

# Development of Phonetic Accuracy and Speech Intelligibility in Tamil Speaking Typically Developing Children

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## Abstract

Intelligibility can play a major role in communication systems. The aim of the study is to investigate the development of phonetic accuracy and speech intelligibility in typically developing (TD) Tamil speaking children and to find the relation between phonetic accuracy as measured using Percentage of phoneme correct and speech intelligibility rating. A total of 150 TD native Tamil speaking children between the age range of 2 and 6.11 years participated in the study. These children were further divided into 5 groups. Stimuli consisted of 9 sentences and 15 words in Tamil. Each child was seated comfortably and pictures of the words and sentences were randomly presented one after the other. The investigator said the word/sentence as the respective picture was shown, and the child was instructed to repeat the word/sentence after the investigator. The responses of the children were audio recorded using wavesufer software through a laptop. The investigator listened to therecorded samples, transcribed and identified the correct/incorrect phonemes. Phonetic accuracy was determined using PPC. Results revealed that PPC and speech intelligibility increased with age.

**Keywords:** Speech Intelligibility, Percentage of Phoneme Correct, Phonetic Accuracy

## 1. Introduction

Speech intelligibility is the clarity in speech. Kent, Rosenbek & Weismer (1989) defined “speech intelligibility as the degree to which the speaker’s intended message is recovered by the listener”. Effective communication depends on how intelligible the speaker is, how well the speaker’s speech meets the cultural standards and how much the listeners perceives or understands of what the speaker conveys. Bowen (1998) stated that intelligibility improves as, i) listener’s ability to understand speech increases, ii) phonetic acquisition progresses and, iii) phonological processes are eliminated. In typically developing children, phonetic accuracy increases and phonological processes reduces with increase in age.

In a typically developing (TD) child, mastering the production of individual phoneme, suppression of various phonological processes and improvement in speech intelligibility occurs simultaneously. Speech intelligibility rating by parents of young TD children (Lynch, Brookshire and Fox, 1980) indicated that children of 18 months had 25% intelligibility, 24 months had 50 – 75% of intelligibility and 36 months were 75-100% intelligible. Similarly, Chin and Tsai (2002) found children’s

speech to have 53.9% percentage of word correct by 2 years, 71.8% by 3 years, 95.2% by 4 years, 96.2% years by 5 years, by 6 years 99.1% and at 7 years 95.7%. It was then concluded that children with normal hearing achieve adult – like speech by 4 years of age or shortly after that.

Phonetic accuracy is an important factor that affects speech intelligibility. One method to investigate phonetic accuracy is by calculating Percentage of consonant correct (PCC). Shriberg and Kwiatkowski (1982) showed that PCC correlates significantly with clinical ratings of severity of speech intelligibility. Percentage of consonants correct is then calculated by dividing the correct productions of consonants by total number of consonants and multiplying by 100. PCC values less than 50% indicates severely reduced speech intelligibility. Lau Wang Han (2010) reported speech intelligibility and phonetic accuracy measured using PPC has strong correlation and using PPC, it is possible to differentiate speech sound disorder and normal speech language development. Another study by Hodge, Brown and Kuzyk (2012) predicted speech intelligibility from phonetic measures for children with dysarthria and cerebral palsy. Word and sentence imitation tasks were used and its audio recordings were transcribed. Further analyzed by calculating percentage of phoneme correct, percentage of consonant correct and percentage of vowel correct. Results revealed a strong correlation between PPC scores and overall intelligibility rating for both word and sentence task.

Speech intelligibility is measured using open-set word identification task, closed- set word identification task, and rating scales. Listeners judgments are made on intelligibility using rating scales. One such Speech intelligibility scale that is commonly used in Indian context is Ali Yavur Jung National Institute of Hearing Handicapped (AYJNIHH) intelligibility rating scale. This scale is used in the current study to rate children's speech intelligibility.

Developmental data on speech intelligibility will aid in the assessment, decision making on the need for intervention, pre-post intervention analysis and termination from speech therapy for children with speech sound disorder/communication disorder. It is crucial to study language and culture specific speech intelligibility development as well. However, till date no studies were reported on the development of speech intelligibility in terms of phonetic accuracy in Tamil speaking typically developing children. The current study focusses on development of phonetic accuracy and speech intelligibility in Tamil speaking TD children. Phonetic accuracy is evaluated using PPC and speech intelligibility is measured using AYJNIHH speech intelligibility rating scale. Further, the relation between phonetic accuracy and speech intelligibility is also explored.

