DEVELOPMENT OF PERCEPTION OF COARICULATION

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Reg No M 9103

A Master's Dissertation submitted as part fulfillment for the Final Year M.Sc. (Speech and Hearing) to the university of Mysore Mysore.

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Mysore 570 006
INDIA.
May 1993.

AMMA My friend philosopher and guide.

LALITHA Trusted Confidante and an Adorabte Sis.

Dr. S. R. SAVITHRI & Mrs. MANJULA. R for being peerless in their respective areas of interest and are yet so modest, sincere and have thus inspired in me the urge to imbibe the same.

Mr. Antony Thomas for all the support and encouragement.

GERTIFICATE:

This is to certify that this Dissertation entitled :

"DEVELOPMENT OF PERCEPTION OF COARTICULATION",

is the bonafide work in part, fulfilment for the Final Year M. Sc. (Speech and Hearing), of the Student with Reg. No. M. *9103.*

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GERTIFICATE:

This is to certify that this Dissertation entitled :

"DEVELOPMENT OF PERCEPTION OF COARTICULATION.

has been prepared under my

supervision and guidance..

Savithri S R

MYSORE
MAY, 1993.

Dr. S. R. Savithri,
Guide.

DECLARATION

I hereby declare that this Dissertation entitled,

"DEVELOPMENT OF PERCEPTION OF CORTICULATIO

Is the result of my own study under the guidance of Dr. S. R. Savithri, Lect urer. Dept. of Speech Sciences, All India Institute of Speech and Hearing. Mysore, has not been submitted earlier at any University for any other Diploma or Degree.

MYSORE
MAY, 1993.

Reg. No. M 9103.

ACKNOWLEDGEMENTS

I would like to extend my sincere gratitude to:

Dr. (Mrs.) S.R. SAVITHRI, Lecturer, Dept. Speech Sciences, All India Institute of Speech and Hearing, for kindly consenting to be my guide and for being easily approachable and showing infinite patience in helping me out whenever I needed.

Dr. (Miss.) S. NIKAM, Director, All India Institute of Speech and Hearing, Mysore, for having given me the permission and opportunity to undertake this dissertation.

Dr. N.P. NATARAJA, Prof. and HOD, Dept. Speech Sciences, AIISH, for permitting me to use the instruments for the study.

Mr. C.S. VENKATESH, Lecturer, Dept. Speech Sciences, All India Institute of Speech and Hearing, for his kind nature to help unflinchingly even till the v*ery* last moment.

Mr. RAMESH BABU, Mr. GANESHAIAH, Mr. JAYARAJ, Mr. RAMACHANDRA RAO (RCE) for helping me collect data for this study.

Dr. SHUKLA, Mrs. PREMA, for having brought their children as subjects for the study.

ALL THE LIBRARY STAFF for helping me in searching the references.

ALL MY FRIENDS and PATHAKJI, without whose perennial moral support, constant encouragement and timely help, this work would have been an extremely impossible task.

Mrs. & Mr. MANOHARAN, VIOLA, SAM, Mrs. RADHIKA and CHINTHALA BALARAJU (CHINTU) (RECKON COMPUTER CONSULTANCY) for their kind stenographic assistance.

AND

CHITHI & JAYAPPA, for their love, affection and concern in my welfare.

ALL MY COUSINS: JAYASHREE, VEDHAKA, VENUNNA, SHREEMATHI, BALA, VIDYA, VATSAN,SRIDHAR, SHREERAM, SHRIVIDHYA, ARUN & APARNA, - I don't have words to express my affection to you.

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CHAPTER I

INTRODUCTION

The only reason that everyone understands each other, and there are those who do a poor job of it, is that the human mind has developed into a remarkable seeker of patterns. It receives the seemingly chaotic variety of sights, sounds and textures, searches for common properties among them, makes associations and sorts them into groups. In this sense, we all perceive in the same way. In speaking to one another, one extracts the essence of sound and meaning from utterances devise in dialect, vocabulary and voice quality. (Borden & Harris, 1980).

In perceiving the speech communications of others, one tends to impose one's own point of view upon the messages. That is one often thinks he hears what he expects to hear. If part of a word is missing, one's minds supplies it and one fails to notice its absence. (Borden A. Harris, 1980).

In speech communication, one retains his/her individuality and language-based perspectives. On receiving the same acoustic signal, the ears act upon this signal in similar ways. Those acoustic patterns that correspond to the distinctive speech sounds overlap in time which is referred to as coarticulation. Thus, the process in which

the articulatory characteristics, features or properties of one sound are modified by another sound, is known as coarticulation (Sharf & Ohde '81).

In the broadest sense, coarticulat ion refers to the fact that in the production of adjacent or near-adjacent speech sounds, the movement associated with one sound are sometimes made simultaneously with movements associated with another. Coarticulation production has been studied extensively whereas perception of coarticulation is being studied only recently by Ali etal (1971) Lehiste & Shockey (1972) Repp & Mann (1980) Fowler (1981) Nittrouer & Whalen (1989). These authors have studied the perception of coarticulation in adults. Most of their studies correlated with tho reports on production. They indirectly brought out evidence to report the presence of coarticulation.

Perception of coarticuat1ion in adults have been studied in fricatives and stops the most, as it's easy to apply the cut and splice technique for these sounds. Also, the nasals have been studied. In the fricatives, the frication portions of ¦f¦ & ¦o¦ carry more consonantal information. Transition is also a major cue for tho perception of tho fricatives (LaRiviero otal, 1970 Repp & Mann, 1980).

So far as stops are concerned, when segments upto and inciuding half the consonants of the cluster were present, subjects identified the following vowel. Listeners performance in supplying the (missing) initiai or final vowel was at chance.

Generally, adults were able to make use of the coarticulatory information, even when tokens were cut and presented in segments which did not physically contain cues. They make use of both place and manner cuoa but moro of place cues has been found (Kuehn & Moll 1972) Syllabic stress and length of the syllable duration also played important roles in the perception of coarticulatory information from syllables (Fowler, 1981).

The adult listeners sort the phones into categories prior to the point in time at which the closest approach to a target (for that phone) is reached (Kuehn & Moll, 1972). They make use of such strategies in this process, whereby there is modification of acoustic pattern of preceeding and following sounds. For such sounds to be perceived or identified, there requires a degree of invarianco in production. This is brought about by normalisation where the listeners system compensates for the discrepancy between the encoding system of the speaker and the decoding system

of the listener. It has been found in all of adult studios that adults do make use of this princip!e, whereby they make use of the coarticulatory information, even when the stimuli are presented to them with as minimum acoustic cues, as possible.

Can children also make use of such coarticulatory information when presented with such stimuli ? Is there a developmental trend in the perception of coarticulation ? At what age do children make use of adult - like strategies in the perception of coarticulation ? If there in a correlation between perception and production of coarticulation, what is the extent ? Are n few continuing questions. In this context four major studies have boon done by Parnell & Amerman (1978), Nittrouer (1989) Nittrouer Studdert-Kennedy (- 1986:-) and Sereno and Liberman (1987). The results of these studies have partly indicated that children start perceiving coarticulation as early as throe years but it is not well defined as in adults. Though there is an indication about the development of coarticulation in children, much needs to be done in this area. In this context the present study was planned. The aim of the present study was to find out the development of coarticulatory perception Kannada speaking children in the age range of 4 to 7 years.

CHAPTER II

REVIEW OF LITERATURE

Physiologically, coarticulation refers to the integration of generation of neural commands to the speech musculature, timing and movement patterns of articulators and aerodynamic forces, which results in the spreading of features from one sound to another. Acoustically, it refers to the influence due to modifications by certain contextual features on the spectral and temporal characteristics of speech sounds and perceptually it refers to the interacting effects of the contextual cues for consonants and vowels, in the perception of sounds (Sharf & Ohde, 1981).

Coarticulation is a phenomenon that helps in maintaining the continuity of speech at the rate of speech of 12 speech sounds per second. Perception too will suffer due to the listeners' inability or delay in stringing together all the uttered speech sounds and to make sense out of them. Also, this concept has provided a basis for the elucidation of mechanisms to account for the sound changes observed.

Clinically, the contextual influence on sound production was a concern before coarticulation developed into a major area of research. In recent years, research

has been directed toward clarifying the influence of context on the production of error sounds by children and the coarticulatory basis of the same (Sharf & Ohde, 1981).

The contextual effects in adults' speech perception has been variously studied across fricatives, stops & nasal a. Also, the contextual effects in adults' speech perception have been studied by using pre-vocalic & post - vocalic transition. As the present study is on the development of coarticulatory perception in children, a detailed review on adult studies is beyond the scope of this chapter & only a summary of these studies is presented in Table - 1.

Sl. No.	Author	Material	Task	Conclusion
1 1.	All, etal (1971)	CVC & CWC in which final cons-onants were [m or n] or non-nasal consonants (b,v,f,z,d) The entire final consonant along with v-c transi-tion was spliced away.	To determine the perception of coarticulated nasality.	Results indicated that the presence of nasal consonants could be predicted and that listeners utilize this information to lengthen the phoneme-processing load Consonants which followed low back vowel /a/ perceived as nasal with significantly , greater frequency than vowels /u/, /el/, /i/ (high vowels). Perceptually significant coarticulation of velar opening across the vowel in CWN-type sequences is supposed to have counterparts in the coarticulation of other articulatory gestures and this way perception is related to production.

