Chapter III

EXPERIMENTAL RESULTS

The introductory section has reviewed the studies of speech perception across languages and age groups. These studies (Burnham, O'Connor, Clark, & Earnshaw, 1985; Burnham, O'Connor, & Earnshaw, 1986) claimed that English subjects have better perception ability in the perception of the phonemic sounds than the non-phonemic sounds in their perception of bilabial stops. However, there are other factors which may effect the perception ability of the subjects i.e. age, second language learning, and the interstimulus interval (ISI) (the time between the first and the second sounds presented in a discrimination task given in duration terms). The perception ability of subjects varies among different age groups and there is a loss of perception ability of some age groups (Burnham, 1986.). Language learning could enhance subject's perception ability (William, quoted in Strange & Jenkins, 1978; Streeter & Landauer, 1976.).

Earlier litrature (Werker & Tees, 1984; Werker & Logan, 1985.) revealed that the interstimulus interval (ISI) can be used to examine the level of speech processing in speech

perception. The short ISI (500 ms) leads to the phonetic processing whereas the long ISI (1500 ms) leads to the phonemic processing. In the phonemic processing the subjects will process those sounds which are phonemically significant while in the phonetic processing, they will process any different sounds. Age, language learning, and ISI were taken into account in this experiment as the factors which may correlate to the subject's perception ability. It is expected that the results will show the enhancement of the subject's perception ability effected by age and amount of the exposure to a second language. And the subject's perception ability effected by different ISIs is also investigated. See details of Hypothesized DI scores in Table 2.2 (Between-Subjects Analysis) and 2.3 (Within-Subjects Analysis), and their explanations in chapter 2 at 2.5.2 page 39-47.

3.1 DISCRIMINATION INDEX (DI) ANALYSIS

3.1.1 Discrimination Index (DI) Measurement

This experiment used the Discrimination Index (DI) (see details in 2.5.1 *b* page 38) to measure the subject's discrimination ability. A mean score of +1 indicates perfect ability and a score of 0 indicates a chance discrimination while a negative score indicates erroneous responding. The scores which are close to +1 indicate a good discrimination ability of the subjects and the scores which are close to 0 indicate a bad or error discrimination ability.

3.1.2 Subjects' Discrimination Indices

The discrimination indices (DIs) of all the subjects were calculated. Each subject had 12 scores, one score for each of the 6 discrimination tasks of the sound pairs: (f-s), (f-θ), (f-ʃ), (s-θ), (s-ʃ), and (θ -ʃ). The discrimination tasks of the sound pairs were done at 2 different ISI levels: 500 ms and 1500 ms. The means of DI scores were calculated from those of the subjects' DI scores. The results of the subject's DI scores are shown in Table 3.1, 3.2, and 3.3. The abbreviations and terms used in the tables are:

1. Subject Group: 48 Thai children age 6 and 8 years, half of whom have English language experience, and the rest have only Thai language experience.

a. T-6 group: the subjects age 6 years old who are exposed to only Thai language.

b. T-8 group: the subjects age 8 years old who are exposed to only Thai language.

c. TE-6 group: the subjects age 6 years old who are exposed to both Thai and English language.

d. TE-8 group: the subjects age 8 years old who are exposed to both Thai and English language.

2. Sound pairs: the speech stimuli consist of six pairs of English voiceless fricative contrasts.

a. P- sound pair or Phonemic sound pair: the sound pair consists of 2 English fricative sounds (f-s) which are also

phonemically significant in Thai language i.e. both sounds are phonemic sounds in Thai language.

b. NP-sound pair or Non-phonemic sound pair: the sound pair consists of 2 English fricative sounds (θ -ʃ) which do not occur as phonemic sounds in Thai language i.e. both sounds are non-phonemic sounds in Thai language.

c. PNP-sound pair or Phonemic and Non-phonemic sound pair: there are 4 sound pairs which consist of both phonemic and non-phonemic sounds. They are (f- θ), (f-ʃ), (s- θ), and (s-ʃ).

Table 3.1 showed the discrimination indices (DIs) of the subjects' discrimination ability in the perception of all sound pairs at the 2 ISI levels, this table revealed overall DI scores of each subject group in the perception of all sound pairs at the 2 ISI levels. Table 3.2 showed the average values of the subjects' discrimination indices (DIs) in the perception of all sound pairs at the 2 ISI levels. The subjects' perception ability of each sound pair can be seen clearly from this table. Table 3.3 showed average values of the discrimination ability of each subject group in the perception of all sound pairs at the 2 ISI levels. The perception ability of each subject group at each ISI level can be easily examined from this table.

Table 3.1 The discrimination indices (DIs) of the subjects discrimination ability in the perception of all sound pairs

Language Experience x Age variables / Linguistic variables	ISI	Exposed to Thai language only (T-group)		Exposed to both Thai and English language (TE-group)	
		6 yrs	8 yrs	6 yrs	8 yrs
Phonemic pair f - s	500	.583	.292	.375	.333
	1500	.333	.25	.375	.417
Non-phonemic pair θ - ʃ	500	.875	.833	.917	.75
	1500	.875	1	.958	.917
Phonemic and Non-phonemic pair f- θ	500	.208	.042	.125	.125
	1500	-.04	0	-.08	-.04
f -ʃ	500	.708	.875	.625	.917
	1500	.875	.917	.75	1
s - θ	500	.292	.375	.458	.375
	1500	.25	.583	.208	.667
s - ʃ	500	.917	.917	.5	.958
	1500	.667	.917	.708	.792
All sound pairs	avg	.545	.583	.493	.601

Table 3.2 The average values of the subject's discrimination indices (DIs) in the perception of all sound pairs at 2 ISI levels

Sound pairs / ISI	P	NP	PNP				avg of all sound pairs at 2 ISIs
	(f-s)	(ɵ-ʃ)	(f-ɵ)	(f-ʃ)	(s-ɵ)	(s-ʃ)	
500 ms	.396	.844	.125	.781	.375	.823	
1500 ms	.344	.938	-.04	.886	.427	.771	
avg	.37	.891	.042	.833	.401	.797	.556

Table 3.3 The discrimination ability of each subject group at 2 ISI levels

Subject group / ISI	T-6 yrs	T-8 yrs	TE- 6yrs	TE- 8yrs
500 ms	.597	.556	.500	.576
1500 ms	.493	.611	.487	.626
avg	.545	.584	.494	.601

3.1.3 Discussions of the Subjects' Discrimination Indices

According to the tables, it can be viewed generally from the DIs scores in 3 points (1) the subjects' perception ability of each sound pair, (2) the effects of the exposure to English language and (3) the subjects' age as related to their perception abilities. The effect of the different ISIs on perception ability will be also explored.