## 2. Method

### 2.1. Participants:

A total of 150 TD native Tamil speaking children between the age range of 2 and 6.11 years participated in the study. These children were further divided into 5 groups. Group I included children in the age range of 2 – 2:11 years; group II were children in the age range of 3 – 3:11 years; group III were children in the age range of 4 – 4:11 years; group IV were children in the age range of 5 – 5:11 years and group V were children in the age range of 6 – 6:11 years. Each group consisted of 30 children. The details of children are given in Table 1.

Table 1: Details of TD children

Groups	Age in years	Boys	Girls
Group I	2 – 2:11	19	11
Group II	3 – 3:11	21	9
Group III	4 – 4:11	17	13
Group IV	5 – 5:11	19	11
Group V	6 – 6:11	17	13

Children were randomly taken from kinder garden and primary classes in four different schools in Chennai. Inclusion criteria for the children to participate in the study are as follows:-

1. Child should pass informal speech, language and hearing screening.
2. He/ She should not have any oro- facial abnormalities.
3. He/ She should not have any neurological deficits.
4. Teachers should report that the child has good learning and academic skills.
5. Children who did not fit in the inclusion criteria were excluded from the study.

**2.2.Material:** Nine sentences in Tamil with increasing complexity were initially developed for the study. A pilot study conducted in 10 children in the age range of 2- 3.11 years, indicated that 50% of them were not able to repeat the sentences. Hence, 15 simple picturable words were also developed to study the developmental trend of speech intelligibility of this younger groups I and II. Kinder garden and primary class books were carefully reviewed and language abilities of TD children in the age range of 2 and 7 years were considered while developing the sentences and the word list. The stimuli were simple and picturable and commonly used in everyday life. Thus stimuli consisted of 9 sentences and 15 words in Tamil. Picture cards were prepared for the sentences and words. Three pictures were developed for each stimulus by the investigator and was given to 7 judges to rate the appropriateness of the picture with the corresponding sentence / word. The judges were native Tamil speakers in the age range of 30 to 40 years. Picture that was mostly opted by judges among the three options were used in the study.

**2.3.Procedure:** Formal written consent to collect children's speech samples was taken from the school head or principal prior to data collection. Data was collected from each child individually in a quiet room in the school. The child was seated comfortably and pictures of the words and sentences were randomly presented one after the other. The investigator said the word/sentence as the respective picture was shown, and the child was instructed to repeat the word/sentence after the investigator. The responses of the children were audio recorded using wavesufer software through a laptop. Microphone (i ball distortion free mic, Model No:M27) was placed 10cm from the child's mouth. In

case if the child had not listened or understood any stimuli, the investigator repeated it again. Recorded speech samples were then perceptually analyzed by the investigator.

**2.4. Perceptual Analysis:** Sentences and words were analyzed perceptually. The investigator listened to the recorded samples through headphones in a quiet room and transcribed using the transcription sheets and identified the correct/incorrect phonemes. Phonetic accuracy was determined using PPC. Total number of phonemes in the utterance and number of phonemes correctly produced by the children were analyzed and calculated. Percentages of phoneme correct for sentences and words were calculated using the formula:-

$$\text{PPC in sentence} = \frac{\text{No. of correct phonemes in sentences} \times 100}{\text{Total no. of phonemes}}$$

$$\text{PPC in word} = \frac{\text{No. correct phonemes in words} \times 100}{\text{Total no: of phonemes}}$$

Incorrect phonemes in the sentences were analyzed for the presence of phonological processes and their occurrences were calculated and tabulated across each age group.

Overall sentence intelligibility for each child was calculated using – Intelligibility Rating scale developed by AYJNIHH (Mani, 1991). It's a 7 point rating scale, in which score "0" indicates 'normal' and "6" indicates 'cannot understand at all even then content I know'. Statistical package for the social sciences-20 (SPSS) was used for statistical analysis. Mean, standard deviation (SD), and range of PPC and intelligibility for each group were obtained using case summaries option of SPSS. Independent 't' test was used to find the gender and group differences.

