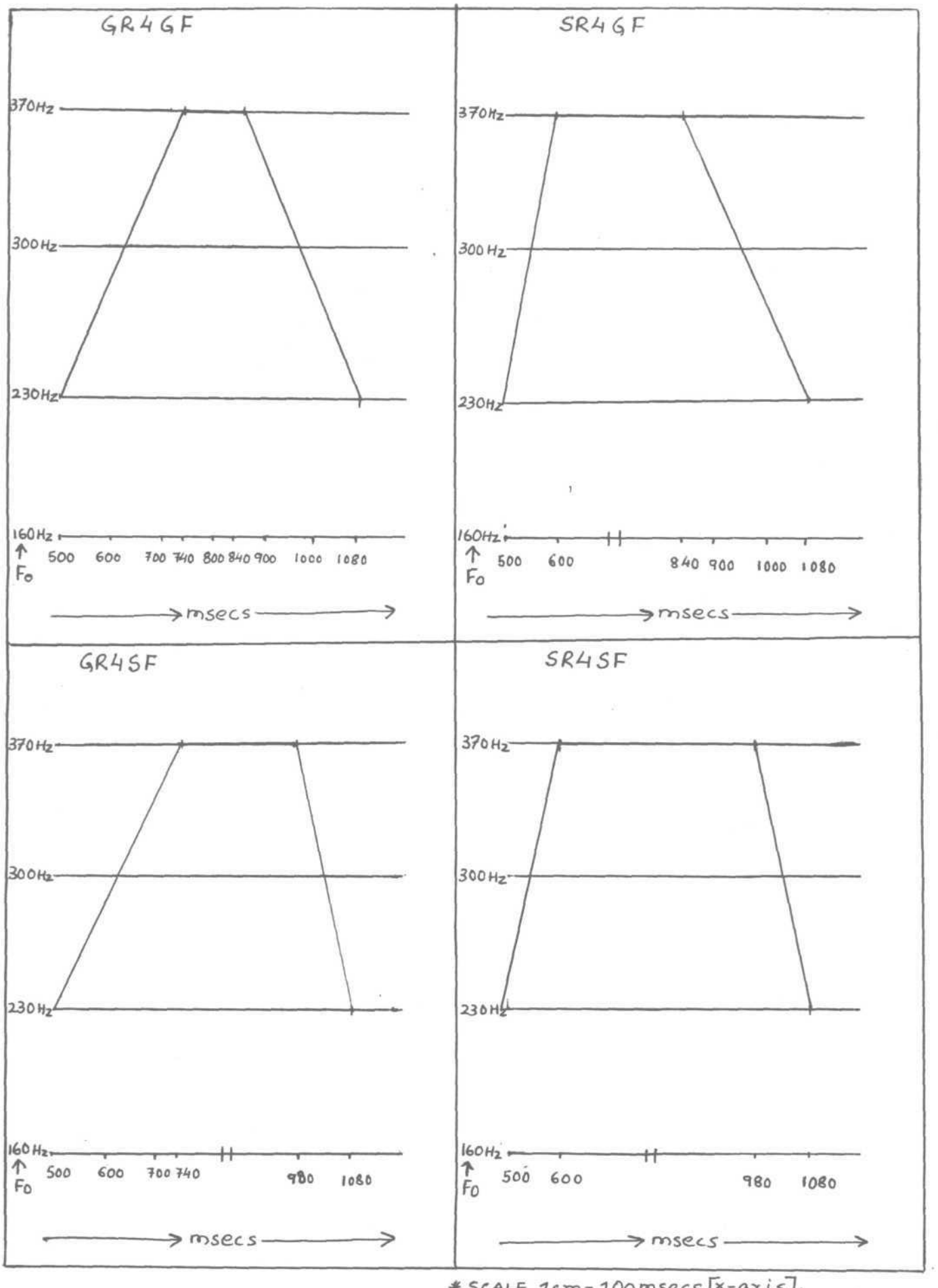
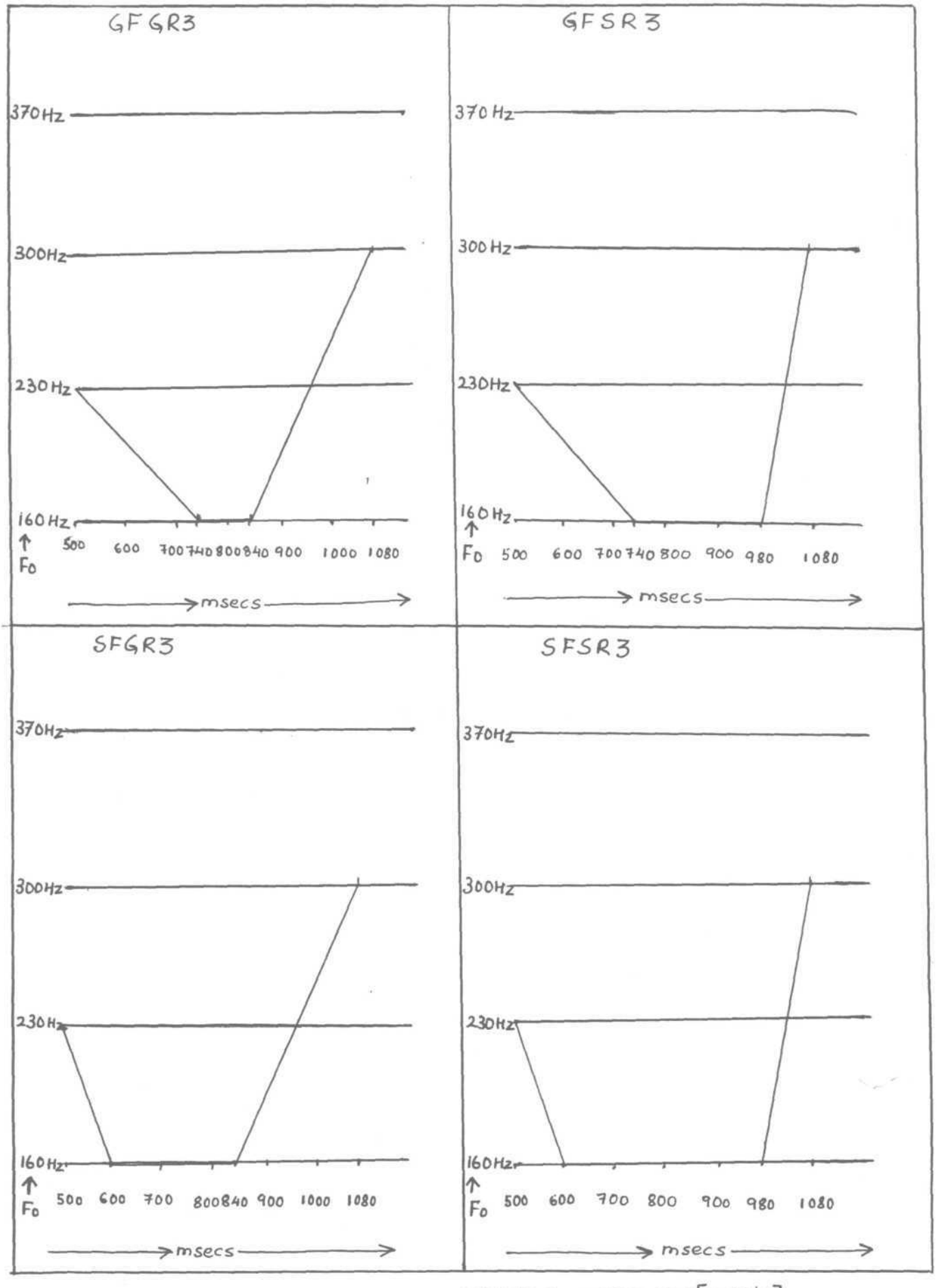
0-500msecs indicates silence.
Total stimulus duration = 1080msecs.