! SI. No.	Author	Material	Task	Conclusion
<	La Riviere etal (1970)	CV Syllables c = s, ʃ, ʃ, ʧ v = a, i, , u	To study the presence of useful perceptible infot— mation in the fri- cative that precedes the vowels	It was found that: /ʃ, ʒ/ use vocalic information for perception and /s, ʃ/ use information based on frication. Transition is a cue for /ʃi/ and /θi/ Frication portions of /ʃ/ and /θ/ carry more consonantal information. No evidence at R-L coarticulation had on consonant recognition. The pre-post vocalic segment according to the authors, may yield through a normalization process information concerning the dimensions of the vocal tract, which facilitates phonetic interpretation of frication.

si. No.	Author	Material	Task	Conclusion
3.	Kuehn& Moll (1972)	CV Syllable out of which 4 truncations were made in each of the phrase final boundary of a) T+V+C b) inital boundary of T + v. c)Center of T + V	Perceptual effects of forward coai—ticulation- listeners had to identify the consonants & vowels partially by adding or deleting	Acoustic segments preceding consonants contain' perceptual cues primarily related to physiological place of production. Perceptual manner cues were not as strong as place cues when related to production. Acoustic segments preceding vowel contains perceptual cues primarily related to the front/back placement of the tongue for that vowel. Majority of vowel confusions occur between vowels adjacent on the

sl. No. :	Author	Material	Task	Conclusion
		d) Slope of T + V e) Uncut condition.		traditional vowel triangle. This suggest 1isteners begin to sort phonemes into categories prior to the point in time at which the closest approach to a target (for the phone) is reached.
4.	Lehiste Etal (1972).	VCV Syllable C= /p,t,k/ V = /i,æ,a,u/	To determine whether the change in formant transi-tion due to the anticipation of the following vowels were perceptually significant.	Results showed that: Listener's performance in supplying the (missing) initial or final vowels was at chance. A final vowel may have an implosive transition or an initial vowel may have on expiosive transition are not perceptible to listeners.

s l . N o :	Author	Material	Task	Conclusion
5	Benguerel and Adelman (1975)	Clusters /kstr/, /rstr/ and /rskr/ followed by one of the vowels /i/, /y/ or /u/ in all pos sible combi-nation.	Perception of Coar—ticular lip-round-ing	When segments up to and including half of the final consonant of the cluster are present, subjects correctly identified the vowel above chance level. Some subjects identify the vowels even when presented with short utterances. No significant difference in performance was found between French and English subjects or subjects with and without phonetic training. As coarticulation begin by first consonant of cluster, its likely that several segments contain information which can be used in perception process.

SI. No.	Author	Material	Task	Conclusion
				Coarticulation effects due to lip rounding (as well as horizontal place of articulation) provide perceivable information and is used in perceptual mechanism to aid in speech sound identification.
6.	Mann (1980)	FCV F = S, / C = k, t V = a	Assessing Perceptual dependence of stops on preceding fricatives in synthetic & natural speech.	Perception of /k/ was more following /s/. This effect was found to be related to a coarticulatory influence of the preceding fricative or stop production. Subjects response to naturai CY were biased towards a more forward place of articulation when CVS preceded by /s/.

sl. No. :	Author	Material	Task	Conclusion
7.	Hepp, & Mann, (1980)	CV FCV VFCV Where C = / t , k/ F = /s, ∫ / V = / a , u/	Perceptual evidence of Frie-stop coarticulation was studied.	Formant transition onsets following stop consonants release were systematically influenced by the preceding fricative. zF3 and F4 tended to be higher following /s/ than when following, /ʃ/. Coarticulatory effects were equally large in FCV (/sta/) and vfcv/asta/ i.e. weren't reduced when syllable boundary intervened between fricatives and stop. Identification of stop consonant depended on the place of articulation which revealed coarticulatory effects due to excised fricative context.

SI. No.	Author	Material	Task	Conclusion
8.	Soli, (1981)	/s, z, ʃ, 3/ in isolation and in pv where V = /a, l, u/		Presence of peaks in fricative spectra indicate that during latter part of fricatives constriction begins to open in anticipation of vowels and hence format excited. Fricative place of constriction assimilated to high vowels /i,u/results in different formants. Such effects not seen with /a/ as two opposing gestures are involved with minimal overlap.
9.	Yeni-kom Shian& Soil, (1981)	C = /s,z,ʃ,3/ V = /a.i.u/	Recognition of vowels from information in fricative, perceptual evidence of fricative vowel coarticulation	High vowels /i/and /u/ are identified 60% to 80% of the time mall fricative context (with exception of /i/ in context of /s /.

SI. No.	Author	Material	Task	Conclusion
				The above shows that fricatives segments with high vowel identification scores exhibit clear evidence of spectral changes associated with vowels. These are explained as due to variation in articulatory compatibility of tongue movements required to produce fricative-vowel sequences.
10.	Fowler. (1981 a)	VCV After splicing at the center of the conson-ant.	Perception of coar-ticulation in stressed vowels.	The use of voiceless stops may make a dif-ference in both perceptual salience of coarticulatory influence into/out of a consonant, and also in the occurrence of such effects. This precludes any

Sl. No.	Author	Material	Task	Conclusion
11	Fowler. (1981 b)			coarticulatory effect of a final stressed vowel on transition from an initial stressed vowel to voiceless stop. Shortening that may be seen is not articulatory shortening, but reflects the sort of articulatory overlap reported by other authors. This is identified as shortening only because measurements do not include those parts of its coarticulation extent where another segment predominates in the signal. This articulatory and shortening measures together suggest that consonants and vowels are overlapped in production in a

SI. No.	Author	Material	Task	Conclusion
12.	Fowler. (1985)			consistent way with the perceptual segments of the acoustical signal. Coarticulation does not destroy the coherence of features of individual phonetic segments or the separation among distinct segments. This research on CV coarticulation merges with production research where segment durations are measured. In that literature, vowels are measured to shorten as consonants are added to a syllable.

Sl. No.	Author	Material	Task	Conclusion
				Stressed vowels are measured to shorten as unstressed vowels are added to a word. Also Fowier has repeatedly found that perceived duration of vowel does exceed its measured duration.

Table-1: Summary of studies on coarticulation.

CHILD STUDIES

White coarticulation and its perceptual effect, has been well studied for adults, only recently it has been studied developmentally. Four studies have been conducted in the area of coarticulation in children.

Parnell, & Amerman (1978) investigated the maturational influences on the coarticulatory effects. They took three experimental groups consisting of ten four-year-olds, 10 eleven-year-old and 10 adults. The listeners were provided with stimuli which was aimed at in the following manner. The material used for the study was CV syllable, where C = !p,t,k!, V = !a,i,u!. From the intact syllable, the following subsegments were isolated.

1. Burst + Aspiration (B + A)

2. Burst + Aspiration + Vocalic transition (B + A + V)

3. Vocalic transition alone (VT) and

4. Vocal transition + Vowel

This was for experiment - I.

For experiment II, tho syllables ¦!ti¦, ¦ta¦ and !tu! were segmented in a manner similar to task -1. The voiceless stop ¦t¦ rather than ¦p¦ or ¦k¦ was selected as

the consonant on the basis of the observation made by the previous investigators.

The results of this investigation provided additional evidence of the adults' ability to utilize coarticulatory information to aid speech perception. The adult subjects were able to identify both consonants and vowels in voice teas stops + vowel syllables with significantly above chance level. Observations, suggest that skills for decoding information i.e. provided by a speaker's coarticulation behavior are available and operant in the perception mechanisms of young children of both sex by the age of 4 years. However, results also indicate that these perceptual functions. in young children are much less efficient than those observed for the older population.

The 4 year old children differed from 11-year old children and from the adults primarily in their less effective use of segments that contained a periodic information (B + A) and B + A + VT segments. Consistency of responses reflect developmental influences relating to intra-subject variability. The 4-year-olds were less consistent than 11-year-olds and adults. The perceptual confusions indicate an association between subject age and magnitude of preferences for error substitutions.

Age	Preferences for error substitution
Four year old	Evenly distributed for a given syllable between two response alternatives.
Eleven year old	Less than four year old, i.e. more consistant substitutions of one syllable.
Adults	Most marked substitution preference.

Older individuals showed a well defined and consistently applying strategies for guessing" governed by "rules" for making perceptual decisions on the basis of minimum information.

The duration of the across stimuli affected the accuracy of responses, all age levels and stimulus of longer duration associated with greater accuracy of phonetic identification. This relationship reflected the maturational influences. The magnitude of positive coarticulation between duration and response accuracy decreased progressively with increased subject age.

Age	Influence of stimulus, duration.
4-yr-old	Greater influence exhibited than adults than l1-yr-olds.

11-yr-olds	Greater than adults
Adults	Less than 11-yr-olds.

This influence indicates presence of higher information content (in the precision of perception processing). Conversely, the amount of influence present in longer duration stimulus may be no greater than that in shorter duration segments. However, response accuracy was enhanced by increase in segment duration. The additional duration permits the perceptual mechanism to carry out a more thorough detection and analysis of the relevant acoustic characteristics of the segment. Long duration signals are more perceptible as they bear resemblance to the speech signal.

Although accuracy in utilization of coarticulation information appears to be estimated at a level commensurate in adult perception by age 11, several response characteristics observed in this investigation suggest that modification of perceptual strategy may continue beyond the 11-12 years period.

The influence of stimulus duration on the response accuracy of 11-yr-old children was less than for 4-yr-olds

but slightly greater than adults. The trend involving consistency of responses suggests that stabilization of strategies has not reached asymptote by age 11. Subjects became progressively more consistent in their response to the four presentations of identical stimulus as age raised.