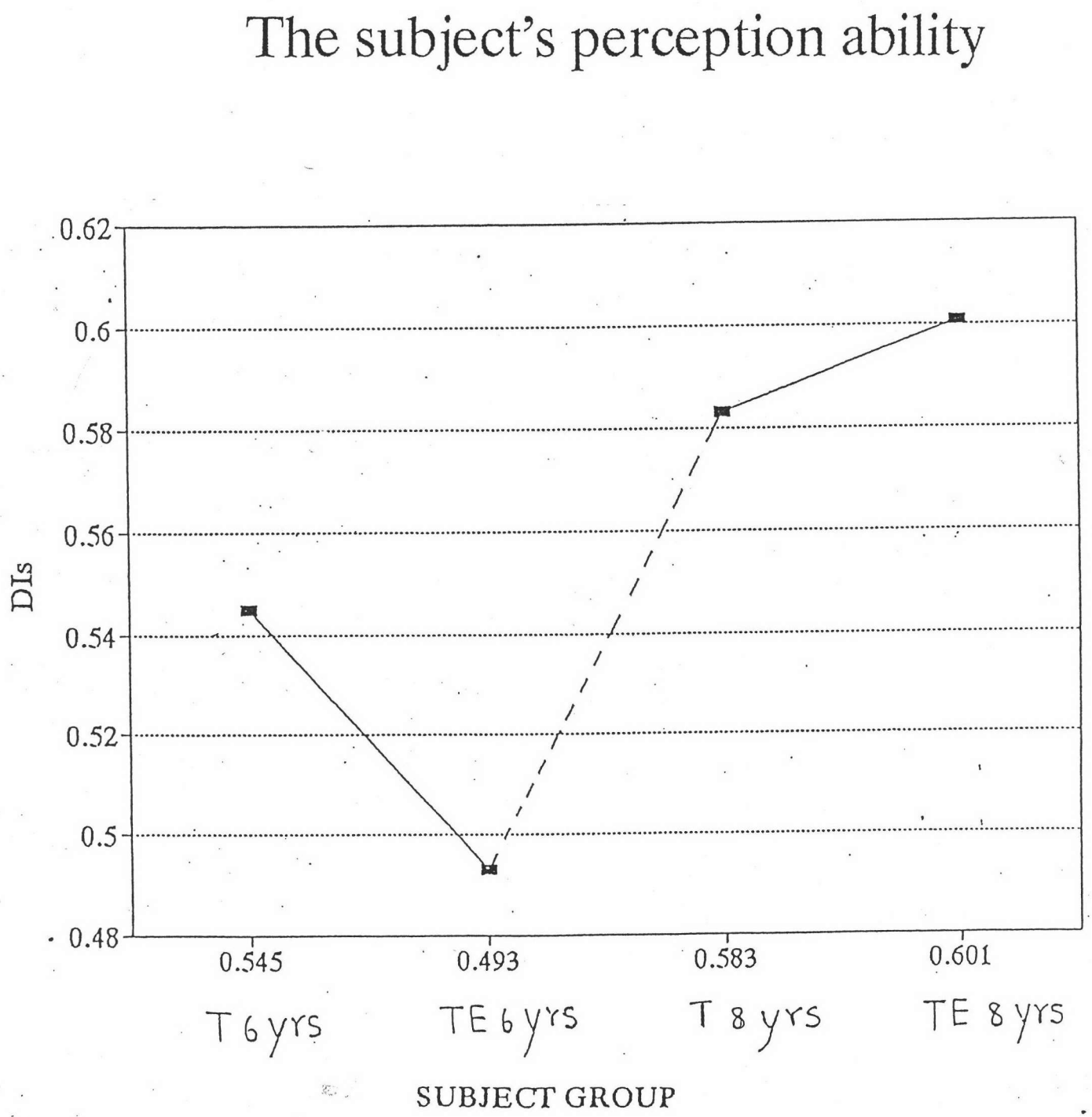
3.1.3.1 The Subjects' Perception Ability of the Sound Pairs:

The 3 kinds of sound pairs are the phonemic sound pair P: (f-s), the non-phonemic sound pair NP: (ɵ-ʃ), and the sound pairs of phonemic and non-phonemic sounds PNP: (f-ɵ, f-ʃ, s-ɵ, and s-ʃ). All of the subjects were able to discriminate all sound pairs. However, the best discrimination ability is in NP-sound pair instead of P-sound pair (see detail in Table 3.2). Within the PNP-sound pairs, it is apparent that the discrimination of the phonemic sound (f) and (s) contrasted with (ʃ) are better than when (f) and (s) are contrasted with (ɵ). It can be suggested here that in discrimination task, the acoustic properties of the sounds play an important role in the perception of sounds as well as the acquaintance of the subjects to the sounds used in the experiment (see detail in 3.2.2.2.1).

3.1.3.2 The Effect of Exposure to English Language and Age on Perception Ability:

The means of the discrimination indices (DIs) of the 4 subject groups averaged across sound pairs and ISI were given in Table 3.3. These means are presented graphically in figure 3.1. The results showed the best discrimination ability in the TE- 8 group as hypothesized. It can be concluded that English language experience enhances perception ability of English sounds. The DIs of the T- 8 group which was the next group who had good discrimination ability also help to confirm that age of the subject has an effect on the subject's perception ability, that is the children age 8 years will have the perception ability better than the children age 6 years. The T-6 group was the third group, and the worst group was the TE- 6 group. Since the result of the TE- 8 group showed the enhancement of the perception ability effected by the exposure to the English language, the worst discrimination ability of the TE- 6 group is interesting. The TE- 6 group should have had a discrimination ability better than the 2 subject groups who have no English language experience, however, the result of the TE- 6 group is quite unexpected. The result will be further discussed in detail in 3.2 below. There may be other factors which cause a failure of the perception ability of the TE- 6 group i.e. subject's age, the age to begin second language learning.

Figure 3.1


The subject's perception ability
0.62
0.6
0.58
0.56
0.54
0.52
0.5
0.48
DIs
0.545
0.493
0.583
0.601
T 6 yrs
TE 6 yrs
T 8 yrs
TE 8 yrs
SUBJECT GROUP

3.1.3.3 The Effect of Different ISIs on the Subjects' Perception Ability:

According to Table 3.3 which showed the subjects' perception ability on the different ISI levels, it is apparent that the discrimination ability of the 6 years old group in the ISI 500 ms is better than the discrimination in the ISI 1500 ms level. In contrast, the discrimination ability of the 8 years old group in the ISI 1500 ms level is better than their discrimination abilities in the ISI 1500 ms level. These results showed that age of the subjects may be related to their perception abilities at the different ISI levels.