### 3. Results

#### 3.1. Phonetic accuracy in words

**3.1.1. Gender difference:** All the children (19 boys and 11 girls) in group I, could repeat the words. The mean percentages of phoneme correct for boys and girls are 70.6 % & 68.2%, respectively. Figure 1 shows PPC (words) in boys and girls across age groups and table 2 shows the details of mean, standard deviation (SD), subject size (n), number of children who did not respond (no response) and 'p' value and 't' value of independent 't' test.

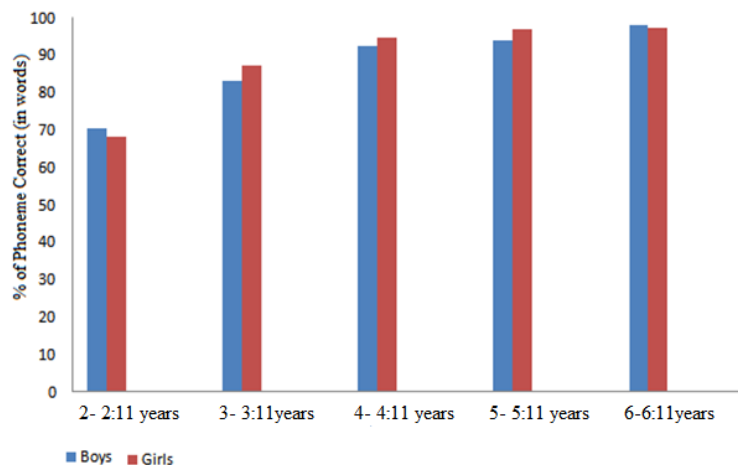
.All the children in group II (21 boys and 9 girls), were able to respond to word task. Mean PPC for boys and girls are 83.1 % and 87.4%, respectively. Similarly, all the children in group III (17 boys and 13 girls), were able to repeat the words. Mean PPC for boys and girls are 92.3% and 94.7%, respectively. In group IV (5- 5:11 years), mean PPC for boys and girls are 94.1% and 97%. And in group V, mean PPC for boys is 98% and girls is 97.2%.

Results of independent 't' test revealed no significant gender difference for all age groups.

Table 2: Mean, SD, n, NR (no response) and ‘p’ value and ‘t’ value of independent ‘t’ test of PPC in words

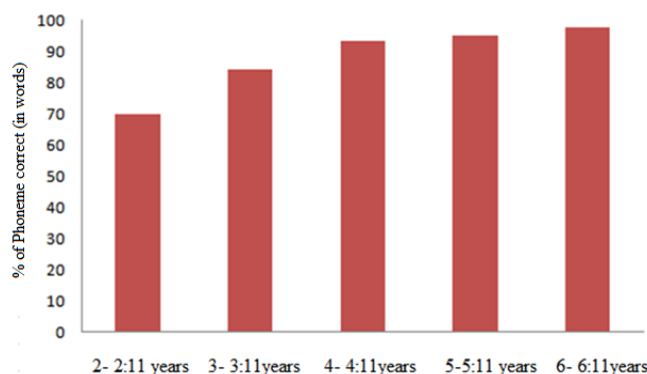
Children	2- 2:11 years (Group I)				3- 3:11 years (Group II)				4- 4:11 years (Group III)			5-5:11 years (Group IV)			6- 6:11 years (Group V)		
	n	NR	Mean	SD	n	NR	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
<b>Boys</b>	19	0	70.6	21.0	21	0	83.1	20.1	17	92.3	9.2	19	94.1	8.3	17	98.0	2.6
<b>Girls</b>	11	0	68.2	18.7	9	0	87.4	5.3	13	94.7	3.0	11	97.0	2.3	13	97.2	1.8
<b>Total</b>	30	0	69.8	19.9	30	0	84.4	17.0	30	93.4	7.2	30	95.2	6.8	30	97.6	2.3
<b>‘p’ value</b>	.767				.324				.068			.211			.078		

Figure 1: Percentage of phoneme correct in words compared between boys and girls across groups.



**3.1.2. Group difference:** Mean values of PPC in words increased with age. Mean values of PPC of group I is 69.8%, group II is 84.4%, group III is 93.4%, group IV is 95.2% and group V is 97.6%. Figure 2 shows the mean values of PPC in words across age.