Nittrouer and Studdert-Kennedy (1986) investigated the role of coarticulatory effects in the perception of fricatives by children and adults. Their study tries to delineate the development of sensitivity to acoustic variations, in children, by examining their responses to coarticulatory effects in fricative vowel syllables.

Children at each of the ages, three, four, five and seven years and adults identified tokens from a synthetic ¦s¦ - ¦ʃ¦ continuum followed by one of the four natural vocalic portion of !i! or !u!, spoken with transitions appropriate for either ¦j¦ or ¦S¦. Children demonstrated larger shifts in fricative phoneme boundaries as a function of vocalic transaction than adults, but relatively smaller shifts as a function of vowel quantity; responses were less consistent for children than for adults and differences between children & adults decreased as children increased in age.

It was expected that "s" responses would be given to ¦u¦ tokens than to ¦i¦. The size of this effect was larger for ¦u¦ than for ¦i¦. Younger subjects demonstrated greater transitions than older subjects, as they gave more ' s ' responses to the !su! context than their older counterparts.

Thus, the younger subjects were more influenced by transitional information than older subjects & less by vowel quality. This shows that vowel and transition effects are additive.

Three-year, four-year and Five-year olds exhibited shallower slopes of identification functions indicating their inability to pay attention to the task at hand. Vowel effect was also found as the fricative spectrum differs as a function the quality of the following vowel.

Overall, these results indicate that perceptual sensitivity to certain coarticulatory effects is present at the age of three years of age. Moreover, the decrease in the effect of the vocalic transition with age suggests that, contrary to a commonly held view, the perceptual organisation of speech may become more rather than less segmental as the child develops.

Sereno and Liberman (1987) investigated the effects of lingual coarticulation in the speech stimuli of five adults and 14 children. CV syllables { ¦ki¦ , ¦ka¦) were analyzed acoustically and perceptually to determine the effect of vocalic environment on the preceding velar stop consonant. In childrens data, the differences between the velar stops. Preceding front and back vowels are not always present which are in contrast to the adults' data where they ahow significant coarticulatory effects. The stimuli of the children have poo!—vowel identification scores. The children's' ¦Ka¦ spectra show peaks at approximately the same locations as their ¦Ki¦ spectra, and it seems that listeners are sensitive to shifts because almost all errors are ¦ka's¦ misidentified as ¦ki¦ ¦s¦.

Thus their experiment demonstrates that speech of some children doesn't show perceptual effects of lingua! coarticulation. The differences among the child speakers did not correlate with age as the children whose ¦ki¦ and ¦ka¦ spectra showed the most similar patterns weren't the youngest children in study.

Nittrouer (1989) investigated the emergence of phonetic segments using evidence from the spectral structure of fricative vowel syllables spoken by children and adults. They hypothesized that phoneme-sized phonetic segments

emerge as functional units of perceptuo motor control from the child's gradual reorganisation of the gestures forming its early words or syllables.

A group of eight adults and four groups of eight children each at the ages, three, four, five and seven were the subjects for the study. Ten tokens each of the reduplicated syllables ¦sisi¦, ¦sisi¦!, ¦jufu¦ and ¦/ufu¦ served as the material.

From the patterns of ¦s¦ & ¦f¦ centroids and of F2 frequencies before ¦i¦ and !u!, it was observed that the 3-year-old children already execute lip-rounding and co-ordinate it with tongue and jaw action in an adult-like fashion. The pattern of age related decline in F2 frequencies lends further support to this argument. Vowel-context ratios decrease with age, due to a much larger drop in F2 frequencies before ¦i¦ than before ¦u¦.

Thus, it was made clear that children's stronger fricative-vowel coarticulation, was evidently not duo to child adult differences in either construction or anticipatory lip rounding. If children and adults do not differ in anticipatory lip-rounding, the children's stronger fricative-vowel coarticulation must be due to greater

overlap between their consonant and vowel lingual gestures.

The authors argue that children's relatively poor fricative differentiation and relatively strong fricativo-vowel coarticulation, could be duo to their immature systems of motor control and that they were perhaps trying to produce intrasyllabic segmental contrasts identical to those of adults, but lacked the motor skill to do so. However, the results of the earlier perception experiment (Nittrouer & Studdert-Kennedy, 1986) indicate that the childrens' perceptual organizations were less segmental than those of adults.

The childrens' fricative judgments, presumably unconstrained by their motor control abilities, were relatively more influenced by fricative-vowel transition and less strongly by fricative-spectrum than adults' judgments. The results indicate that, coarticulatory effect, the co-occurrence of lip-rounding for the vowel with a preceding fricative gesture, was the same for both groups of speakers (adults & children). Positioning of the tongue during fricative production, however, was found to be more vowel dependent for the children than for the adults.

Given this difference between children and adults in perceptual organization, one might expect a corresponding

difference in production. This is consistent with the hypothesis that phonological development involves learning to reorganise syllabic patterns of gesture into sequences of phonemically based patterns. The results also suggest that this development may still be going on in early childhood.

There is also an alternative account of early speech development that holds that a child's utterances are more, rather than less, segmentally organized than an adults'. The implication of this notion is that coarticulation increases with age, as a way of making production more effective.

Nittrouer & Whalen(1989) extended the work of Nittrouer etal (1989) to answer the three following questions.

1) Do the enhanced coarticulatory effects of children' FV syllables provide usable perceptual information?

2) If childrens' enhanced coarticulation is perceptible, do the perceptual tasks indicate that the age-related differences are greater in temporal extent or only in magnitude ?

3) Are there interactions between fricative & vowel judgments when those judgments are based on fricative noise alone ?

Three experiments were conducted to answer these questions. In experiment I the speech material used was the same used in their previous study (fi, Ju, si, su). There were five slices extracted from each syllable, (1) The first half of the fricative (1/2 f), (2) The first three quarters of the fricative (3/4 f), (3) The entire fricative (all f) (4) The fricative plus the first quarter of the vowel (f + 1/4 v) & (5) Entire syllable (all fv). The listeners were asked to identify the syllable from which they thought the slice was extracted and not just the upcoming vowel, in order to determine whether or not fricative and vowel judgments interact to any extent.

The results indicated the following:

1) Adult listeners were able to interpret correctly the vowel information in the fricative noises of childrens' productions.

2) Identification of the vowel was generally better for childrens' productions. When only the fricative noise was given, but was of essentially the same accuracy for adults' and childrens' samples when some or all of the vocalic segment was present. This confirms the acoustic results which indicated greater anticipatory coarttculation in childrens' fv syllables than in adults.'

3) The finding that listeners could correctly identify the vowel in all the four adult's samples coupled with the difference in identification accuracy between adults' children's productions indicated that both sources of vowel information were used.

In experiment -II the questions, concerning the Lime comes of childrens' enhanced coarticulation and interactions of fricative and vowel judgments were standardized. In addition, the relation between perception results and earlier acoustic findings were more closely examined.

Three groups of speakers served as subjects. Group I - 4 adults (2 males and 2 females); Group III - 4 children of ages samples 3, 4, 5, 7. Group III - 2 children (4 5 years).

The results of experiment II supported the findings of experiment I. The results indicated the following:

1) Fricative identity was easier to recover from adults' productions than from childrens' but vowel context was recovered both more reliably and earlier from childrens'.

2) For vowel identification, samples from the adult-like children were not adult tike, but rather demonstrated more accurate judgements beginning earlier in the fricative noise, as did samples from the child-like group.

3) Correct identification of the vowel for childrens' productions was found in the case of misidentifications of the fricative. The main prominence of the noise was tower in frequency before ¦u¦ than before ¦i¦ & ¦j¦ noises are lower than ¦s¦.

There are evidences for interactions between vowel and fricative judgements. Having established in experiment II that there was an interaction between fricative and vowel judgements, experiment III was carried out to investigate the magnitude of this interaction. For this, the fricative was identified to the listeners (converse of the experiment).

For those syllables which showed an interaction between fricative & vowel judgements in experiment II, i.e. ¦fi¦, ¦fu¦ were used, knowing the fricative identity resulted in an average gain in vowel identification scores of 22% points for adults' samples & 17% points for childrens' samples. For the syllables that did not demonstrate an interaction between fricative & vowel judgments (i.e. ¦ju¦, ¦]i¦), knowing the identity of frication contributed little. In

the earlier two experiments, the ability of the listeners to accurately judge fricative identity for childrens' samples actually degrade vowel identification scores.

On the whole, the following answers, were found to tho three questions posed:

1) The greater coarticulation between vowel and fricative gestures reported by Nittrouer (1989) for childrens' speech was perceived by adult listeners as phonetic information and not as noise.

2) The enhanced coarticulation of children's FV syllable was greater in temporal extent, as well as in magnitude.

3) Perception of a coarticulated phone included both processes that are independent on the recognition of the prominent phone, as well as processes that are independent of recognition of that phone.

One additional result of interest wan also observed. Tho F2 frequency per se did not determine perceptual judgements. Nittrouer etal (1989) showed that absolute values of children's fricative F2 frequency were always higher than those of adults. If identification of vowel

context was dependent on this parameter, all slices from children's samples would have been coming from ¦i¦ context. The fact that this wasn't seen, shows that listeners' do not perform direct acoustic phonetic mappings. Neither could listeners have some sort of normalization as the parameters considered necessary for normalization were not available in these experiments.

In this experiment, listeners, could, to a large extent, separate the information concerning vowel identity from information associated with fricative identity. It thus, seems that when simultaneous articulatory, events shape different positions of the acoustic signal, listeners divide the signal into temporally overlapping but qualitatively separate units, about which they make independent phonetic judgements. If simultaneous articulatory events shape same part of acoustic signal, listeners make dependent phonetic judgements that divide the signal into qualitatively separate units.