3.2 STATISTICALLY SIGNIFICANT DIFFERENCES

The observations above are reviewed from the subjects' discrimination indices which are different in numbers. Among these different results, the statistically significant differences of the interaction between the effect of language experience, age and ISIs on the perception will be sought. Thus, analysis of variance was conducted on these data (DIs table). Refer to the details of the analysis of variance in 2.5.2 page 40, the analyses consist of the Between-Subjects Analysis and the Within-Subjects Analysis. The Between-Subjects Analysis compared the perception ability of the 4 subject groups with 2 different ages (6 and 8 years old) and 2 different language backgrounds (exposed to only Thai language and exposed to both

Thai and English languages). The Within-Subjects Analysis compared the discrimination ability of the subjects in their perception of each sound pair (6 sound pairs) at 2 different ISI levels (ISI 500 ms and 1500 ms). There were 3 comparisons in the Between-Subjects Analysis and 11 comparisons in the Within- Subjects Analysis (see table 2.2, 2.3 page 43, 44). The interactions of the 2 analyses were calculated. There were overall 14 comparisons and 33 interactions which were sought for the significant F value. The present experiment used the critical F ratio at the .05 level of significance. The degrees of freedom are 1 and 44.* Therefore, the critical F value for 1 and 44 degrees of freedom was 4.06. Thus, the F value of those comparisons and interactions which exceeds 4.06 is regarded as a significant F value or the difference is statistically significant.

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* Degrees of freedom: 1 is the degree of freedom of the meansquare between the groups and 44 is the degree of freedom of the meansquare within the groups.

3.2.1 Significant Differences of the Subjects' Discrimination Ability

There were 13 significant differences found in this experiment. Those significant differences were found only in the Within-Subjects Analysis and they are shown in Table 3.4. The significant results were listed into significant difference types with reference to the explanation of Table 2.2 and 2.3: Hypothesized DI scores in Between- Subjects Analysis and Within-Subjects Analysis in chapter 2 page 42-47 which the 12 significant difference types were given. The 6 significant types found in the experiment were (1) the perception of sound pairs, (2) the perception of sound pairs effected by age, (3) the perception of sound pairs effected by language experience and age, (4) the perception of sound pairs effected by ISI, (5) the perception of sound pairs effected by ISI and age , (6) the perception of sound pairs effected by ISI, language experience and age. The significant differences in each group were listed from the highest F value to the lowest F value. (the table of the analysis of variance of all data was shown in Appendix E).

Table 3.4 Significant difference types of the subjects' discrimination ability of sound pairs.

Table 3.4.1 The Perception of Sound Pairs

The perception of sound pairs	F value
c1: NP vs P and PNP sounds pairs	231.295
c4 : f-ɵ vs s-ʃ	214.342
c5: f-ʃ vs s-ɵ	44.866
c3: within 4 PNP sounds pairs	28.517
c2: P vs PNP sounds pairs	7.401

Table 3.4.2 The Perception of Sound Pairs Effected by Agec

The perception of sound pairs effected by age	F value
c1 x age: NP vs P and PNP sounds pairs x age	5.588
c2 x age: P vs PNP sounds pairs x age	4.613
c4 x age: f-ɵ vs s-ʃ x age	4.496

Table 3.4.3 The Perception of Sound Pairs Effected by Language and Age

The perception of sound pairs effected by language and age	F value
c1 x language x age: NP vs P and PNP sound pairs x language x age	5.967

Table 3.4. Significant difference types of the subjects' discrimination ability of sound pairs

Table 3.4.4 The Perception of Sound Pairs Effected by ISI c

The perception of sound pairs effected by ISI	F value
ISI x c3: ISI x within 4 pairs of PNP	7.799
ISI x c1: ISI x NP vs P and PNP	6.902

Table 3.4.5 The Perception of Sound Pairs Effected by ISI and Age -

The perception of sound pairs effected by ISI and age	F value
ISI x c5 x age: ISI x f-ʃ vs s-θ x age	8.857

Table 3.4.6 The Perception of Sound Pairs Effected by ISI, Language and Age t

The perception of sound pairs effected by ISI, language and age	F value
ISI x c3 x language x age: ISI x within 4 PNP sound pairs x language x age	4.718

3.2.2 Overall Significant Differences

Since the section 2.5.2 page 42 revealed that there were 2 analyses (Between-Subjects Analysis and Within-Subjects Analysis) of which the significant differences in this experiment have to be sought. The significant differences from both analyses would be reported and discussed below. The significant differences were found only in Within-subjects Analysis.

3.2.2.1 The Significant Differences in the Between-Subjects Analysis:

The Between-Subjects Analysis of this experiment compared the perception ability of the 4 subject groups. The factors are the difference in age and language background of the subjects which are hypothesized to play an important role in the subject's discrimination ability. It was aimed to examine the effect of language experience and age on speech perception. The hypotheses are (1) the perception ability of the subject groups who have English language experience should be better than the subjects who have no English language experience, and (2) the perception ability of the subjects age 8 years old should be better than the subjects age 6 years old. It was found that there was no statistically significant difference of the subjects' ability on discriminating English sound pairs in this analysis. Although there was no statistically significant difference between the subject groups, the DIs of the perception

of each subject group showed different DI scores (see Table 3.1 and 3.3). The TE-8 group had the best perception ability (0.601), next was the T- 8 group (0.583), followed by the T-6 group (0.545), and the worst perception ability was the TE- 6 group (0.493). The better perception ability of the TE- 8 and the T- 8 groups than that of the T- 6 and TE- 6 groups suggested that English language experience and age may have an effect on the subject's perception of the English sounds.

About the effect of age on the perception ability, it may be suggested here that the phonological bias to non-phonemic sounds, which has been noted to occur at around the time children begin to formally acquire language skills (Burnham, 1986), has effected the perception of the children age 6 years.

Burnham (1986) proposed that when the children begin to learn their language formally at around age 6 years, they will learn to segment speech sounds into phonemes and associate those phonemes with graphemes. The competence in language and segmentation skills will enable, and possibly forces, children around this age to use a phonemic processing strategy when listening to speech and have little capacity for phonetic processing, thus the perception ability of non-phonemic sounds was reduced. However, as children become more experienced at phonemic processing, it becomes more autometic and requires less attentional capacity. Thus, there will be an increase discrimination ability in older

children. The discrimination ability of the 8 years old group which is better than the discrimination ability of the 6 years old group in this experiment supported Burnham's theory on "Phonological Bias".

Although the effect of English language learning on the perception ability of English sounds was found only in the TE-8 group, the perception ability of the TE- 6 group is interesting. Instead of showing good perception ability, the TE- 6 group showed worst perception ability. It may be suggested here that learning a second language at the time that children begin to learn their language formally is inappropriate. The children may be confused with the phonemic sounds of both languages. Thus, the contribution of English language learning on the perception ability of the TE 6 group was not found. Therefore, it can be concluded here that the contribution of English learning on the perception ability may depend on several factors such as age of the subject, the method of learning or teaching, and the amount of exposure to the second language.