SET - III



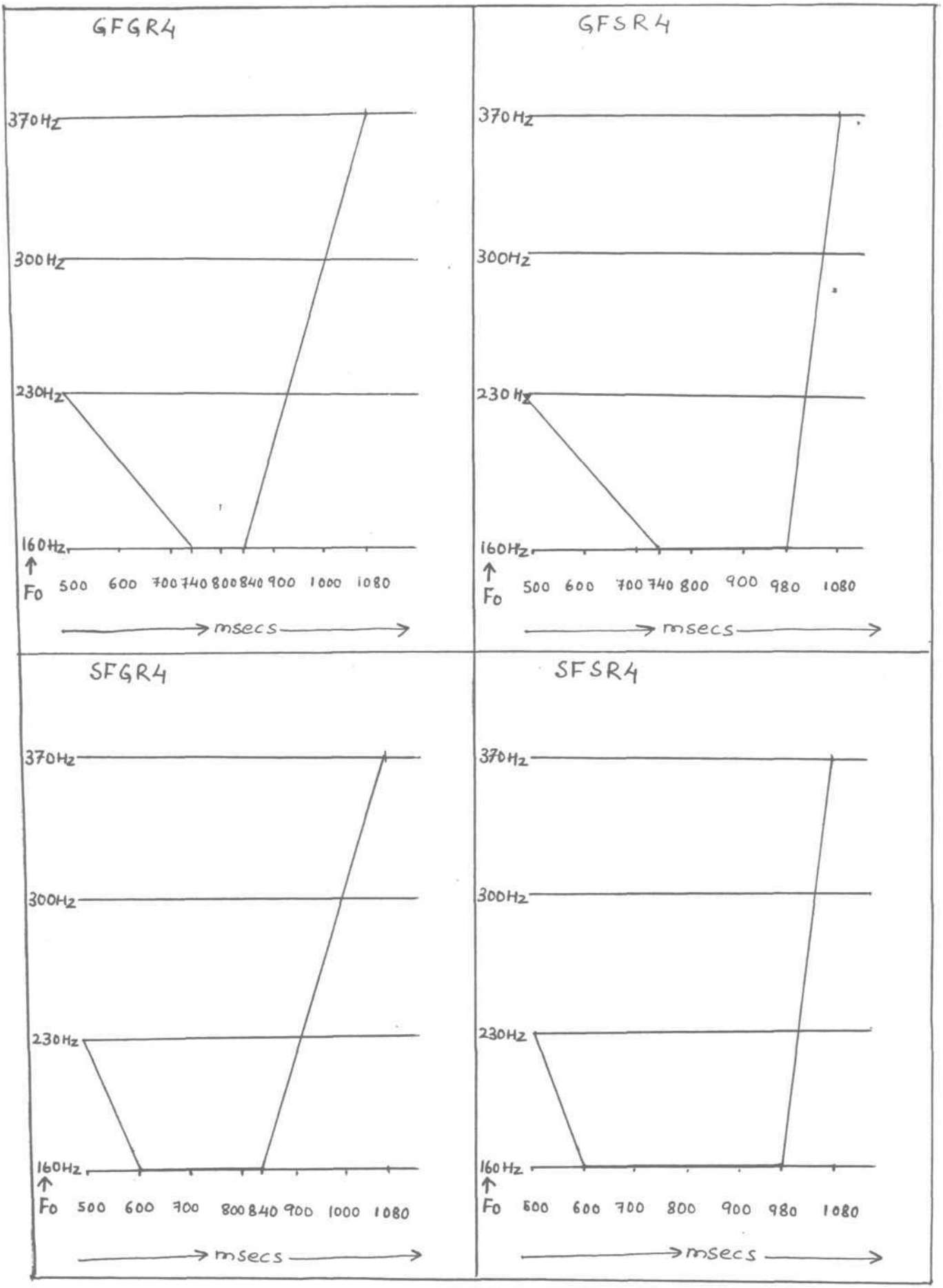
* SCALE 1cm = 100msecs [x-axis].
0-500msecs indicates silence.
Total stimulus duration = 1080 msecs.

SET-IV



* SCALE 1cm = 100 msecs [x-axis].
0-500 msecs indicates silence.
Total stimulus duration = 1080 msecs.