Thus, these studies indicate the possibility of development of coarticulatory production & perception. However, with these limited studies, nothing is conclusive about coarticulatory development. In the present study, an attempt has been made to gain a knowledge about the development of coarticulatory perception in kannada speaking normal children in the age range of 4 - 7 years.

CHAPTER III

METHODOLOGY

MATERIAL: Four voiceless stop consonants |k| (velar) |ṭ| (retroflex), |t| (dental) & |p| (bilabial) as embedded in the medial position of four meaningful Kannada words were selected for the study. These CVCV words (pa:pa, pa:ṭa, pa:ta and pa:ka) had the same phonemes except for the stop consonants which ensured the experimenter about the contribution of the stop consonants. These words, as uttered by a 22-year-old normal adult male were digitized in a computer memory using a 12 bit A/D converter, at a sampling frequency of 8000 Hz with a filter cut-off frequency of 3500 Hz.

Five synthetic stimuli for each word were prepared to understand the perception of coarticulation aa cued by the features-burst, transition, burst and transition burst, transition and the following vowel. All the synthetic stimuli were generated from the DWSSLC software developed by the voice & speech systems, Bangalore. These stimuli were as follows:

1) Original word = -vbtv.

2) Stimuli from the beginning of the initial consonant till the burst of the key stop = -Vcb.

3) Stimuli from the beginning of the initial consonant till the transition of the key stop consonant. However, the burst were removed using the cut and splice technique = - Vt.

4) Original word with the burst removed = - Vtv.

5) Stimuli from the beginning of the initial consonant till the transition of the key stop consonant. The stealyportion of the end vowel was removed using the cut & splice technique = - Vcbt.

The wave form was visually displayed on the screen of the computer and the transition was identified from the beginning of the onset of the regular wave after the burst of the stop consonant till the steady state of the wave. Fig. - 1-4 shows the wave form of various stimuli.

Thus, totally 20 synthetic stimuli were generated. The stimuli for each word were randomized and iterated five times to totally make 100 stimuli. Using the play batch programme (Voice and Speech Systems, Bangalore) these 100 stimuli were audio recorded onto a metallic cassette with an inter-stimulus interval of one second & inter-iteration interval of five seconds. These formed the material.

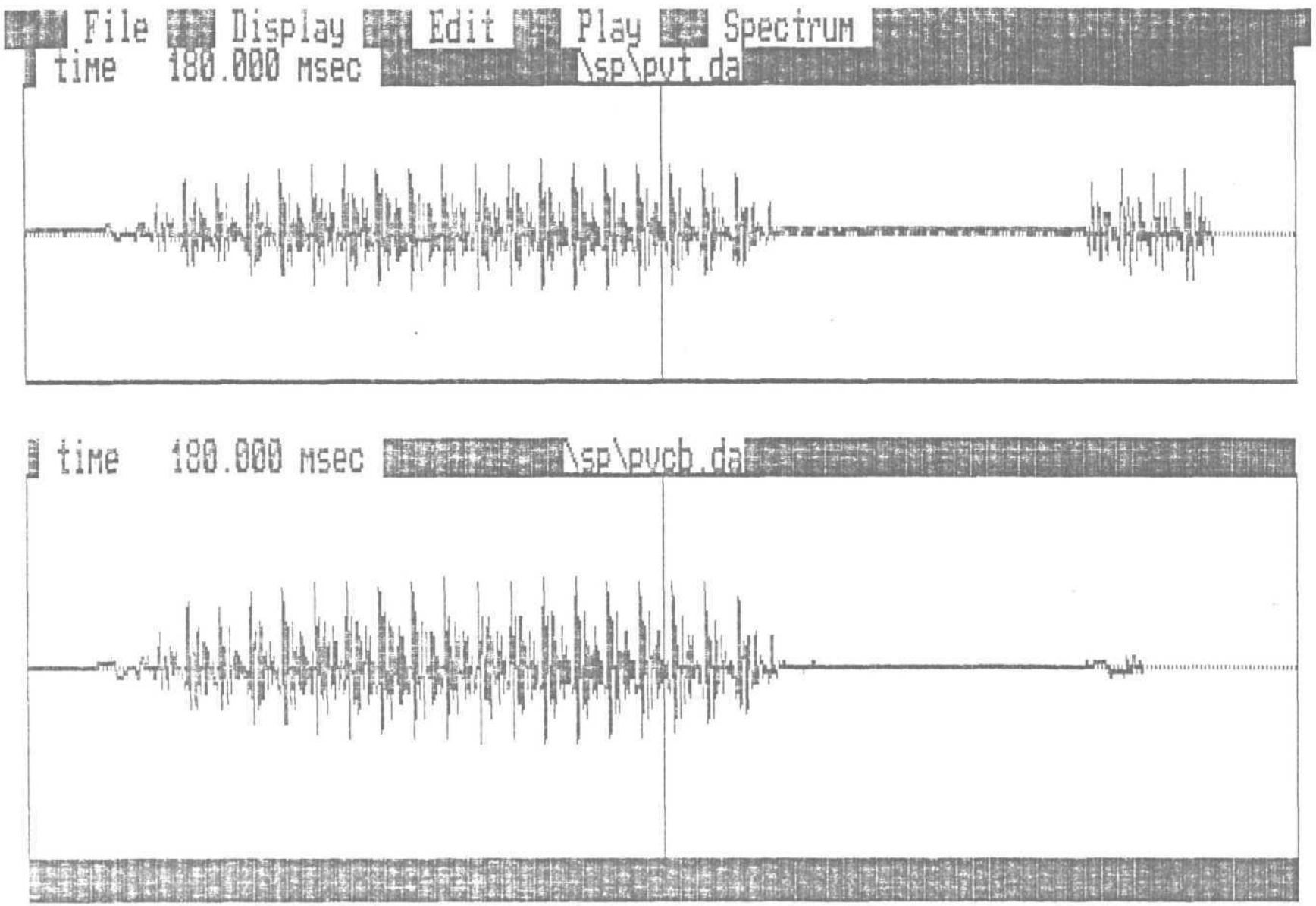


Fig.1: Stimulus from the beginning of the initial consonant till the transition of the key stop consonant, with the burst removed and the stimuli from the beginning

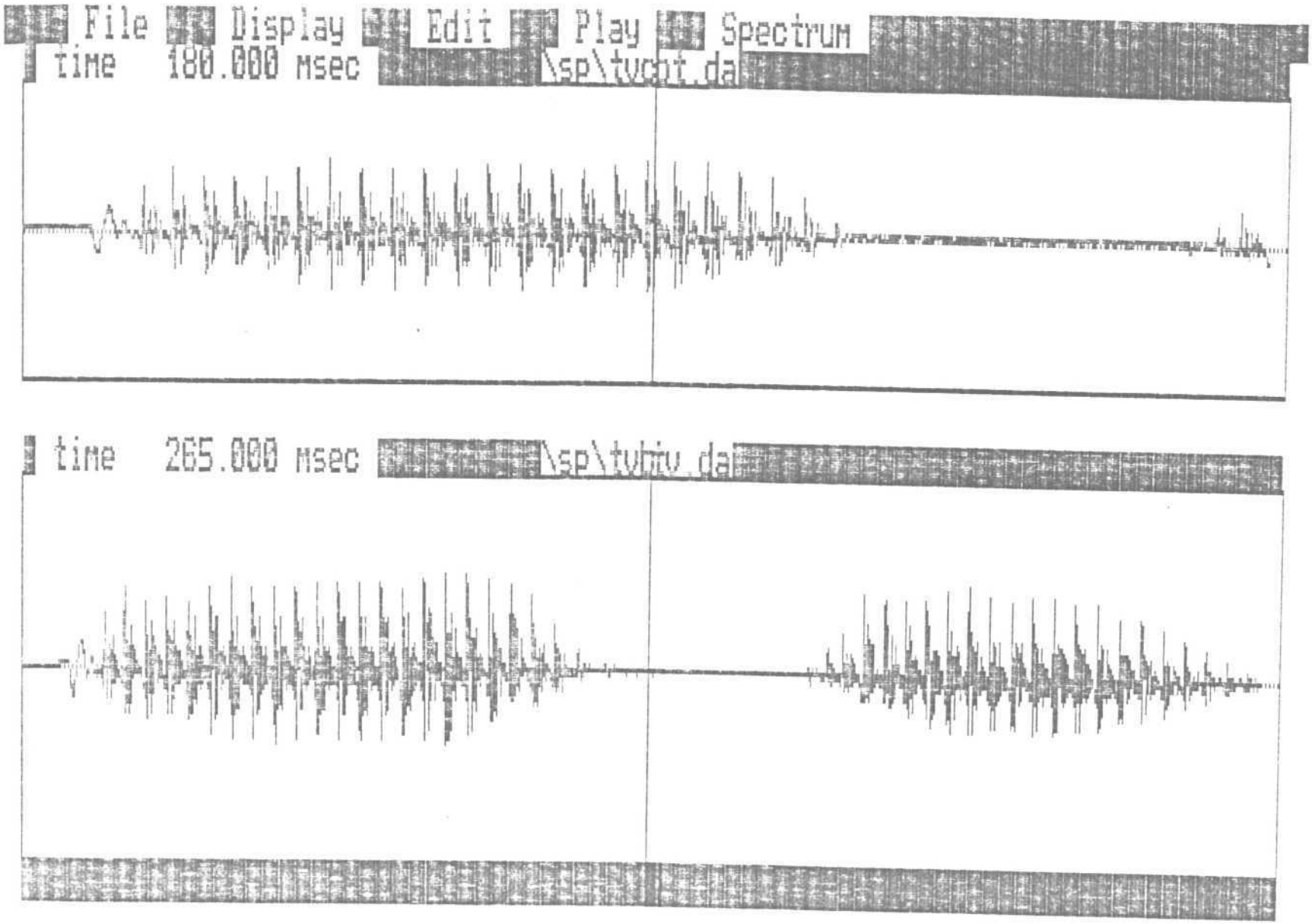


Fig.2: Stimulus from the beginning of the initial consonant till the transition of the key stop consonant, with the end vowel removed and the original word.