3.2.2.2 The Significant Differences in the Within-Subjects Analysis:

There are a total of 11 comparisons of the perception of sound pairs in Within-Subjects Analysis. The 11 comparisons are (1) one comparison of the perception at 2 different ISIs, (2) 5 comparisons of the perception of 6 sound pairs at ISI 500 ms,

(3) 5 comparisons of the perception of 6 sound pairs at ISI 1500 ms. And there are a total of 3 comparisons of the 4 subject groups in Between-Subject Analysis. There are a total of 44 interactions which are statistically tested. The 44 interactions comprise of (1) the 11 interactions of the perception at 2 different ISIs and the perception of 6 sound pairs at ISI 500 ms and at ISI 1500 ms, (2) the 33 interactions of the 11 interactions of the perception of 6 sound pairs at 2 different ISIs and the 3 comparisons of the 4 subject groups.

Out of the 44 interactions there are 13 interactions which are statistically significant. They can be grouped into 6 groups (see detail in Table 3.4 above). Including another interesting difference found in the perception of sound pairs in different groups of language experience, there are 7 topics to be reported and discussed in the following order:

1). The significant differences within the perception of each sound pairs

2). The differences of the perception of sound pairs effected by language experience

3). The significant differences of the perception of sound pairs effected by age

4). The significant differences of the perception of sound pairs effected by language experience and age

5). The significant differences of the perception of sound pairs effected by ISI

6). The significant differences of the perception of sound pairs effected by ISI and age

7). The significant differences of the perception of sound pairs effected by ISI, language experience and age.

3.2.2.2.1 The Significant Differences Within the Perception of Sound Pairs:

To compare the subjects' performances in the perception of each sound pair, 5 significant differences were found between the three kinds of sound pairs: (1) the phonemic sound pair P: (f-s), (2) the non-phonemic sound pair NP: (θ-ʃ), and (3) sound pairs of the phonemic and non-phonemic sound pairs PNP: (f-θ , f-ʃ , s-θ , s-ʃ).

According to the analysis of variance which uses the F value to indicate the significant difference of whatever which is compared. The significant difference is indicated by the degree of F value, the higher the value, the higher the degree of difference is. Thus, the significant differences within sound pairs are revealed as follow.

a). Subjects were significantly better at discriminating NP-sound pair than P- and PNP-sound pairs with $F_{(1,44)}$= 231.295, $p<.05$.

b). Comparing (f-θ) sound pair with (s-ʃ) sound pair, it was found a different significance. The subjects were much better at discriminating (s-ʃ) than (f-θ) with $F_{(1,44)}$ =214.342,

p<.05.

c). Comparing (f-ʃ) sound pair with (s- θ) sound pair, subjects were significantly better at discriminating (f-ʃ) than (s- θ) with $F_{(1,44)}$= 44.866, p<.05.

d). There were significant differences within the PNP-sound pairs: comparing between (f- θ, s-ʃ) and (f-ʃ, s- θ) sound pairs the subjects were significantly better at discriminating (f-ʃ, s- θ) than (f- θ, s-ʃ) with $F_{(1,44)}$= 28.517, p<.05.

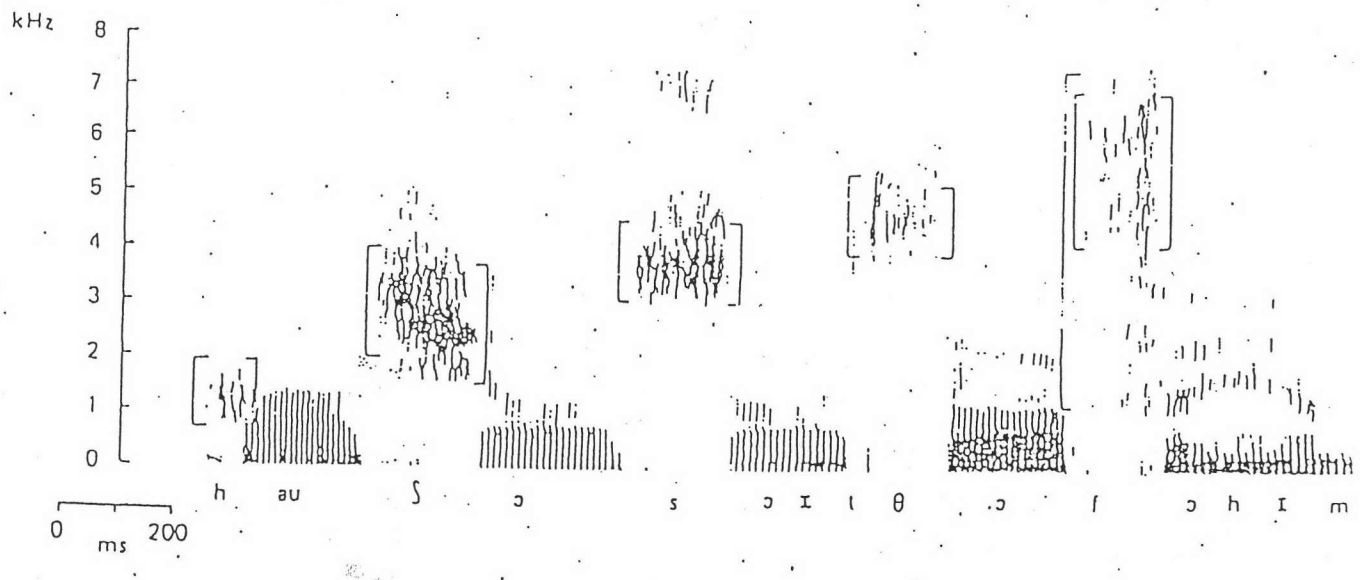
e). Comparing the perception of the P-sound pair and PNP- sound pairs, it was apparent that the subjects were significantly better at discriminating the PNP-sound pair than P-sound pair with $F_{(1,44)}$= 7.401, p<.05.

The children in this experiment were able to discriminate all sound pairs. This finding supports previous perception studies that human beings have the ability to perceive all sounds, even those sounds that are not used in their language. (Eilers, Gavin, & Wilson, 1979; Lasky el al., 1975; Streeter, 1976). However, the ability to perceive each sound pair was different. It was apparent that the result of the significant differences within sound pairs showed good perception ability in the sound pairs with the non-phonemic sound (ʃ) as the member of the pair. Thus, Thai children's discrimination ability of non-phonemic sound pair [NP] was better than the discrimination ability of the phonemic sound pair [P] and the phonemic and

non-phonemic sound pairs [PNP].