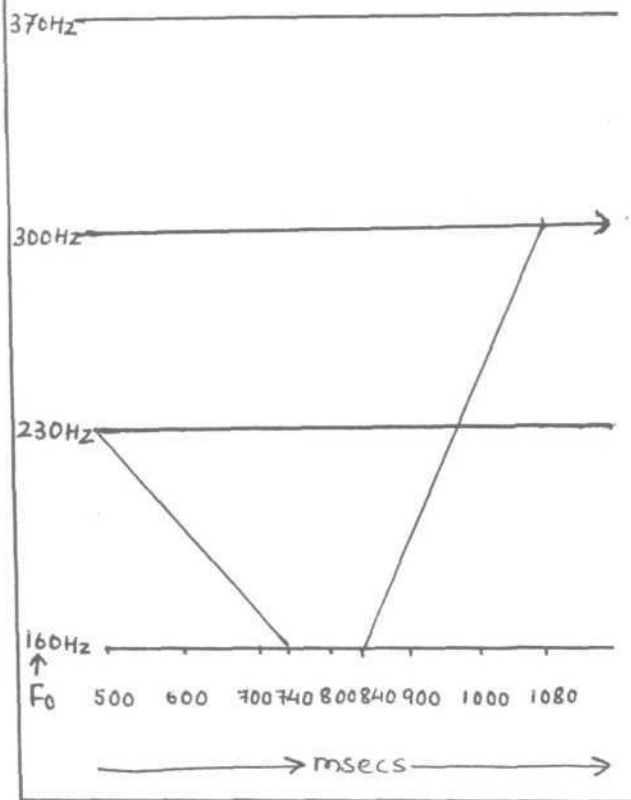
SET - V



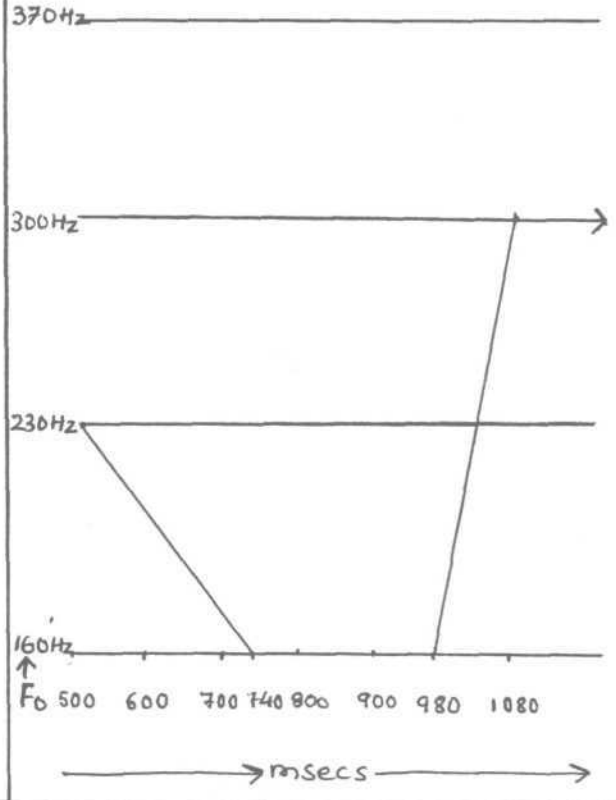
* SCALE 1cm = 100msecs [x-axis].
0-500msecs indicates silence.
Total stimulus duration = 1080msecs.