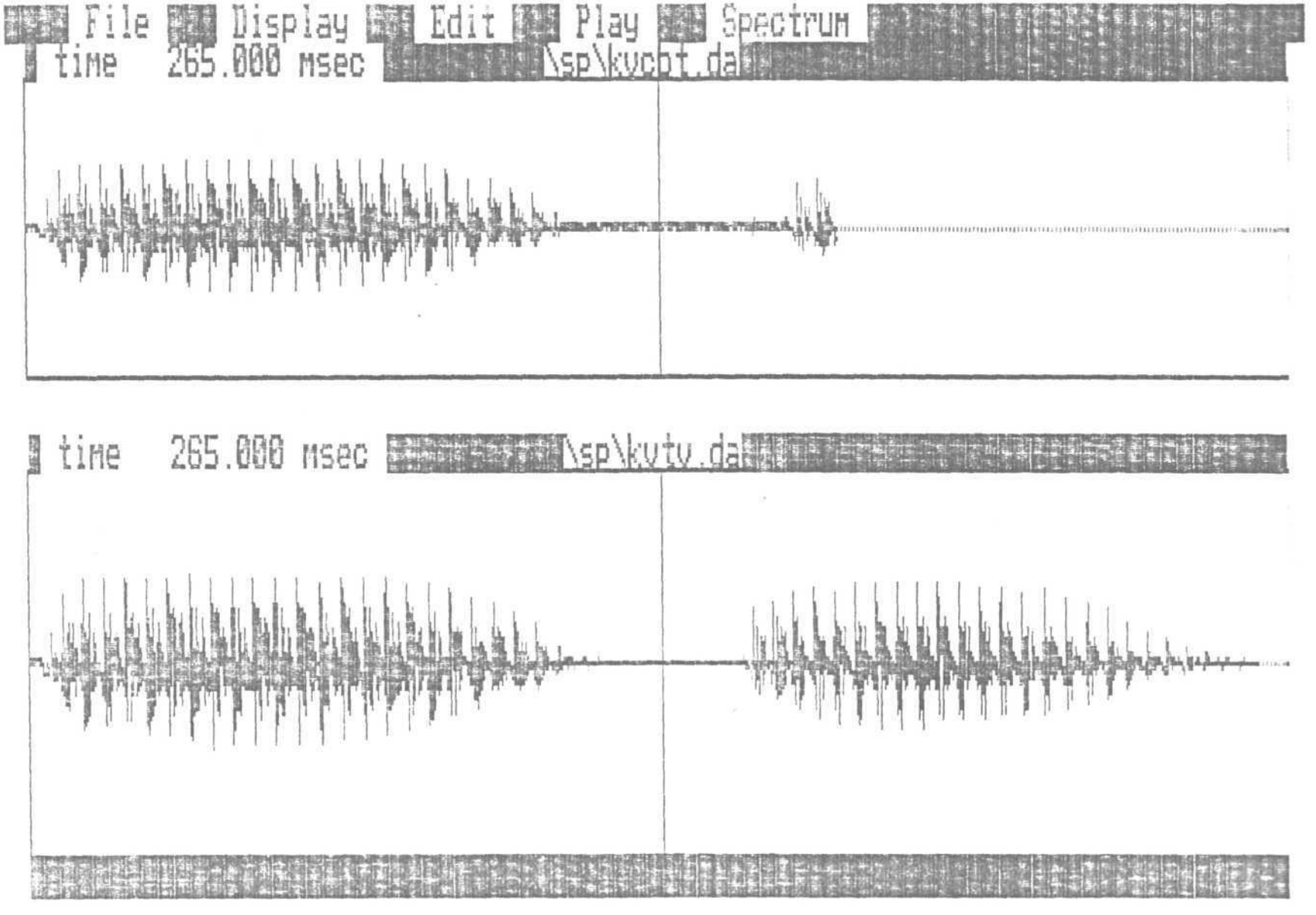


Fig.3: Stimulus from the beginning of the initial consonant till the transition of the key stop consonant, with the end vowel removed and the original word with the burst removed.

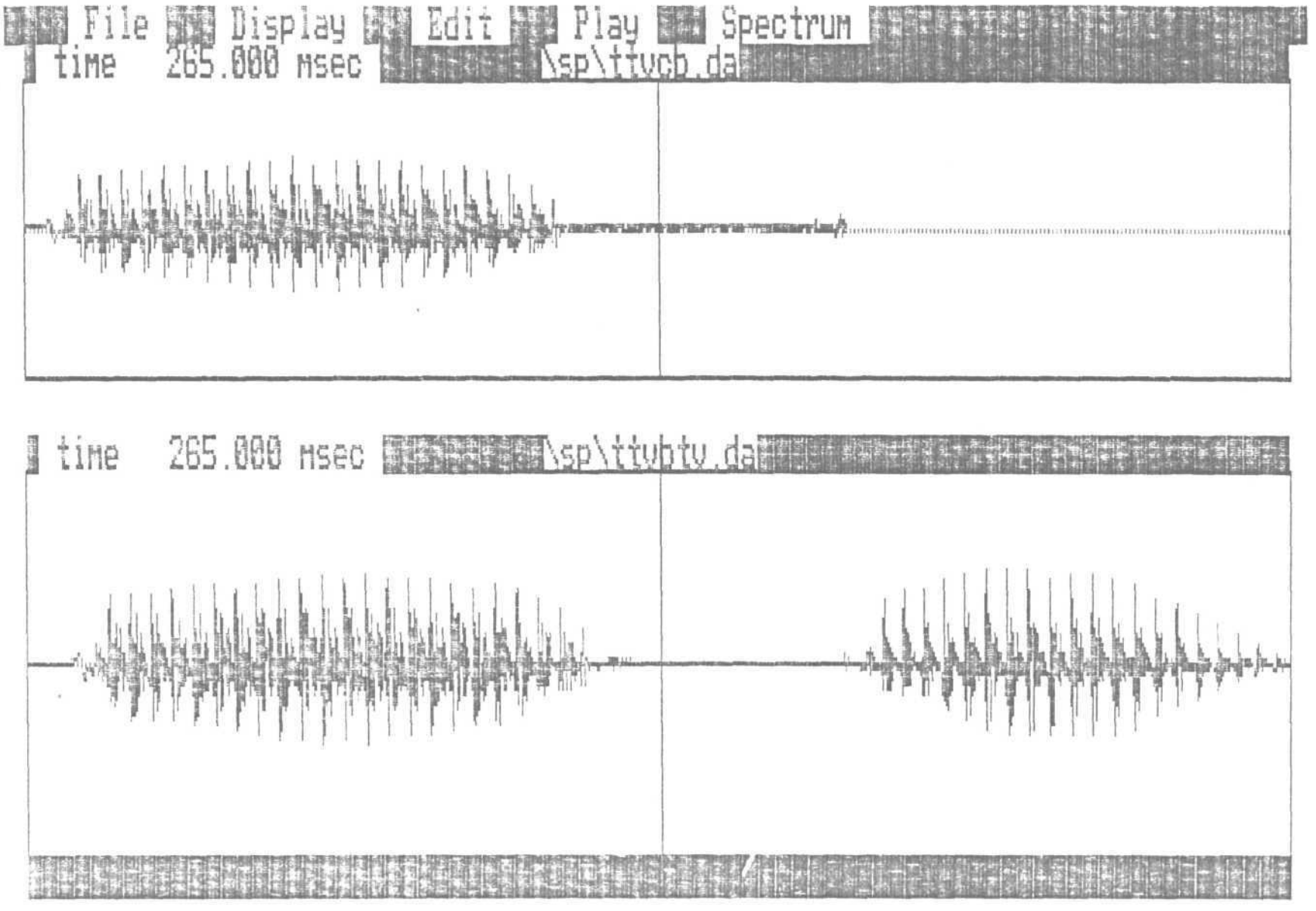


Fig 4: Stimulus (pa:ta) till burst and

SUBJECTS: Two Kannada speaking normal children each in the age range of 4-5, 5-6 & 6-7 years were selected as subjects. All the subjects had normal speech as identified by a speech pathologist. The details of the subjects are in Table - II.

Age range	Males	Females
4-5	1	1
5-6	1	1
6-7	1	1

Table - II. Details of Subjects Selected for the Study

METHOD: The synthetic stimuli were presented one at a time through two loud speakers positioned at an angle of 60 on either side of the child. Eight cartoons were selected with each cartoon representing a stimulus word. The child was instructed that the Mickey Mouse, a brightly coloured mask, would call out the names of the cartoons and he had to point to them or repeat them. The child was conditioned to respond to two pictures kept in front of him. For example, for the tokens of ¦pa:pa¦, he was instructed to point to a picture when he perceived the final vowel and to another picture when he did not.

The subjects were tested individually in a tow-noise room at the speech science laboratory, A.I.I.S.H. As children lose interest very easily, a play model was adopted which was a reinforcer. The mickey mouse, with the rolling up of ears was used as a reinforcer. The reinforcer was used during conditioning when the child's response was correct.