Figure 2: Percentage of phoneme correct in words compared across group.



**3.2. Phonetic accuracy in sentences:** Percentages of phoneme correct was calculated in sentence task and the findings are as follows.

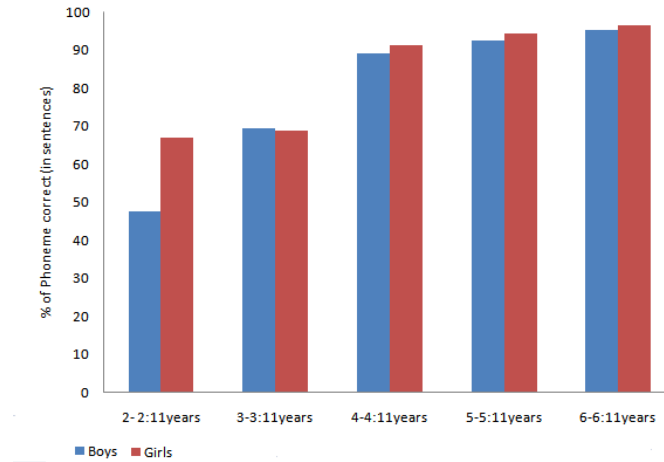
**3.2.1. Gender difference:** Of 19 boys and 11 girls in group I, only 14 boys and 6 girls could repeat the sentences and mean PPC for boys and girls are 47.7% and 67.0%, respectively. In group II, of 21 boys and 9 girls, 19 boys and 9 girls could repeat the sentences. Mean PPC for group II boys and girls are 69.4% and 68.8%, respectively. All the children in group III (17 boys and 13 girls) were able to repeat the sentences and their mean PPC for boys and girls are 89.2% and 91.2%, respectively. Similarly, in group IV and V all the children were able to repeat the sentences. Mean PPC for boys and girls in group IV are 92.5% and 94.3%. and group V are 95.4% and are 96.6%, respectively.

Independent ‘t’ test was conducted to determine the gender difference. Results showed no significant gender difference in any of the age groups indicating that development of phonetic accuracy is similar in both boys and girls. Figure 3 shows PPC in sentences in boys and girls across age groups and table 3 shows mean PPC, standard deviation (SD), subject size (n) and number of children who did not respond (no response) and ‘p’ value, ‘t’ value of independent ‘t’ test.

Table 3: Mean percentage of PPC, SD, subject size (n), NR (no response) and ‘p’ value of independent ‘t’ test in phonetic accuracy in sentence task

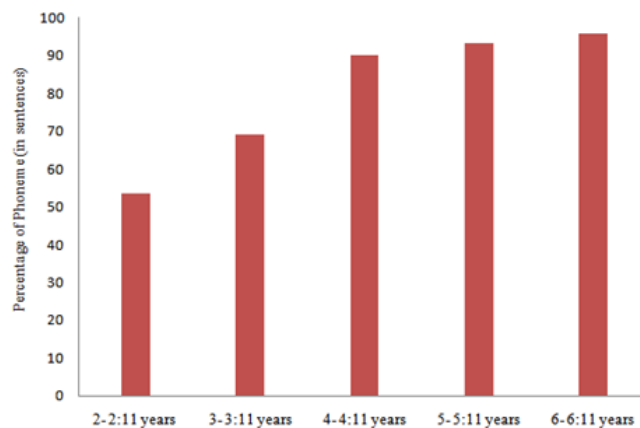
Childr en	2- 2:11 years (Group I)				3- 3:11 years (Group II)				4- 4:11 years (Group III)			5-5:11 years (Group IV)			6- 6:11 years (Group V)		
	N	N R	Mean %	SD	N	N R	Mean %	SD	N	Mean %	S D	N	Mean %	S D	N	Mean %	S D
<b>Boys</b>	19	5	47.7	26.7	21	1	69.4	15.6	17	89.2	7.4	19	92.5	2.4	17	95.4	2.6
<b>Girls</b>	11	5	67.0	13.9	9	-	68.8	18.1	13	91.2	4.0	11	94.3	3.3	11	96.6	1.8
<b>Total</b>	30	10	53.5	24.9	30	1	69.2	16.1	30	91.1	6.2	30	93.2	2.9	30	95.9	2.3
<b>‘p’val ue</b>	.069				.636				.143			.409			.281		

Figure 3: Percentages of phoneme correct in sentence in boy and girls across age groups.