SET - VI

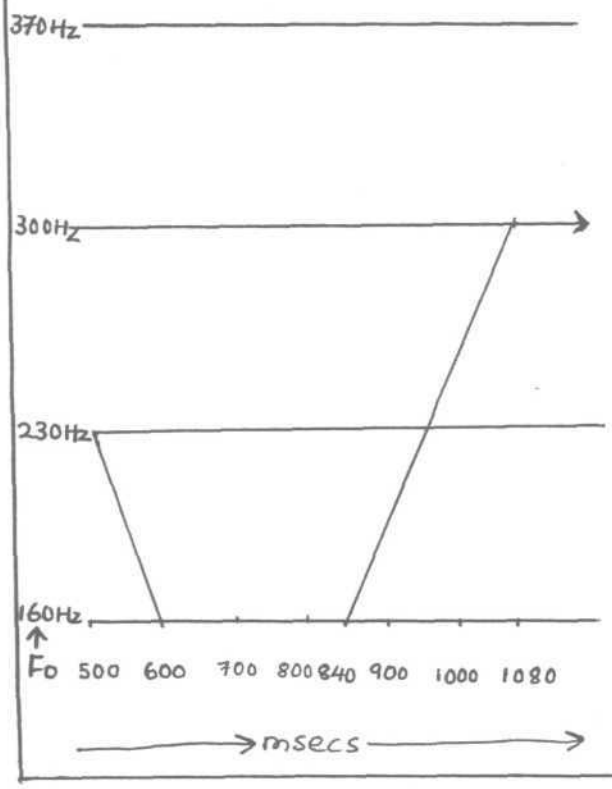
GFGR3S



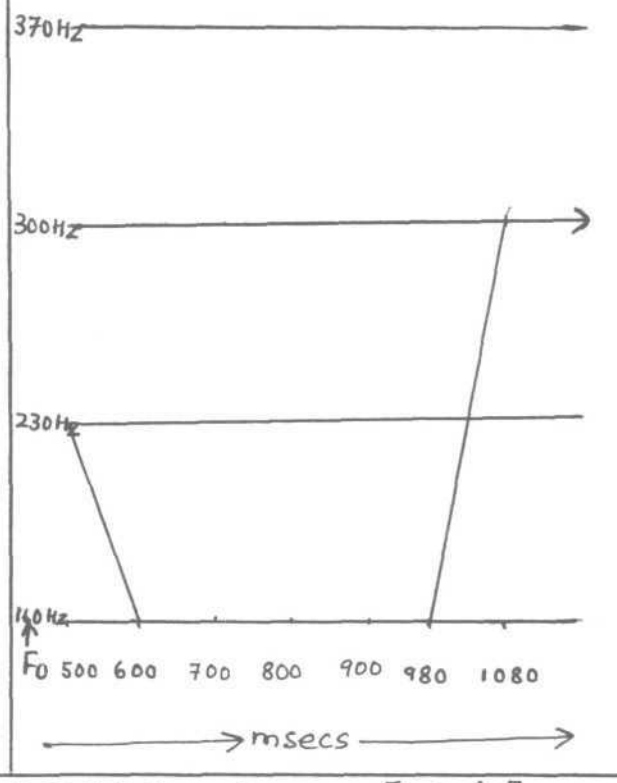
GFSR3S



SFGR3S

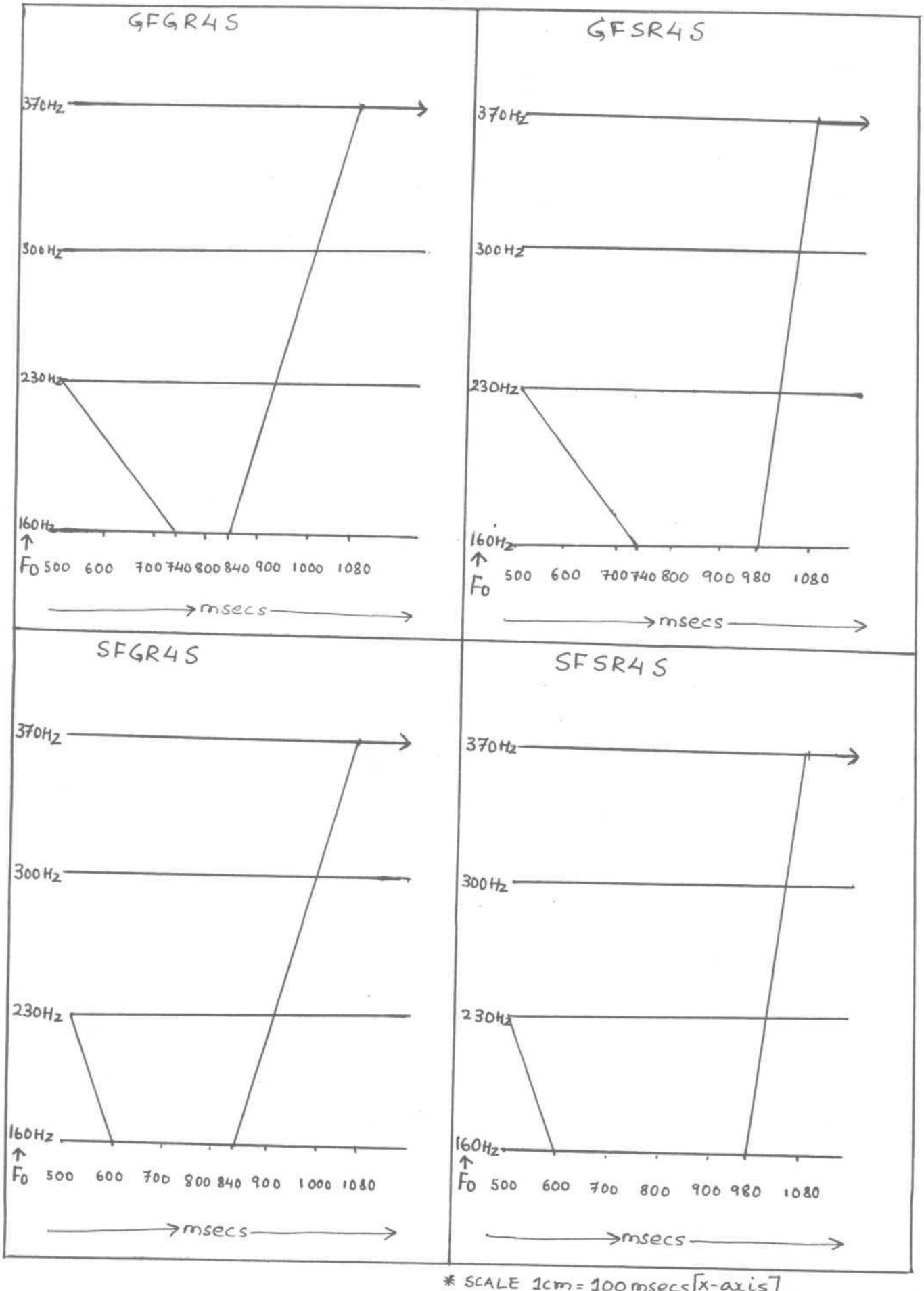


SFSR3S



* SCALE 1cm = 100msecs [x-axis].
0-500msecs indicates silence.
Total stimulus duration = 1330msecs.
→ [steady portion] extends from 1080 to 1330 msecs

SET- VII



* SCALE 1cm = 100 msecs [x-axis]
0-500 msecs indicates silence.
Total stimulus duration = 1330 msecs.
→ [steady portion] extends from 1080 to 1330 secs

Table 5 :- Represents the different intonation patterns synthesized (pages 50 - 56).

EXPERIMENT I : IDENTIFICATION OF INTONATION PATTERNS BY ADULTS

SUBJECTS :- Three (Two Females aged 24 years and 44 years respectively, and 1 male aged 23 years) normal hearing (hearing levels within 0 - 25 dB HL - ANSI) speech pathologists, with Kannada as their mother tongue, well versed in perceptual judgements were the subjects for this study.

METHOD :- The audio recorded synthetic stimuli were audio presented to the three subjects through head phones, one at a time and they were instructed to carefully listen to each stimulus and transcribe the stimuli for intonation patterns in terms of gradual rise, gradual fall, steep rise, steep fall and steady components in their multiple combinations and also for the respective level.

ANALYSIS :- The transcriptions were analysed and a score of 1 was awarded for each pattern and level correctly indicated. Thus, for example, if the subject indicated a gradual rise to level 3 for the stimulus GRL3 he had a score of 1 + 1 = 2. A wrong pattern or level had a zero score. Also a score of 1 was given for correct identification and zero for non-identification of a steady component.

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A score of ½ was given when a subject indicated the general type of contour with reference to its steepness. For eg., a gradual fall instead of a gradual rise (gradual being the common factor).

All these scores were tabulated to determine patterns that were better identifed and those patterns that were not.

The co-relation co-efficient was determined between judges 1 & 2, 2 & 3, and 1 & 3 respectively by Rank correlation. Further more the average percentage score was calculated for each synthetic pattern by the following formula,

$$\frac{\text{TOTAL SCORE OBTAINED FOR ALL THREE JUDEGES}}{\text{TOTAL / MAXIMUM POSSIBLE SCORE FOR THREE JUDGES}} \times \text{IOC}$$

EXPERIMENT 2 :- IMITATION OF INTONATION PATTERNS BY CHILDREN

SUBJECTS :- A total of Twenty normal Kannada speaking children in the age range 4 - 8 years, with 5 children each in the four age groups were selected for the study. Each age group had three males and two female children. Children from both the sex were included in the study to maintain heterogenity.

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	MALES: SUB Nos	MEAN AGE	FEMALES: SUB Nos	MEAN AGE
4-5 Years	S_1 = age = 4yrs S_2 = age = 4yrs S_5 = age = 4yrs 8mths	4 years, 3 months	S_3 = age = 4yrs 6mths S_4 = age = 4yrs 6mths	4 years, 6 months.
5-6 Years	S_1 = age = 5yrs 3mths S_4 = age = 5yrs 6mths S_5 = age = 5yrs 6mths	5 years, 5 months	S_2 = age = 5yrs 4mths S_3 = age = 5yrs 6mths	5 years, 5 months.
6-7 Years	S_1 = age = 6 years, 2mths S_2 = age = 6yrs, 4mths S_3 = age = 6yrs 6mths	6 years, 4 months.	S_4 = age = 6yrs, 6mths. S_5 = age = 6yrs, 8mths	6 years, 7 months
7-8 Years	S_2 = 7yrs, (age) 4mths S_3 = age = 7yrs 4mths S_5 = age = 7yrs, 9mths	7 years, 6 months	S_1 = age = 7yrs. S_4 = age = 7yrs 8mths	7 years, 4 months.

Table 6 :- Represents the details of the subjects (children).

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METHOD :- Each child was tested individually in a room free from external noise. Five practice trials were given to each child (to familiarize the child) and the child imitated these practice trialstimuli which were chosen randomely (stimuli - 31 - 35).

Following the practice trials the stimuli were audio presented one at a time from a tape recorder. The child was allowed sufficient time to listen to the stimulus and then imitate the pattern heard. These imitated patterns were audio recorded. If the child exhibited difficulty in imitating after listening to the stimulus once, he/she was provided the same stimulus as many times as he/she wanted.

ANALYSIS : The synthesized stimuli and the imitated responses were compared by two speech - language pathologists (Judges). If a similarity in terms of intonation patterns between the synthesized stimuls and the imitated pattern existed it was marked ' S '. If the synthesized stimulus and imitated pattern were dissimilar in terms of intonation patterns it was marked ' D '.
A rank co-relation test was applied to find out the corelation between the two judges. All these data were tabulated to find out the emerging pattern of intonation in children.