The responses were recorded by the experimenter on a forced choice response sheet immediately after the child's repetition. All these responses were tabulated and % response was calculated by the following formula.

$$\text{Percent response} = \frac{\text{No. of responses for the key word}}{\text{Tota! no. of stimuli}} \times 100$$

Thus the % responses for the perceived presence or absence of final vowel were tabulated for each of the test stimuli on the basis of which graphs were plotted for each word.

CHAPTER IV

RESULTS AND DISCUSSION

The aim of the present experiment was to study the developmental trend in the perception of coarticulation in children ranging from 4-7 years of age. 20 synthetic tokens were prepared from the four syllables ¦pa:pa¦, ¦pa:ta¦, ¦pa:ka¦ & ¦pa:ta¦ which served as stimuli. Each set had the tokens arranged in the following sequence:

1) Original word - vbtv.
2) Stimuli from the beginning of the initial Consonant till the burst of the key stop -vcb.
3) Stimuli from the beginning of the initial consonant till the transition of the key stop consonant. However, the burst was removed using the cut and splice technique - vt.
4) Original word with the burst removed - vtv.
5) Stimuli from the beginning of the initial consonant till the transition of the key stop consonant. The steady portion of the end vowel was removed using the cut & splice technique - vcbt.

The tokens used were

1. pvbtv, tvbtv, kvbtv, ttvbtv (-vbtv)
2. pvtv, tvtv, kvtv, ttvtv (-vtv)

3. pvcbt, tvcbt, kvcbt, ttvcbt (-vcbt)

4. pvt, tvt, kvt, ttvt (-vt)

5. pvcb, tvcb, kvcb, ttvcb (-vcb)

(Refer to the figures in the Methodology section)

The first set (-vbtv) consisted of complete vowel information and the other sets successively regressed in terms of vowel information. The intention of using these five token was that the vowel information is truncated in steps from 1-5 and if the plosive is coarticulating with the vowel, inspite of decreasing vowel information the vowel should be perceived. Hence, the % perception of vowel depends upon the coarticulatory information provided by various positions of the plosive and the voiced transition into the vowel. The results of the study will be discussed for each word.

STIMULI ¦pa:pa¦

Figure 5 depicts the percent response for the stimulus ¦papa¦ in the age range of 4-7 yrs. It was observed that the children in all the three age groups were able to perceive the final vowel in the tokens one and two.

While the children in the age groups of 5-6 & 6-7 years identified the final vowels in tokens three, four and five

(above 50%); the % identification for token four was reduced in the age group of 5-6 when compared to 6-7 yrs. The % identification for token five was less when compared to other tokens in all the age groups. The % identification of tokens one, two and three by children in the age group of 4-5 was above 50% & was below 50% for tokens four and five.

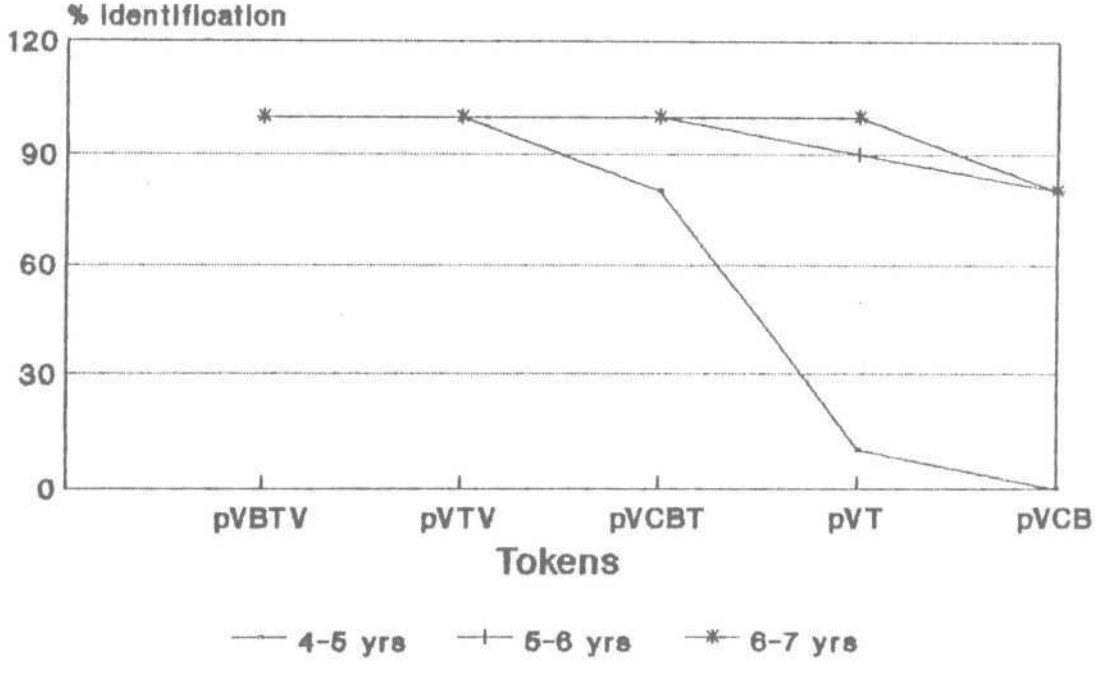


Fig 5: Percent identification of the stimulus (pa:pa).

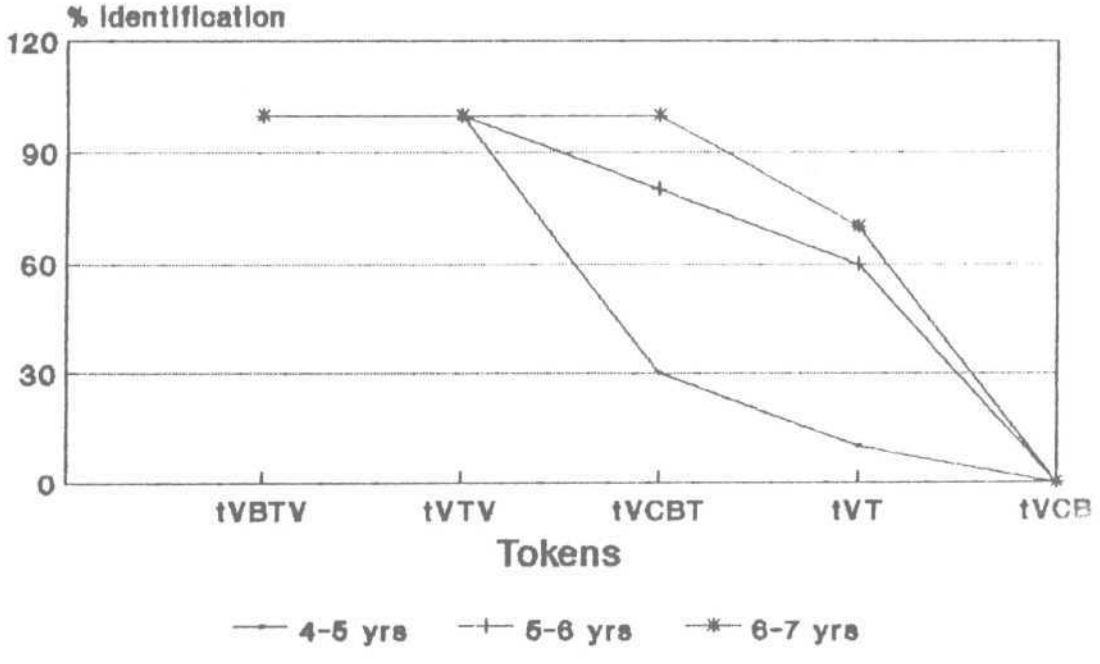


Fig 6: Percent identification of the stimulus (pa:ta).

STIMULI ¦pa:ta¦

Figure 6 depicts the percent response for the stimuius !pa:ta! in the age range of 4-7 yrs. It was observed that the children in all the three age groups were able to perceive the final vowel in the tokens one and two. White the children in the age group of 6-7 yrs identified the final vowel in token three and four, % identification for tokens four was reduced. The % identification for token three and four reduced in the age group of 5-6 yrs when compared to that of 6-7 yrs. However, the final vowel identification was above 50%. For the children in the age group of 4-5 yrs the % identification of tokens three, four and five reduced below 50%.

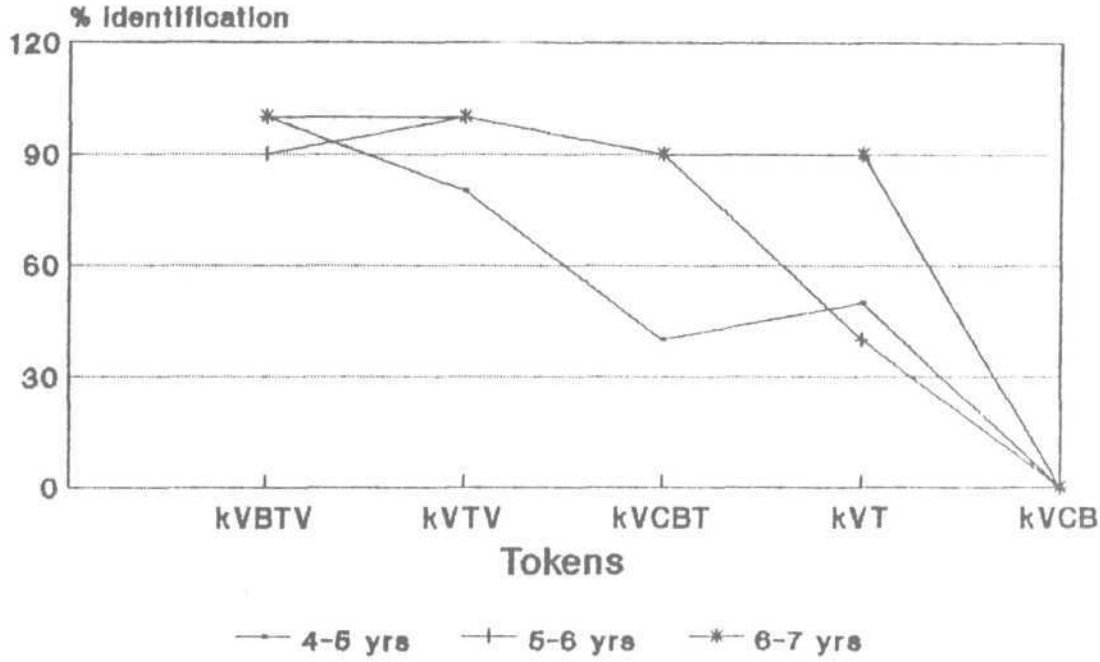


Fig 7: Percent identification of the stimulus (pa:ka).