Since the results of the perception of each sound pair was different from the hypothesis, which expected that subjects would discriminate the phonemic sound pair better than other sound pairs. The hypothesis on the better perception of phonemic sounds was not supported. The discrimination of fricative sounds may depend partly on the acquaintance of the subjects with the sound used in the test, and partly on the physical properties of the sounds. The physical differences of the sounds which were contrasted in those sound pairs may have a major role in the discrimination task. The explanation of the physical differences of the sound pairs has already been referred to in section 1.5.5.2 (Cues to Fricative Place of Articulation). Heinz and Stevens (1961) suggested that there is a general filtering rule to differentiate fricative sounds. The sounds which have large front cavity in productions will also have low frequency. And the frequency will increase when the front cavity becomes smaller. The front cavity also indicates the energy and intensity friction of the sound produced, the sound which has more large front cavity will has more energy and intensity friction. (see Figure 4.1, the spectrograms of English fricatives which showed the rising frequency as the front cavity becomes smaller.) It is clear that /h, θ, and f/ in English have low intensity as opposed to /s and ʃ/.

Figure 3.2 Fricative Spectogram



Spectrogram of a special phrase having a series of fricative consonants going from large to small front cavity. The main resonant frequencies of the fricatives are bracketed and are seen to rise in frequency as the front cavity becomes smaller and smaller.

From Pickette (1980).

Harris (1958) indicated that high intensity friction of the (s) and (ʃ) made listeners perceived them correctly independent of information from the transition to the adjacent vowel, but on the perception of (f) and (θ), the listeners need both the friction cues and the transitions into neighboring vowels to determine the place of articulation of (f) and (θ). The low intensity friction of (f) and (θ) accounts for the difficulties that listeners have in identifying them out of the context. Thus, it seems that the intensity friction or energy of each fricative sounds is important for discriminating fricative sounds. Fricative sounds as (ʃ) and (s) which have low and mid frequency and high intensity friction were better differentiated than (f) and (θ) which acquire higher frequencies and lower range of intensity friction.

Since the present experiment used the discrimination task, the listeners had to discriminate the two sounds which were compared and their responses would be same or different, it is hypothesized here that the property of sound such as intensity friction, and frequency of fricatives, have an effect on the perception ability of fricative sounds. The difficulty to discriminate sound pairs also depend on the differences between the physical properties of the two sounds contrasted. According to Table 3.5, all high scores of the perception abilities were found in the sound pair which one of its sounds was (ʃ). The perception ability of sound pairs was presented

graphically in Figure 3.3.

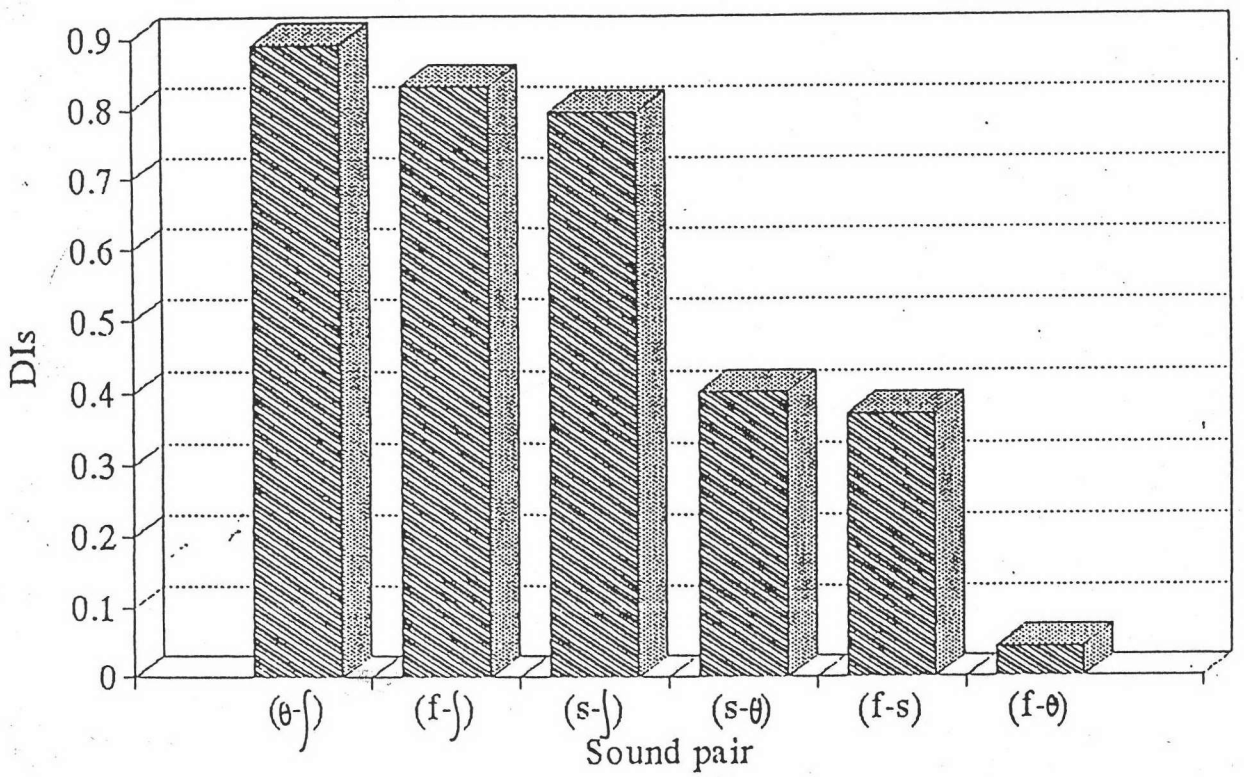
Table 3.5 The perception ability of sound pairs

sound pairs	discrimination scores
θ -ʃ	.891
f-ʃ	.833
s-ʃ	.797
s- θ	.401
f-s	.37
f- θ	.042

According to the results in this experiment, it seems that when (ʃ) was contrasted with other sounds the listeners' ability to perceive those sound pairs was better. In other words, it seems that the highest energy and highest intensity friction of (ʃ), make (ʃ) more prominent than the rest 3 sounds, thus listeners were able to discriminate it from the others