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RESULTS AND DISCUSSION

EXPERIMENT I : IDENTIFICATION OF INTONATION PATTERNS BY ADULTS:

Table 7 shows the scores representing the identification of intonation patterns by adults. No single pattern was i-dentified completely in its level / steepness and pattern. It was observed that the pattern GFSR3 was identified the best (66.66%) of all the Thirty Five synthetic stimuli. However, all the three judges identified only the steepness and the pattern but not the level. Next to be identified were the GR3GF & SR4GF (55.55%) patterns. However, the level in these two patterns was not identified by any of the judges and GFGF3S (50.00%) was the next pattern to be identified. In this pattern the steepness was not identified by any of the judges and one of the judges failed to identify the level and pattern also. However, the steady portion was identified by two judges.

The patterns GRL3, SRL3 and SFLl were not properly identified even by a single judge. The remaining stimuli fell in between this range as indicated by the average score of the three judges converted to percentage in Table No.7.

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PATTERNS SYNTHESIZED	JUDGE 1	JUDGE 2	JUDGE 3	MAXIMUM POSSIBLE SCORE/ (INDIVIDUAL PERSTIMULUS	AVERAGE OF SCORES FOR THE THREE JUDGES CONVERZEDTO PERCENTAGE
1. GRL3	0	0	0	2	0%
2. GRL4	1	0	0	2	16.66%
3. SRL3	0	0	0	2	0%
4. SRL4	0	½	0	2	8.33%
5. GFL1	½	½	½	2	25%
6. SFL1	0	½	0	2	8.33%
7. GR3 GF	2	2	1	3	55.55%
8. SR3 GF	0	1	1	3	22.22%
9. GR3 SF	0	1	1	3	22.22%
10. SR3 SF	0	1	1	3	22.22%
11. GR4 GF	1	1	0	3	22.22%
12. SR4 GF	2	1	1	3	44.44%
13. GR4 SF	0	2	1	3	33.33%
14. SR4 SF	1	1	1	3	33.33%
15. GFGR3	1	2	½	3	38.88%
16. GFSR3	2	2	2	3	66.66%
17. SFGR3	0	0	1	3	11.11%
18. SFSR3	0	1	0	3	11.11%
19. GFGR4	2	1	1	3	44.44%
20. GFSR4	2	1	1	3	44.44%
21. SFGR4	1	2	1	3	44.44%
22. SFSR4	0	1	1	3	22.22%
23. GFGR3 S	2	3	1	4	50.00%
24. GFSR3 S	2	2	1	4	41.66%
25. SFGR3 S	1	2	1	4	33.33%
26. SFSR3 S-	2	1	1	4	33.33%
27. GFGR4 S	0	1	1	4	16.66%
28. GFSR4 S	2	2	1	4	41.66%
29. SFGR4 S	1	0	2	4	25.00%
30. SFSR4 S	1	2	1	4	33.33%
31. GRL3	0	0	0	2	00.00%
32. SFL1	0	0	0	2	00.00%
33. SR4 GF	2	2	1	3	55.55%
34. SFSR3	1	1	1	3	33.33%
35. GFSR3 S	2	1	1	4	33.33%

7.TABLE 7:- SCORES REPRESENTING IDENTIFICATION OF INTONATION PATTERNS BY ADULTS

Table 8 shows the parameters not identified by the judges in each set. The first judge could not identify the levels and combination of patterns in sets 2 and 6. Judge 2 exhibited difficulty in identification of combination of intonation patterns. Further?- more, he could not identify the steady portions in sets 6 and 7. Judge 3 could not identify the level, combination of intonation patterns and steadiness in sets 6 and 7. The results of the Spearman's rank corelation test indicated that the corelation co-efficients between I and II, II and III and I and III (Judges) were high being 0.6,0.6 and 0.58 respectively at 0.05 level of confidence.

In this study a difference of 70 Hz was used between the baseline - level 1 and level 1 to level 2. The results indicate that this 70 Hz difference may not be sufficient for One to identify the levels distinctly. The 70 Hz difference was selected on the basis of the results of the study on intonation in normal Kannada speaking population. In sentences however, because the contour is spread over time, the listener may be capable of identifying the/levels. In this study, as the levels are spread within a restricted time limit of 100 - 240 msecs, it might be difficult for the listener to identify the levels.

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SETS	1	2	3	4	5	6	7
J1	Level	Level Comb ••	Level	Level	Level	Level Comb ••	Level
J2	Level	Level	Comb ••	Level	Comb ••	Level	Level
——	STEAD ••	Comb ••		Comb ••		STEAD ••	STEAD ••
J3	Level	Level Comb ••	Level Comb ••	Level Comb ••	Level Comb ••	Level Comb •• STEAD ••	Level Comb •• STEAD ••

Table 8 :- Represents parameters not identified by the judges.

NOTATIONS:- Comb •• :- Combinations of patterns

STEAD •• :- Steadiness.

Further, in this study, the frequency fall or rise is interpolated from the steady portion leading to a linear increment or decrement. However, Nijland (1951), Quirk & Crystal (1966) have suggested intonation patterns such as convexe and concave wherein the increment and decrement in frequency is not linear. In natural speech it is more likely that frequency movements are non-linear. This might be another reason for listeners not identifying the patterns.

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Also the fact that listeners exhibited difficulty in identifying the combination of two intonation patterns suggests that given a temporal domain of 250 msecs it might be difficult for the ear to percieve two fluctuations i.e., rise and fall. Further, the fact that the steady portion of 250 msecs is not identified by two judges suggests that the temporal domain needs to be changed.

Thus, the synthetic stimuli used in this study need to be modified for the tem oral domain, in that it needs lengthening. On lengthening, if the level is still not perceived, the difference between levels 1 & 2 might be increased. Also, convex and concave (non-linear) types of patterns could be synthesized. Garding and Abromson (1965), Hadding Koch (1961) suggest that the shape and level of the entire contour seems to affect listeners judgements.

Hadding Koch and Studdert Kennedy (1961) believe that the peak of the contour and the turning point of the fundamental frequency also affects listeners judgements. These factors may also be considered in modifying the synthetic stimuli.

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EXPERIMENT II:IMITATION OF INTONATION PATTERNS BY CHILDREN

Table 9 depicts the intonation patterns imitated by children (4-8 years) as evaluated by judges Jl & J2.

It was observed that the ability of the children to imitate the intonation patterns i creased from 4 - 7 years and declined thereafter.

	PATTERNS IMITATED BY ALL THE CHILDREN	PATTERNS IMITATED BY FOUR CHILDREN
4-5Years	1. SR3 SF	1. GR3 GF 2. GR3 SF 3. SESR4 4. GRL3
5-6Years	1. SRL4 2. GFL1 3. SR4 SF 4. GFGR3 5. GFSR4 6. SFL1	1. SRL3 2. SFL1 3. SR3 SF 4. GR4 GF 5. SFSR4 6. GFGR3 S 7. GFSR3 S 8. GRL3
6-7Years	1. GRL3 2. GR4 GF 3. SFGR3 4. GFGR4 5. GFSR4	1. GFL1 2. GR3 GF 3. SR3 GF 4. GR3 SF 5. SR4 GF 6. GR4 SF 7. SR4 SF 8. SFSR3 9. SFSR4 10. GFSR3 S 11. GRL3 12. SFL1
7-8Years	1. SRL4	1. SR4 SF 2. GFGR3 3. SFGR4 S 4. GRL3 5. SFL1 6. SR4 GF

TABLE 9 :- Represents the intonation patterns imitated by the children (4 - 8 Years) as evaluated by the Two judges.