**3.2.2. Group difference:** Mean values of PPC in sentences increased with age. Mean values of PPC of group I is 53.5%, group II is 69.2%, group III is 91.1%, group IV is 93.2% and group V is 95.9%. Figure 4 shows the mean values of PPC in sentences across age.

Figure 4: Percentages of phoneme correct in sentence across age groups.



### 3.3. Speech Intelligibility

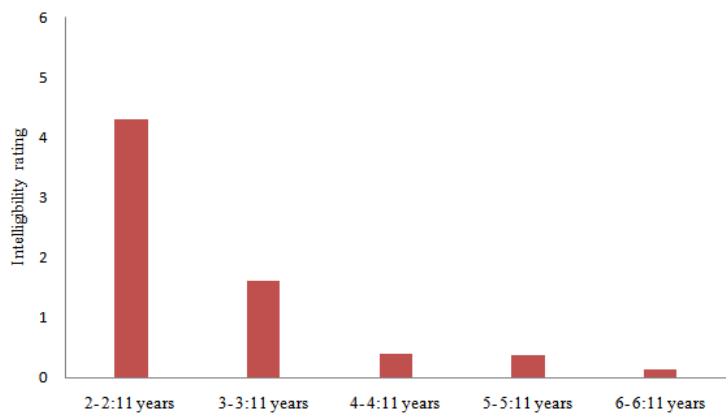
**3.3.1. Group difference:** Mean values of intelligibility using AYJNIHH rating scale for group I is 4.2, group II is 1.7, group III is 0.43, group IV is 0.36 and group V is 0.13 indicating mean values of intelligibility rating score increases with age. Figure 5 shows the mean values of intelligibility across age. Table 4 shows the mean and SD of overall intelligibility across groups.

Table 4: Mean & SD of overall intelligibility across groups.

Age groups	Mean Intelligibility scores	SD
2- 2:11 years	4.3	1.4
3- 3:11 years	1.6	1.0
4- 4:11 years	0.4	0.6
5- 5:11 years	0.36	0.55

6- 6:11 years	0.13	0.34
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Figure 5: Intelligibility rating of AYJNIHH across Group



Note: score ‘0’ indicate ‘normal speech’ and ‘6’ indicate ‘unintelligible speech’

Spearman rank correlation was used to find the correlation between PPC and speech unintelligibility. It was found that unintelligible speech has a strong negative correlation with PPC. This means speech intelligibility reduces with low PPC. Table 5 shows the results of correlation matrix between unintelligibility and variables.

Table 5: Correlation matrix between PPC and unintelligibility.

	<b>PPC sentence</b>
<b>Correlation coefficient for unintelligible speech</b>	-.719**

\*\*p<.01

#### 4. Discussion

Results revealed many interesting findings. First, PPC in sentences and words increased with age. Within groups, there was no significant gender difference for sentences and words. Mean values of PPC in words of group I is 69.8%, group II is 84.4%, group III is 93.4%, group IV is 95.2% and group V is 97.6%. Mean values of PPC in sentences of group I is 53.5%, group II is 69.2%, group III is 91.1%, group IV is 93.2% and group V is 95.9%. From these results it is evident that TD Tamil speaking



children acquire >50 % of PPC by 2 – 2:11 years and >90% of PPC by 4-4.11 years of age. Chin and Tsai (2002) found similar results that is 53.9% of word correct in English speaking 2 year old children. In consonance with the findings of the current study, Coplan and Gleason (1988); Pascoe (2005) and Flipsen (2006), reported that by 4 years of age children achieve speech intelligibility that is understandable to all listeners. Increase in PPC scores with age may be due to acquisition of new phonemes with age. Shakeela, Saleem&Hettiarachchi (2013) reported that Srilankan Tamil speaking children achieve 75% of speech sounds by 4 years of age and also stated that age has a significant influence on phoneme acquisition and on the suppression of phonological error patterns. Also, Sander (1972) found that English speaking children acquired new phonemes as age increases.