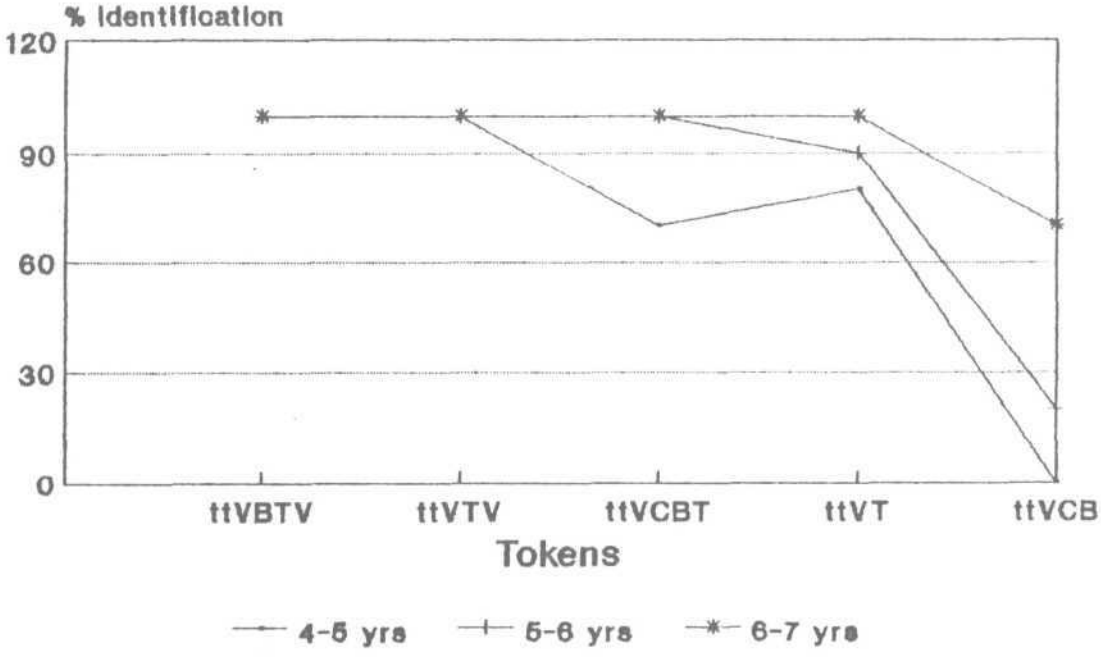


Fig 8: Percent identification of the stimulus (pa:ta).

STIMULI ¦pa:ka¦

Figure 7 depicts the percent response for the stimuius ¦pa:ka¦ in the age range of 4-7 yrs. It was observed that all the chiidren were able to perceive the final vowel in token one (above 50%).

The children in the age group of 5-6 and 6-7 years identified the final vowel in token two and the % identification for token three reduced for both the age groups. The performance identification for the tokens four and five (5-6 yrs) and three, four & five (4-5 yrs) was below chance level.

STIMULI ¦pa:ta¦

Figure 8 depicts the % response for the stimulus !pa:ta! in the age range of 4-7 yrs. It was observed that the children in ail the three age groups were able to perceive the final vowel in the tokens one and two.

While the children in the age group of 6-7 yra identified the final vowel in tokens three, four and five, the % identification for token five was reduced. The % identification for tokens three and four was reduced in the age group of 5-6 yrs when compared to that of 6-7 yrs.

In both the age groups 4-5 & 5-6 yrs, the final vowel identification for token five was below chance level (less than 50%).

Tokens	Age range (in years)	
	5-6	6-7
1	100	100
2	100	100
3	50	100
4	25	75
5	0	25

Table - III% identification of final vowel.

Tab!e - III Summarizes, the % identification by children of various age groups. To summarize, the results indicate the following:-

1) The percent response decreases from token one to token five indicating that stop, coarticulation plays a rote in the perception of vowel.

2) The % response increases from 4 to 7 yrs indicating a developmental tendency of coarticulatory perception. It is evident that the ability to perceive coarticulation linearly increases from the age of 4-7 yrs.

DISCUSSION

The results reveal several interesting points. First of all the ability to perceive coarticulation increases from four to seven years. This is in consonance with Parnell & Amerman (1978). These authors too found a developmental trend in the perceptual processing. However, unlike the present study, they take into consideration the duration of the acoustic stimuli which was associated with the accuracy of phonetic identification. Such an association reflects the maturational influences according to the authors.

Nittrouer (1986), Nittrouer etal (1989), and Nitrouer & Whalen (1989) also found role of coarticulatory effects in

the perception of fricatives by children and adults. These studies delineate the development of sensitivity to acoustic variations in children. Their results showed that three-year olds and four -year-olds exhibited shallower slopes of identification functions indicating their inability to pay attention to take task at hand.

Apart from the conclusion sugesting perceptual sensitivity to coarticulatory effects, these studies further suggest that perceptual organisation, of speech becomes more segmental as the child develops. The evidence for the suggestion is obtained from the decrease seen in the effect of vocalic transition with age.

It appears that the auditory processing of speech signals matures and the processing is not yet complete by 7 years for coarticulation. This has implications in the rehabilitation of the hearing impaired. In these children, the maturation may be delayed or if the maturation is normal it is possible to use the information present in the stop to elicit the perception of the following vowel.

However, the results of the present study was not in consonance with Sereno & Libermans' study (1987) in that, there was no definite developmental pattern reported by them. Another interesting finding was that the tokens with vowel transitions were identified better than those with burst.

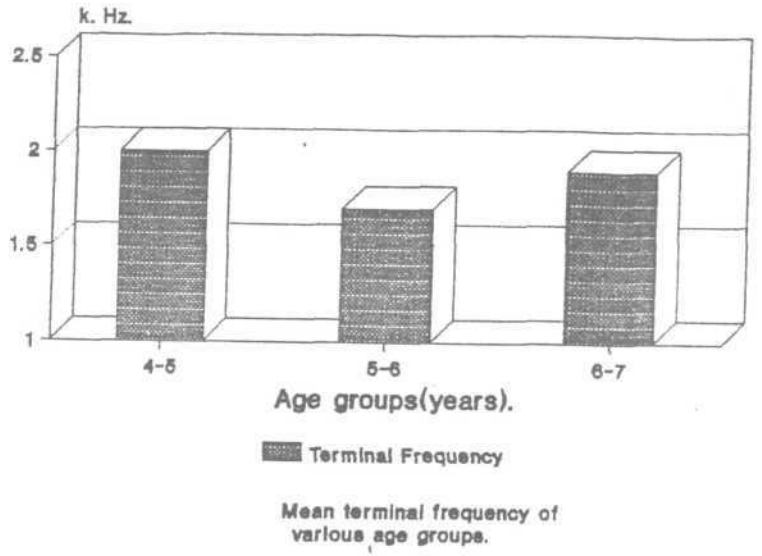
This could be because of the slack articulation children have at young ages. Table -IV shows data on the average burst duration in children between 4-7 yrs (Savithri, 1992). It appears that the burst duration increases with age indicating that children at young ages do not have firm articulatory contact. If three exists a relation between production and perception it's convincing that children who do not have firm articulatory contact for stop production will not perceive it either.

Age groups (yrs)	Average burst duration for the sounds ¦p¦ ¦t¦ ¦t¦ & ¦k¦
4-5	6.92 msecs
5-6	8.75 msecs
6-7	13.16 msecs

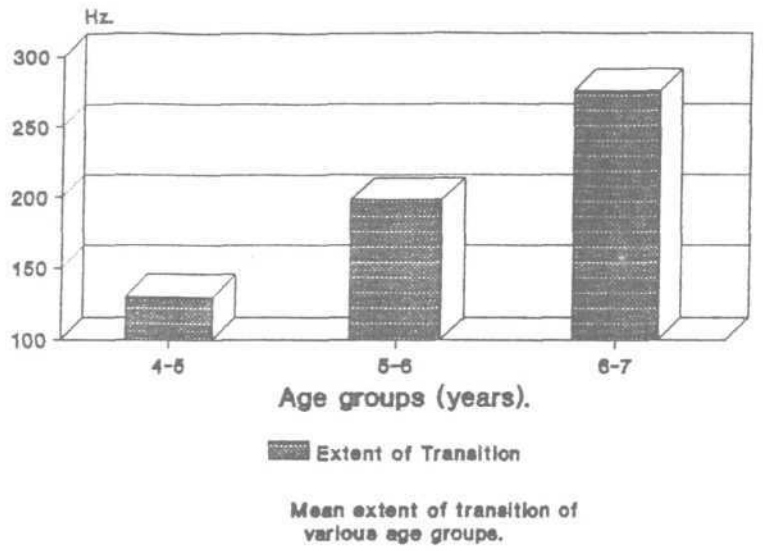
Table IV Average burst duration for the stop consonants ¦p¦,¦t¦, ¦t¦ & ¦k¦.