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The finding of this study is in agreement with the study of Koike (1977), Koike and Asp (1977) who found that 5 year olds performed significantly better than the three year olds on a complex suprasegmental task.

In experiment I the patterns GRL3, SRL3 and SFLl were not identified by any of the judges. However, these patterns were imitated by the children indicating no corelation between the two.

In th^age group of 4 - 5 years, the imitation of patterns in set 2 involving rise to level 3 was better than imitation of patterns in other sets. In the age group 5 - 6 years the children could imitate 5 intonation patterns in set 1, One pattern in set 2 and 4 and Two patterns each in set 3,5 & 6. 6 To 7 year old children were found to imitate 2 patterns each in sets 1 and 4, 3 patterns in sets 2 and 5, 4 patterns in set 3 and 1 pattern in set 6 In general, it was easier for the children to imitate the intonation patterns which did not have steady portions and they imitated these patterns only after 5 years. Also, set 1 involving simpler(single) intonation patterns was imitated better than the sets with combined patterns.

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4 - 5 Years	Jl	48.57%	40.00%	51.42%	37.14%	57.14%	46.85%	48.57%	44.28%
	J2	51.42%	40.00%	57.14%	34.28%	51.42%	46.85%	47.61%	45.71%

	SI	S2	S3	S4	S5	Total Mean (%score)	Mean Male	Percentage Score Female'

Table 11 :- % response on the imit ation task. (4 - 5 Years).

5 - 6 Years	Jl	60.00%	65.71%	85.71%	85.71%	42.85%	67.99%	62.85%	75.71%
	J2	65.71%	62.85%	77.14%	82.85%	40.00%	65.71%	62.85%	69.99%

	SI	S2	S3	S4	S5	Total Mean (%score)	Mean Male	Percentage Score Female

Table 12 :- % response on the imitation task. (5 - 6 Years).

6 - 7 Years	Jl	88.57%	62.85%	97.14%	82.85%	37.14%	73.71%	82.85%	59.99%
	J2	85.71%	62.85%	97.14%	82.85%	45.71%	74.85%	81.90%,	64.28%

	SI	S2	S3	S4	S5	Total Mean (%score)	Mean Male	Percentage Score Female

Table 13 :- % response on the imitation task. (6 - 7 Years).

7 - 8 Years	Jl	74.28%	80.00%	62.85%	71.42%	34.28%	64.56%	59.04%,	72.85%
	J2	71.42%	71.42%	62.85%	68.57%	37.14%	62.28%	57.13%	69.99%

	SI	S2	S3	S4	S5	Total Mean (%score)	Mean Male	Percentage *Score Female

Table 14 : % response on the imitation task. (7 - 8 Years) .

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Tables 11 - 14 indicate the number of patterns imitated by the Twenty subjects (5 in each age group) and the persent imitation. The results indicate that imitation of intonation patterns improves from ages 4 - 5 through ages 6 - 7 as indicated by the total mean percent scores. (. figure). However the total mean percent scores decreases at 7 - 8 years of age which may be due to an influence of motivation in the older age group*

On a comparison between males and females it was observed that males performed better in imitating intonation patterns at 4 - 5 and 6 - 7 years of age. However, in the age group of 5 - 6 and 7 - 8 years, females performed better than males in imitating intonation patterns. The co-relation eo-efficient between judges Jl and J2 for the age ranges using the rank difference method were high being 0.89 (4-5 Years), 0.89 (5-6 Years), 0.91 (6-7 Years), and 0.85 (7-8Years),

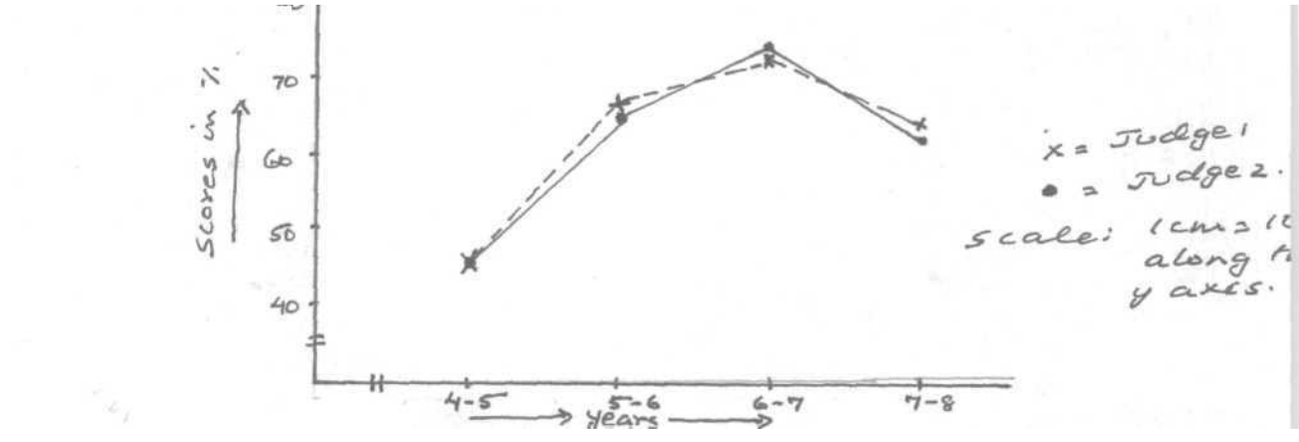

FIG 1 :- Represents' Scoresi in(percent) imitation by children across the four age ranges.

Also the results reveal that children in the age range especially 4 - 5 years, 5-6 years, and 7-8 years had difficulty in imitating patterns like SFLl, SFSR3 S, & SFSR4 S (Appendix) which may be indicative of a lacunae in the acoustic

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features of the simuli themselves.

EXPERIMENTOR(S)	FINDINGS ON THE DEVELOPMENT OF INTONATION
1. Morse (1972)	Infants discriminate between rising and falling patterns of intonation between 1.5 to 2 months.
2. Kaplan (1969)	At around the age of 8 months children demonstrate the ability to discriminate question from statement intonation.
3. Menyuk (1972)	By 18 months, most normal children use intonation patterns typically produced by adult speakers in their language environment.
4. Kressin, Marquardt, Asp (1976)	By 2 years children have less than 3 % error in imitating simple rising and falling inflections.
5. Koike (1977) Koike, Asp(1977)	5 Year old children performed significantly better than 3 year olds on a complex suprasegmental task.
6. Present study	SR3 Sf, SFSR4, GRL3 (4-5 Years) GFL1, SR4 SF, GFSR4, SFLl (5-6 Years) SRL3, GR4 GF, SFSR4, GFSR3 S(6-7 Years)

TABLE 10 : Represents a comparison of studies on development of intonation.