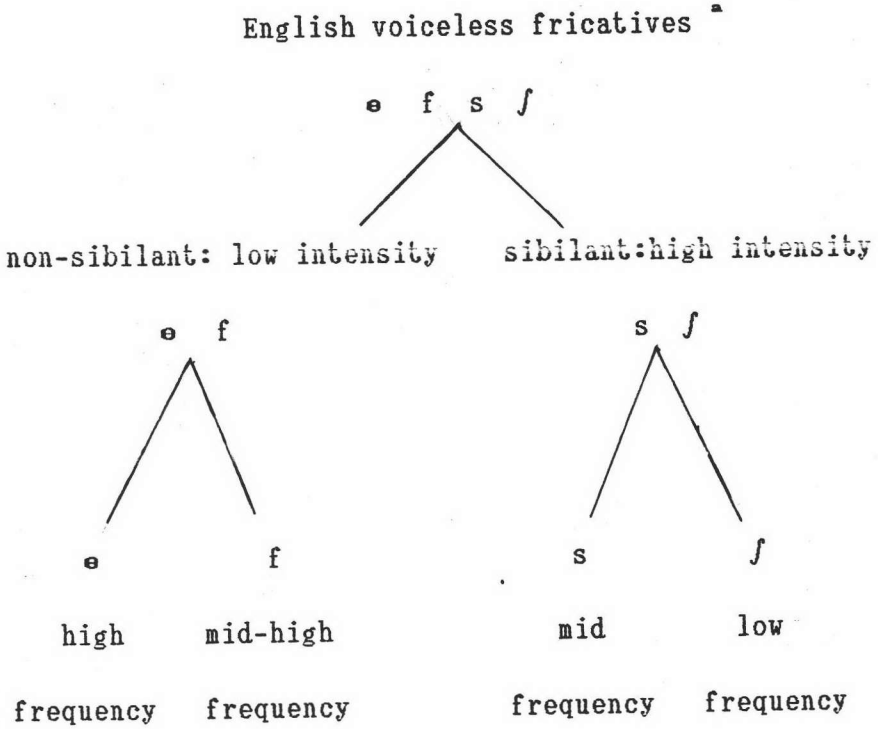
Figure 3.3

The discrimination ability of all sound pair



easily. Refer to the acoustic features for fricative sounds used in this experiment in Figure 1.1, in order to explain the experimental results in the perception of each sound pair easily, Figure 1.1 was rewritten in Figure 3.4 below.

Figure 3.4 Acoustic features of fricative sounds



* fricative sounds used in the experiment

The relationship between the fricatives and the acoustic features in the Figure is given as follow:

1. low energy and low intensity friction for (θ,f), and high energy and high intensity friction for (s,ʃ). (the low and high values were shown from left to right.)

2. high frequency for (θ,f), mid frequency for (s), and low frequency for (ʃ). (the high and low values were shown from righ to left.)

Considering the perception ability of each sound pair from the highest scores to the lowest scores with reference to the data in Table 3.5 and Figure 3.4, it was found that the discrimination scores were related to the difference between the members of each sound pair. Three best discrimination abilities were found in the sound pairs with /ʃ/ as a member (DI 0.891 in (θ-ʃ), DI 0.833 in (f-ʃ), and DI 0.797 in (s-ʃ)). The sound /ʃ/ has high intensity and lowest frequency among the set of sounds used in this experiment. It seems that the 2 features make its physical properties very prominent and can be well discriminated when compared to any other fricatives. The next 2 best discrimination abilities were found in the sound pairs with /s/ as a member (DI 0.401 in (s-θ), and DI 0.37 in (f-s)). The sound /s/ has high intensity and mid frequency as opposed to /θ/ and /f/ which are contrasted, /s/ also belongs to the high intensity set of fricatives (see Figure 4.3). High intensity fricatives, /ʃ/ and /s/ in this experiment, seems to be very distinctive when compared with low intensity fricatives. The worst discrimination ability was found in (f-θ) sound pair (DI 0.042). The sounds /f/ and /θ/ both belong to the low intensity set of fricatives and both of them also have high frequencies.

They are not very distinctive from each other so the discrimination task is found most difficult.

It is natural that the more the two sounds contrasted are different, the easier the discrimination task is. Thus, it can be concluded here that the different results of the subject's perception ability of each sound pair are partly effected by the acoustic properties of the sounds used as stimuli.

3.2.2.2.2 The Difference of the Perception of Sound Pairs Effected by Language Experience:

There was no statistically significant difference effected by language experience on subjects' performances of the perception of each sound pair. According to Table 3.3, the result showed the best subjects' perception ability in the TE- 8 group indicated that there was a contribution of English learning on the perception of English sound pairs. However, it was expected that there would be the effect of English learning on the subject's perception ability of English sounds in both age groups which have been exposed to English language. The effect of the English learning in the perception test was found only in the TE- 8 group. In contrast, the perception ability of the TE- 6 group compared with other groups was the worst group. This indicated that the subject's age related to the effect of English learning on the subjects' perception

ability.

3.2.2.2.3 The Significant Difference of the Perception of Sound Pairs Effected by Age:

The effect of age on subject's perception ability will be discussed as follows:

a). Age of the subject may have an effect on the subject's performances on the comparison of NP-sound pairs versus the P- and PNP-sound pairs. Both 6 and 8 years old groups were significantly better at discriminating NP-sound pair than P- and PNP-sound pair with $F_{(1,44)}= 5.588$, $p<.05$. And the 8 years old group showed better perception ability than the 6 years old group.

b). To compare the effect of age at discriminating (f-θ) and (s-ʃ) sound pair, a significant difference was found with $F_{(1,44)}= 4.496$ $p<.05$. The subjects discriminate (s-ʃ) better than (f-θ) sound pair.

It was apparent that the 8 years old subjects had better discrimination ability than the 6 years old subjects. This indicated that the perception ability developed with age.

The discrimination ability of the 6 year olds which is lower than the 8 year olds may be effected by the Phonological Bias to non-phonemic sounds of the 6 year olds, Phonological Bias has been noted to occur at around the time the children start to read and write their own language (Burnham, 1986). When children begin to learn their own language, they will learn

to read and reorganise the written form. They will develop their segmentation skills and become more aware of phonemes in language. In learning to read, children require attention to significant sounds in their own language for their phonemic processing. Thus, children age 6 years old tend to use a phonemic processing to listen to sound pairs. As a result, they will have better perception ability of phonemic sounds than non-phonemic sounds. Since the sounds used in this experiment are all English sounds and actually are non-phonemic sounds for them, they would have more difficulty to discriminate them. However, as children are older they will have more experience of phonemic processing, the phonemic processing becomes more autometic and requires less attention. In this way, there is an increase perception ability of non-phonemic sounds in the older children.

3.2.2.2.4 The Significant Difference Effected by Language and Age:

Although there was no significant difference effected by language on each sound pair, there was a significant difference effected by language and age. Comparing the DIs between the three kinds of sound pairs: P-, NP-, PNP- sound pairs effected by language and age, significant difference with $F_{(1.44)}=5.967$, $p<.05$ was found. The high and low scores of the perception ability of each sound pair were used to indicate the

difficulty or the easiness to discriminate those sound pairs. As mentioned in 3.2.2.2.1 that the (θ) and (ʃ) are much different in intensity, this (θ-ʃ) sound pair will be easily discriminated. Since, the physical properties of the sound and the physical differences between the sounds has overuled the subject's perception ability, it was found that the perception of the NP-sound pair in this experiment was better than the perception ability of the P- and PNP-sound pairs.