While comparing data on coarticulatory perception with that of coarticulatory production (Ganesh, 1993)*, it was observed that there was a correlation between the two. However, the correlation was not linear While in perception the percent scores increased with age, in production, the terminal frequency, transition duration, extent of transition & speed of transition had a decreasing

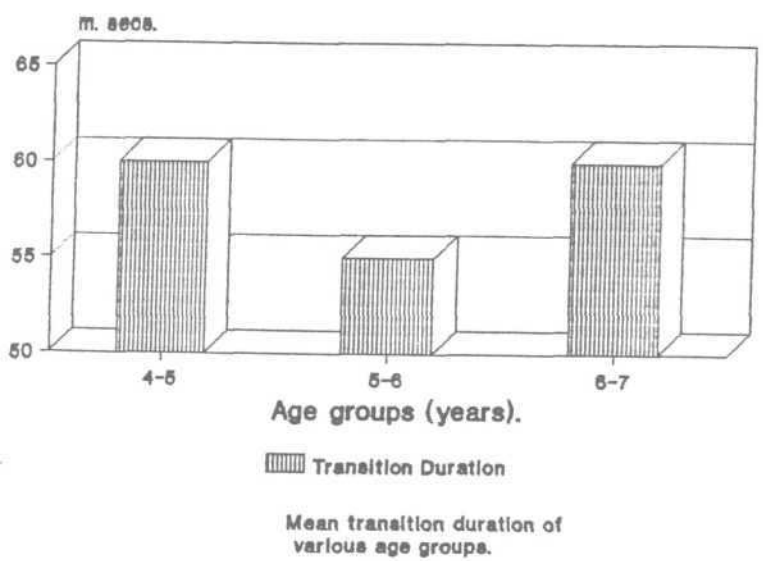
* Personal communication



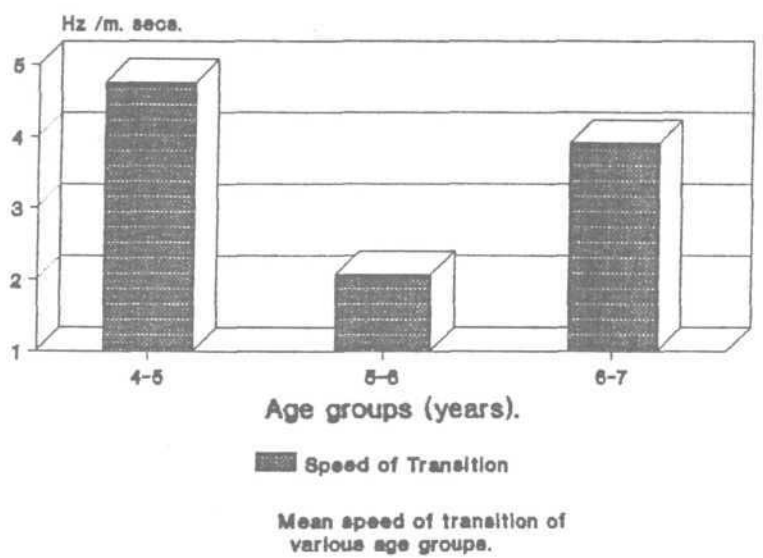
Mean terminal frequency of various age groups.



Mean extent of transition of various age groups.



Mean transition duration of various age groups.



Mean speed of transition of various age groups.

FIG. 9. PRODUCTION OF COARTICULATION

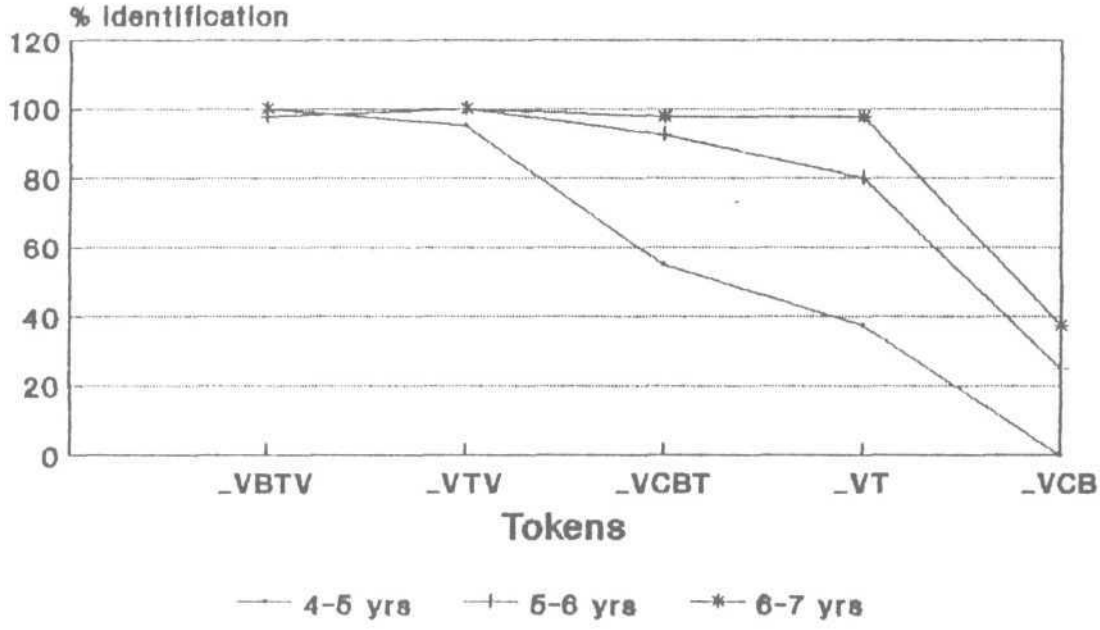


Fig 10: Comparison of the percent identification of the various tokens across age groups.

trend from 4 - 5 yrs. However, at the age of 5-6 years, there appeared a cliip.. it is not known as to why this clip appears in the age of 5 - 6 yrs.

The study derives significance from the point of view of clinical applications. Talkers with normal hearing may move their articulators continuously from one posture to another when speaking (Ohman, 1966, Fowler, 1986). Such a movement is essential for cyclical movements in speech production. Such articulatory organisation is missing in the speech production of the hearing impaired and intelligibility becomes poor. (Tyc Murray, 1987).

Thus, it becomes imperative to include the coarticulatory influences too, into the schedules of articulation training. However, one must exercise caution in being too ambitious regarding this issue. As there is a developmental pattern in the coarticulatory perception and production one must exercise caution while considering the age group for which such training may be adopted. Moreover, much remains to be seen & studies bo carried out in depth in this area. Nevertheless, this should lead to a positive trend in the rehabilitation of stutterers, patients with misarticulation and the hearing impaired.

CHAPTER V

SUMMARY AND CONCLUSIONS

The term coarticulation denotes an overlap in the production of gestures for successive segments of an utterance (MacNeilage '80). In the past, studies have been conducted on coarticulation and there has been some tight thrown on the development of coarticulation in children. However, the research is not very conclusive and much remains to be done in this regard. The present study was an attempt to investigate and gain insight into the development of the perception of coarticuiation in Kannada speaking children from 4-7 yrs of age.

Four voiceless stop consonants velar - ¦k¦, retroflex ¦t¦, dental ¦t¦ & bilabial ¦p¦ embedded in the medial position of four meaningful kannada words were selected. Five synthetic stimuli for each word were prepared using the cut and splice technique (voice & speech systems, Bangalore). 20 synthetic tokens were prepared with five tokens in each set. Each set had the words arranged in the following sequence.

1. Original word - vbtv
2. Stimuli from the beginning of initial consonant till the burst of the key stop - vcb

3. Stimuli from the beginning of the initial consonant till the transition of the key stop consonant. Burst was remained using the cut and splice technique - vt.

4. Original word with the burst removed using cut & splice technique - vtv.

5. Stimuli from the beginning of the initial consonant till the transition of the key stop consonant. The steady position of the end vowel was removed using the cut and splice technique - vcbt.

These stimuli were randomized and iterated five times to make 100 stimuli. They were then audio recorded onto a metallic cassette with an inter-stimulus interval of one second and inter-iteration interval of five seconds.

These stimuli were presented one at a time through loud speakers to six normal Kannada speaking children (three males and three females) in the age range of 4-7 yrs. They were given two pictures for each word where he or she had to point one word when he perceived the final vowel and to another picture when he or she did not. The responses were recorded by the experimenter on a forced choice response

sheet after the child's repetition. The responses were recorded and graphs were plotted.

The results revealed that

1. The %response decreased from token one to token five indicating that coarticulation of stops plays a rote in the perception of the vowel.

2. Also, the % response increased from four to seven years indicating developmental trend in the coarticulatory perception. It is apparent that the ability to perceive coarticulation linearly increases from the age of four to seven years.

3. There also exists a correlation between production and perception of coarticulation to some extent.

The results indicate that maturation may play a major role and the auditory processing capacity appear to develop in children. However, it is not completed yet by the age of seven years. While considering the pattern of development of coarticulation perception, one could well understand that caution should be taken to implement these research findings in the rehabilitation of the handicapped.

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