On comparing the development of intonation as reported by other investigators (Table 10) the present study partly agrees with them in that the simple rising pattern is acquired in the early age group. However, as none of the other patterns are mentioned in the earlier studies, the results cannot be compared with them. It is evident that the children could imitate rise - fall, fall - rise and rise patterns followed by fall and fall - rise - steady patterns in order.

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TEST - RETEST RELIABILITY :-

	GRL3	SFL1	SR4 GF	SFSR3	GFSR3 S
Trial 1	0.00%	8.33%	44.44%	11.11%	41.66%
Trial 2	0.0%	0.0%	55.55%	33.33%	33.33%

Table 15 :- Represents an average of scores of the Three judges in Two Trials. (Trial 1 includes Stimuli No. 1,6,12,18,&24). (Trial 2 includes stimuli Nos. 31,- 35).

Results of the walsh tests indicated relability between the Two Trials.

Thus, the results indicate that :-

1. The normal listeners were unable to identify all the 35 synthetic patterns.
2. The ability of children to imitate the synthetic intonation patterns increases from 4 to 8 years indicating a developmental trend. However, even at 8 years 100% scores was not obtained.
3. Children imitate single and combined intonation patterns earlier than the combined + steady intonation patterns
4. No difference between males and females in terms of imitation capacity was noticed.

The developmental trend is supported by the developing physiological mechanisms in children (Dejours,1963, Klatt 1968, Bouhuys 1974). Lieberman (1982) comments that " Human ling-uistic behaviour is structured by

physiological mechanisms ". The greater lung volumes developed in the growing children provides for longer speech utterances. 'Further, the expiratory pressure changes are related to the rise and fall in frequencies. The results of this study reveal that the intonation patterns synthesize din this study needs to be modified to consider it as a test of intonation patterns. The stimuli needs to be modified in terms of the termporal domains, frequency variation and the shape of the contour. On modifications and further deletion of a patterns (SFL1 , SFSR3 S, SFSR4 S) a test could be constructed.

Conclusively suprasegmental skill acquisition might serve not only to facilitate segmental development, but also improve intelligibility during the therapeutic process thereby facilitating more natural sounding speech at the end of the therpy program.

Clearly speech - language pathologists need to evaluate and implement suprasegmental development in the therapeutic programme by establishing normative data.

The number of questions remaining, however, points to the need for systematic research in the area of suprasegmental development both in children with adequate and inadequate articulatory stills. The effects of ageing can also be evaluated, especially for people who experience difficulty

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with fast tempo of speech. The levels of motivation in children while evaluating suprasegmental skills needs consideration.

Finally since suprasegmentals play a prominent role in early communication and early linguistic processing, research in suprasegmental feature acquisition must include all aspects of language processing, perception and performance.

**

SUMMARY AND CONCLUSIONS

Suprasegmental are properties of speech that have a domain larger than a single element and include stress, intonation, rhythm and quantity. Of these, intonation is an important mediator in interaction situations. It improves speech recognition and is the primary means of segmenting the relatively continuous speech signal.

This study was aimed to develop a synthetic test of intonation patterns in order to overcome the limitation of the T-TRIP (lack of control over frequency). Furthermore, this study was focused at understanding the performance of children aged 4-8 years in imitating these synthesized intonation patterns.

A total of 30 intonation patterns (GRL3, GRL4, SRL3, SRL4, GFB1, SFL1, GR3 GF, SR3 GF, GR3 SF, SR3 SF, GR4 GF, SR4 GF, GR4 SF, SR4 SF, GFGR3, GFSR3, SFGR3, SFSR3, GFGR4, GFSR4, SFGR4, SFSR4, GFGR3 S, GFSR3 S, SFGR3 S, SFSR3 S, GFGR 4 S, GFSR4 S, SFGR4 s, and SFSR4 S) were synthesized,out of which 5 were repeated for test retest reliability measures. The acoustic features used to generate the syllable /ba/ were based on spectrographic analysis (savithri, 1989)? which formed the stimulus. The stimuli were synthesized using parameters based on the software developed by voice and speech systems (Anantapadmanabha et al 1987).

Three normal hearing subjects (aged 23, 24 and 44 years) listened to these intonation patterns and transcribed these stimuli in terms of steepness, level and combinations of patterns. The scores were tabulated to determine patterns that were better identified and those that were not. The coefficient of correlation between judges was determined between judges 1 and 2, 2 and 3, 1 and 3 respectively by rank correlation. Furthermore, the average percentage score was calculated for each synthetic pattern.

Twenty normal Kannada speaking children (4-8 years) with 5 children each in the four age groups were selected for the study. Each child had to imitate the thirtyfive patterns which were audio-recorded. The synthesized stimuli and the imitated responses were compared by two speech-language pathologists and a rank correlation test was applied to find the correlation between the judges. All these data were tabulated to findout the emerging pattern of intonation in children.

The results indicated that no single pattern was identified completely in its level/steepness and patterns and steadiness by the three normal adult judges.

The pattern, GFSR 3 was identified the best of all the synthetic stimuli and the patterns GRL_3, SRL_3 and SFL_1 were

not properly identified even by a single judge. The remaining stimuli fell in between this range. The coefficient of correlation was found to be high between judges being 0.6, 0.6 and 0.58 between judges 1 and 2, 2 and 3, and 1 and 3 respectively. Regarding the imitation of intonation patterns by children,it was observed that the ability of the children to imitate the intonation patterns increased from 4-7 years and declined thereafter. The co-relation coefficients between judges J_1, and J_2 using the rank difference method for the age ranges were high being 0.89 (4-5 years); 0.89 (5-6 years) 0.91 (6-7 years); and 0.85 (7-8 years). It was also noticed that children imitated single and combined intonation patterns earlier than the combined and steady intonation patterns and no difference between males and females in terms of imitation capacity was noticed.

Conclusively since not all 35 stimuli were identified by adult normal hearing listeners themselves this cannot be considered as a test. Modifications of these in either the temporal dimensions/levels need to be made. Also non-linear types of patterns need be synthesized and their effects studied. On modifications and further deletion of patterns (like SFL_1, $SFSR_3$ S, $SFSR_4$ S) a test could be constructed.