The result of the perception of all sound pairs also showed the effects of English learning and age on the perception ability. As mentioned in the 3.2.2.2.3 that age is a factor which has an effect on the subject's perception ability, so the 8 years old group has better discrimination ability than the younger subjects as was expected. However, the effect of age when related to the effect of language learning is interesting. According to Table 3.3 and figure 3.1, the result showed the contribution of the exposure to second language on the subjects' perception ability only in the TE- 8 group. It supported Streeter & Landauer (1976), and William (1974) that the perception ability can be improved by exposure to second language learning. However, there is no contribution of English language learning on the perception ability of the TE- 6 group. The unexpected result of the perception of the TE- 6 group may be effected by the confusion of the subjects themselves due to learning second language i.e. at the time when they start to

learn to read and write their own language.

It was reported that in learning a language, those sounds which are relevant in that language become more clearly defined and reorganised into phonemes (Werker & Tees, 1984a) and the sounds which are not relevant are ignored. It was found in earlier literature that children age 6 years old paid relatively more attention to the phonologically relevant sounds than the children age 4 and 8 years old (Burnham, Earnshaw, & Quinn, 1987). This phenomenon was referred to as Phonological Bias (Burnham, 1986). The theory is that Phonological Bias may reduce the perception ability of subjects at certain age in the perception of non-phonemic sounds. The result of the present experiment shows Phonological Bias of the children age 6 years old that they had lower discrimination ability than the children age 8 years old and had better discrimination ability in the ISI 500 ms (phonetic processing) than the ISI 1500 ms (phonemic processing). As revealed in the literature that exposure to English language could enhance the perception ability of English sounds. The result of this experiment showed the contribution of English language only on the perception ability of the TE- 8 group, it is possible that the unexpected result of the TE- 6 group is effected by the confusion of starting to learn two languages at the same time. Age 6 is a critical age, it is the time when children begin to learn their own language formally, they require phoneme segmentation skill

for their learning of their own written language, and thier attention direct to the phonologically relevant sounds. If they also have to learn a foreign language at the same time as formal language, their attention which has been directed to their own language may cause a bias to their learning of a second language. This may cause the confusion of the phoneme segmentation of both languages, and may effect their perception ability. Thus, it may be assumed that age 6 is an inappropriate age to begin to learn a second language. This finding confirms the theory by previous research works.

Considering previous research works on the perception of stops (Streeter & Landauer, 1976; William, 1974), which reported that one year experience of English language could enhance the Kikuyu subjects' perception ability in discriminating synthetic English stops, the result of this experiment is different. The contribution of English language on the perception ability of the TE- 6 group was not found. The difference between the research works aforementioned and the present experiment is the age of subjects i.e. 7.5-14 years in the previous studies and 6-8 years in this experiment. It is possible that second language experience plays a role in the achievement of second language learning, especially, after the Critical Age 6.

3.2.2.2.5 The Significant Difference of the Perception of Sound Pairs Effected by Interstimulus Interval (ISI) :

There was no significant difference of all subjects' performances between the ISI 500 ms and 1500 ms but the effects of ISI on the perception ability of some sound pairs were found.

a). There was a significant difference effected by ISI on the comparing of the 4 pairs of PNP-sound pairs with $F_{(1,44)} = 7.799$, $p<.05$. The subjects had better discriminating on (f-ʃ, s-ɵ) than (f-ɵ, s-ʃ) sound pairs. The perception ability of the first two sound pairs (f-ʃ, s-ɵ) is better in the ISI 1500 ms than in the ISI 500 ms. And the perception ability of the second two sound pairs (f-ɵ, s-ʃ) is better in the ISI 500 ms than in the ISI 1500 ms.

b). A significant difference effected by ISI on the comparing of the three kinds of the P-, NP-, PNP-sound pairs with $F_{(1,44)} = 6.902$, $P<.05$ was also found. It was apparent that the subjects had better discrimination ability on the NP-sound pair than P- and PNP-sound pairs at both ISI 500 and 1500 ms.

In order to see the result of the perception ability of sound pairs effected by ISI clearly, Table 3.6 and 3.7 are given below (cf. Table 3.1). And the subjects' perception abilities at different ISIs were shown grapically in Figure 3.5 (cf. Table 3.6).

Table 3.6 The subjects' discrimination ability of the PNP sound-pairs at different ISI levels -

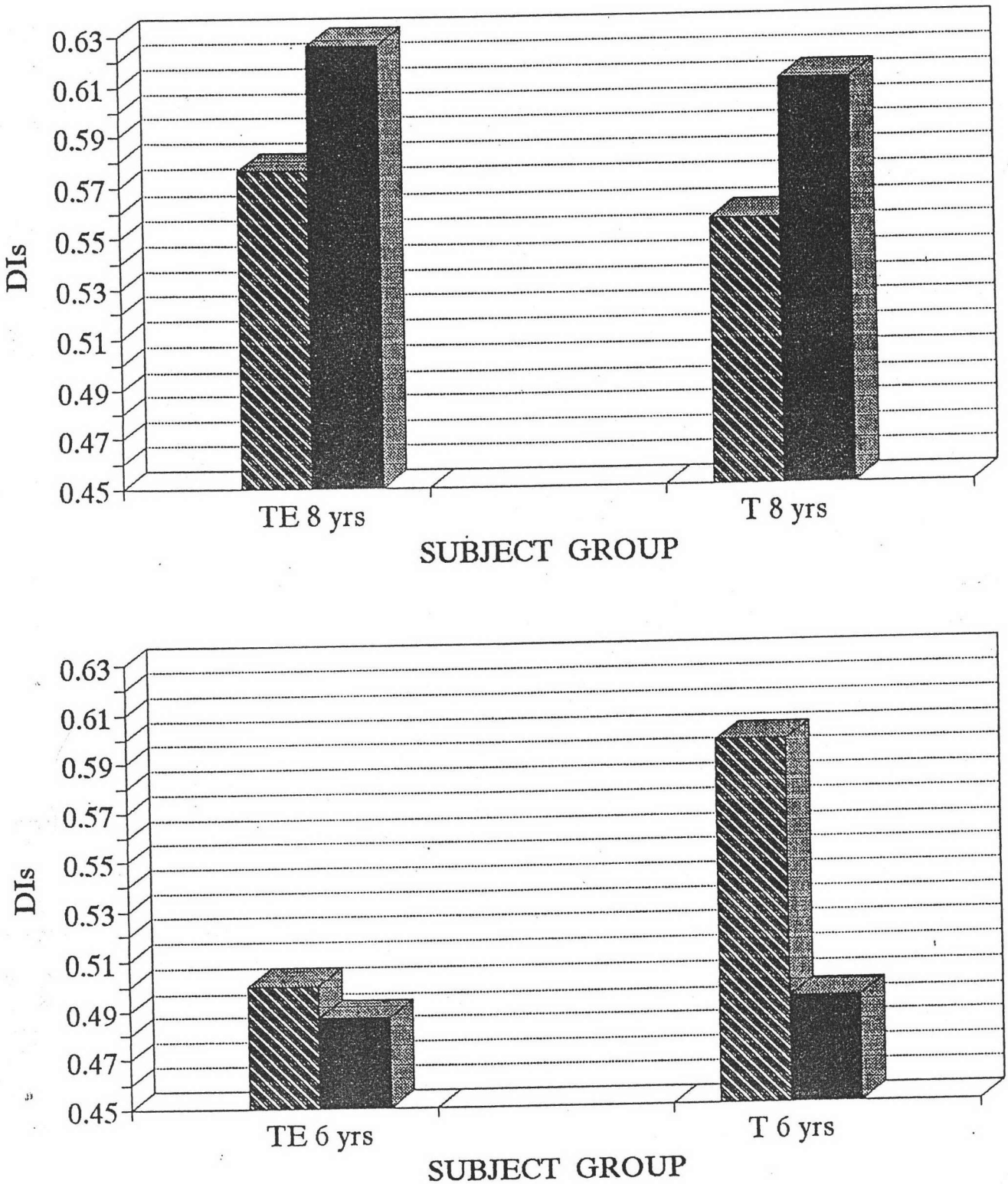
ISI / Subject group	500 ms	1500 ms
T-6-year-olds	.531	.438
T-8-year-olds	.552	.604
TE-6-year-olds	.427	.396
TE-8-year-olds	.593	.604
avg	.525	.510