Second, using AYJNIHH rating scale it was found that mean values of speech intelligibility rating in sentences increased with age. Mean values of intelligibility of children of 2- 2:11 years is 4.2, 3- 3:11 years is 1.7, 4- 4:11 years is 0.43, 5- 5:11 years is 0.36 and for the older group children of 6:6:11 years is 0.13. In consonance with the findings of the current study, Chin and Tsai (2002) has reported that for English speaking children of 2 to 6 years speech intelligibility improved with age. Also, Lynch et al(1980); Bowen (1988); Flipsen (2006) has suggested that percentage of speech intelligibility increases with increase in age.

Third, unintelligible speech showed strong negative correlation with PPC. This means that with increase in speech intelligibility, PPC increases. This finding is in consonance with Masterson and Kamhi (1991) who reported PPC measure determines the overall speech intelligibility. Also, Hodge, Brown & Kuzyk (2012) found strong correlation between PPC and overall intelligibility rating for both word and sentence task.

## 5. Conclusion

The current investigation yielded important findings related to speech intelligibility. Present study recommends to use the normative obtained for the phonetic accuracy, and speech intelligibility in children between 2 and 6:11 years to assess the speech of children with speech sound disorder/communication disorders. Further it is recommended to use PPC during clinical evaluation of speech to obtain reliable information on speech intelligibility. The sentences, words and pictures developed in the study will be a useful tool in the assessment speech intelligibility of children with speech sound disorder.

Current study considered on development of phonetic accuracy and speech intelligibility and their correlation in TD children. Further research may focus on other factors influencing speech intelligibility including vowel space, prosody, phoneme duration, pause frequency, pause duration, formant frequency, formant bandwidth, and spectral balance in TD children in Tamil and other languages. Repetition task was used to study the factors of speech intelligibility. It is recommended also to use spontaneous speech/descriptive task to evaluate the factors of speech intelligibility. The study can also be replicated in other dialects of Tamil to analyze the factors related to dialectal differences in speech intelligibility.

## References

1. Bowen, C. Developmental phonological disorders: A practical guide for families and teachers, 1998, Melbourne: The Australian Council for Educational Research Ltd.

2. Chin. S. B & Tsai. P. L. Speech Intelligibility of Children with Cochlear Implants and Children with Normal Hearing: A Preliminary Report- research on spoken language processing,2002,Progress Report No. 25
3. Coplan. J.,& Gleason. J. R. Unclear speech: recognition and significance of unintelligible speech in preschool children. *Pediatrics*.1988, 82, 447-52.
4. Flipsen, P., Jr. Measuring the intelligibility of conversational speech in children. *ClinicalLinguistics & Phonetics*,2006,20(4), 202-312.
5. Hodge. M., Brown. C., &Kuzyk. T. Predicting Speech intelligibility scores of children with Dysarthria and Cerebral Palsy from Phonetic Measures of Speech Accuracy. *Journal of Medical Speech – Language Pathology*, 2012.
6. Kent, R., Weismer, G., Kent, J. &Rosenbek J. Toward phonetic intelligibility testing in dysarthria. *Journal of Speech and Hearing Disorders*,1989, 54, 482 -499.
7. Lau Wang Han. Development trajectories in toddler’s phonology: Implication for timing and Candidacy of intervention, 2010, A dissertation submitted in partial fulfillment of the requirements for Bachelors of Science (Speech and Hearing Sciences), The University of Hong Kong.
8. Lynch, J.I., Brookshire, B.L., & Fox, D.R. *A Parent - Child Cleft Palate Curriculum: Developing Speech and Language*, 1980, Tigard, OR: CC Publications.
9. Masterson, J., &Kamhi, A. The effects of sampling conditions on sentence production in normal, reading – disabled, and language- learning disabled children. *Journal of Speech and Hearing Research*, 1991, 34, 549-558.
10. Sander, E. K. “When are Speech sounds learned?”. *Journal of Speech and Hearing Disorders*, 1972, 37, 1, 55-63
11. Shakeela., Saleem., &ShyaminiHettiarachchi. Typical phonemic and phonological development of three year old Sri Lankan Tamil – speaking children in the Colombo district. *Annual Research Symposium*,2013, FGS, University of Kelaniya.
12. Shriberg, L., & Kwiatkowski, J. Phonological disorders I: A diagnostic classification system. *Journal of Speech and Hearing Disorders*. 1982,47, 226-241.