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						6-7 Years									7 - 8 Years				
					SS	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
1	D	D	S	D	D	D	D	S	S	S	S	S	S	S	S	S	S	D	S	D
2	S	D	S	D	S	S	D	S	S	D	S	S	S	S	D	S	S	S	D	D
3	D	D	S	S	S	D	S	S	S	S	S	S	D	S	D	S	D	S	S	S
4	D	D	S	D	S	S	S	S	S	S	S	S	S	S	D	S	S	S	S	g
5	D	D	S	S	D	S	S	S	S	S	S	S	S	D	S	S	S	S	D	D
6	S	S	D	D	D	S	S	S	S	D	S	S	S	D	D	D	S	B	D	p
7	D	S	S	S	S	S	S	S	S	S	S	S	S	S	D	S	S	D	D	g
8	S	S	D	D	S	D	D	S	S	D	S	S	S	S	D	S	S	D	D	g
9		S	S	S	D	S	S	S	S	D	S	S	S	S	S	D	S	D	D	D
10		S	S	S	S	S	S	S	D	S	S	S	S	S	S	S	S	g	g	r)
11		S	S	D	S	S	S	D	S	S	S	S	S	S	S	S	S	D	g	B
12	D	S	S	D	S	D	D	S	S	D	S	S	S	S	S	S	D	D	g	D
13	S	S	D	S	S	S	D	S	S	S	S	S	S	S	S	D	S	D	g	g
14	D	S	D	S	S	S	S	S	S	S	S	S	S	S	S	S	S	D	g	D
15	D	O	S	S	D	S	S	S	S	S	S	S	S	S	D	S	S	S	g	J3
16	S	D	S	D	S	S	S	S	S	S	S	S	S	S	D	S	S	S	g	
17	D	D	S	S	D	S	S	S	D	S	S	S	S	S	S	S	S	S	D	g
18	D	D	D	S	D	S	S	S	S	S	S	S	S	S	S	S	S	S	g	
19	S	S	D	S	D	S	S	S	S	D	S	S	S	S	S	S	D	g	g	g
20	S	D	S	D	D	S	S	S	S	S	S	S	S	S	S	D	g	g	g	
21	D	S	D	D	S	D	D	S	S	D	S	S	S	S	D	S	S	S	D	g
22	S	S	D	D	S	S	S	S	S	D	D	D	S	S	D	S	S	S	g	
23	S	D	D	D	D	S	S	S	S	D	D	D	S	S	D	D	S	S	g	
24	D	D	S	D	D	D	D	S	S	D	S	D	S	S	D	D	S	S	g	
25	D	D	D	D	S	D	D	S	S	D	D	D	S	S	D	D	S	S	g	
26	D	D	D	D	D	D	D	D	D	D	D	D	S	S	D	D	S	S	g	
27	S	D	D	D	D	D	D	D	S	D	D	D	D	S	D	S	D	S	g	n<
28	D	D	D	S	D	S	S	D	S	D	D	D	D	S	D	D	S	S	g	S
29	D	D	D	D	S	D	D	D	S	D	D	D	D	S	D	B	D	S	g	S
30	D	S	D	D	S	D	D	S	D	D	D	D	D	S	D	S	D	S	g	D
31	S	S	D	S	D	S	S	S	S	D	S	S	S	S	D	S	S	S	g	D
32	S	D	D	D	D	S	S	S	S	D	S	S	S	S	D	S	S	S	g	D
33	S	S	D	D	D	D	D	S	S	D	S	S	S	S	D	S	S	S	g	D
34	S	D	D	D	S	S	S	S	S	D	S	D	S	S	D	S	S	S	g	D
35	D	D	S	D	D	S	S	S	S	D	S	D	S	S	D	D	S	D	g	D

APPENDIX;:- COMPARISCN OE SYNTHETIC STIMULI AND IMITATED PATTERNS OF CHILDREN BY JUDGE 1 FOR THE FOUR AGE RANGES.

										S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
									S	S	S	S	S	S	S	S	S	D	D
									D	S	D	S	S	D	S	S	S	D	D
									S	S	D	S	S	D	S	D	S	S	S
									S	S	D	S	S	D	S	D	S	S	S
								S	S	S	S	S	D	S	S	S	S	D	D
6	S	D	D	D	D	S	S	S	D	S	S	S	D	S	D	D	D	D	D
7	D	S	S	S	S	D	S	S	S	S	S	S	S	D	S	S	D	D	S
8	S	S	D	D	S	D	D	S	S	D	S	S	S	D	D	D	S	D	S
9	S	S	S	S	D	S	D	S	S	D	S	S	S	D	S	S	S	D	D
10	S	S	S	S	S	S	S	S	D	S	D	S	S	S	S	S	S	S	D
11	S	S	S	D	D	S	S	D	S	S	S	S	S	S	S	S	D	S	D
12.	D	D	S	D	S	D	S	D	S	D	D	S	S	S	S	D	D	S	D
13	S	S	D	D	D	S	D	S	S	D	S	S	S	D	S	S	D	S	S
14	D	S	S	S	S	S	S	S	S	S	D	S	S	S	S	S	D	S	S
15	D	D	S	S	D	S	S	S	S	S	S	D	S	S	D	D	S	S	D
16	S	D	S	D	D	S	S	S	D	S	S	D	S	S	D	S	S	S	D
17	D	D	S	S	S	S	S	S	D	S	S	S	S	S	S	S	S	D	D
18	D	D	S	S	S	D	S	S	D	D	D	S	S	S	S	S	S	S	S
19	S	S	D	S	D	S	D	D	S	D	S	S	S	S	S	S	D	S	S
20	S	D	S	D	D	S	S	S	S	S	S	S	S	S	S	D	S	S	S
21	D	S	D	D	S	D	D	S	S	D	S	D	S	S	D	S	S	S	D
22	S	S	S	D	S	S	S	S	S	D	S	S	S	S	D	S	D	S	S
23	S	S	D	D	D	S	S	S	S	D	S	D	S	D	S	D	S	D	S
24	D	D	S	D	D	D	S	S	S	S	S	D	S	S	S	D	S	D	S
25	S	D	S	D	D	D	D	S	S	D	S	D	S	S	D	D	S	S	S
26	D	D	D	D	D	S	D	D	D	D	S	D	S	D	D	D	D	S	S
27	S	D	D	D	D	S	S	D	S	D	S	S	D	S	D	S	S	D	D
28	D	D	D	S	S	S	D	S	S	D	S	S	S	S	S	D	S	D	S
29	D	D	D	D	S	D	D	D	S	D	S	D	S	S	D	S	D	S	D
30	D	S	D	D	S	D	D	D	D	D	S	D	S	D	D	S	S	S	D
31	S	S	D	S	S	S	S	S	S	D	S	S	S	S	D	S	S	S	S
32	S	D	D	D	S	S	S	S	S	S	S	S	S	S	D	S	D	S	S
33	S	S	D	D	D	D	S	S	S	D	S	S	S	D	D	S	D	S	S
34	S	S	D	D	S	S	D	S	S	D	D	S	S	S	S	S	S	S	S
35	D	D	S	D	D	S	S	S	S	D	S	D	S	S	S	D	S	D	S

APPENDIX 2: - COMPARISON OF SYNTHETIC STIMULI AND IMITITED PATTERNS OF CHILDREN BY JUDGE 2 FOR THE FOUR AGE RANGES.