Table 3.7 The subjects' discrimination ability of the P, NP and PNP sound pairs at different ISI levels

ISI / Subject group	500 ms	1500 ms
T-6-year-olds	.597	.493
T-8-year-olds	.556	.611
TE-6-year-olds	.5	.487
TE-8-year-olds	.576	.626
avg	.557	.554

Figure 3.5

SUBJECTS' PERCEPTION ABILITY AT DIFFERENT ISIs



Although the subjects' perception abilities of each sound pair in the three kinds of sound pairs: P-, NP-, PNP- sound pairs which were mentioned in (a) and (b) are variously different, the effect of ISI is similar. According to Table 3.6 and 3.7, the result showed that the mean DIs of all subjects perception in the ISI 500 ms is better than the perception ability in the ISI 1500 ms. Thus, the claim in the earlier litratures (Werker & Tees, 1984; Werker & Logan, 1985), which proposed that in the phonetic processing at ISI 500 ms subjects could discriminate more sounds than at the phonemic processing at ISI 1500 ms, was supported.

3.2.2.2.6 <u>The Significant Difference of the Perception of the Sound Pairs Effected by ISI and Age</u>:

There was a significant difference effected by ISI and age on the comparing of (f-ʃ) and (s-ɵ) sound pairs with $F_{(1,44)}$= 8.857, $p<.05$. Both 6 and 8 year olds had better perception ability on (f-ʃ) than (s-ɵ), and the 8 year olds had better perception ability of both sound pairs than the 6 year olds. The average values of the 6 and 8 year olds' discrimination ability of the (f-ʃ) and (s-ɵ) showed the effect of ISI and age on the subject's perception ability of (f-ʃ) and (s-ɵ). The discrimination ability of the 8 year olds in the ISI 1500 ms is better than in the ISI 500 ms: the scores were 0.791 and 0.635. In contrast, the discrimination ability

of the 6 year olds is equal in both ISIs with the 0.5207 score.

3.2.2.2.7 The Significant Difference of the Perception of Sound Pairs Effected by ISI, Language Experience and Age:

It was found that there is a significant difference of subjects' performances on the perception of the 4 PNP-sound pairs (f-θ, s-ʃ) and (f-ʃ , s-θ), and the perception was effected by ISI, language experience and age with $F_{(1,44)}$= 4.718, $p<.05$. According to Figure 1.1, the acoustic features of fricative sounds, it may be suggested here that the listeners use the intensity friction, and the frequency of fricative sounds to discriminate fricatives. The perception ability of these four sound pairs reported in this study helps to confirm this proposal. The subjects' performances of the sound pairs (f-ʃ) and (s-θ) were better than (f-θ) and (s-ʃ) on both ISI levels. In the first two sound pairs (f-ʃ) and (s-θ), the sounds which were members of the pair had much difference in intensity friction and frequency. These differences made the listeners' discrimination tasks easier. In contrast, the sound pairs (f-θ) and (s-ʃ) comprised of the sounds which are not much different as compared to the (f-ʃ) and (s-θ) group. The listeners would have more difficulty to discriminate them than the (f-ʃ and s-θ) sound pairs.

The effect of English learning on the subjects' perception ability is similar to the result of the perception

of the three kinds of sound pairs which was mentioned in 3.2.2.2.4 that the contribution of English learning on the discrimination ability of the subjects was found only in the TE-8. And the 8 years old subjects had discrimination performances of these sound pairs better than the 6 years old subjects. According to Table 3.7, the result of each age group at different ISI levels is interesting. Table 3.7 showed that the discrimination ability of the 8 years old group at ISI 1500 ms is better than at ISI 500 ms whereas the discrimination ability of the 6 years old group at ISI 500 ms is better than at ISI 1500 ms.

The interpretation is that when children age 6 years old start to learn their own language formally, they will focus only on their language due to their Phonological Bias (Burnham, 1986). They will use phonetic processing strategy when listening to foreign sounds and they will have less ability to do phonemic processing. However, when they have opportunity to relinguish the phonemic processing strategy to the phonetic processing strategy as in the ISI 500 ms, thus the perception ability of the subjects age 6 years old at the ISI 500 ms level is better than ISI 1500 ms level.

This helps to confirm the proposal which proposed that the ISI 500 ms would evoke better discrimination than the ISI 1500 ms, as the smaller ISI should induce a phonetic mode of processing (Werker & Logan, 1985; Werker etal.,1986).

In summary, the significant differences found in this experiment can be concluded into 4 topics as follow:

1). the subjects' perception ability of sound pairs which is dependent on the physical properties and the physical differences of the sounds used as stimuli.

2). The subjects' perception ability effected by language background which isalso related to age and the amount of exposure to English language.

3). the subjects' perception ability effected by age.

4). the subjects' perception ability effected by ISI related to age.