

Chapter II

THE EXPERIMENT

There are two tests in the present study; speech perception test and non-verbal intelligence test.

a). Speech perception test

The speech perception test is designed to test two groups of Thai children: Thai group (T) and Thai and English group (TE). The subjects in Thai group are exposed to only Thai language and subjects in Thai and English group are exposed to both Thai and English languages (one year and 3 years of Thai and English learning). For each group half of the children are 6 years old and the other half are 8 years old. Equal number of males and females were tested in each sub-group. All of the subjects were tested on both ISI conditions, 500 ms and 1500 ms levels, and all subjects were tested on all 6 sounds pairs i.e. (f-s), (f-e), (f-f), (s-e), (s-f), (e-f). There are 4 Test trials of each sound pair: 2 Same and 2 Different trials. The first sound is similar to the second sound in Same trial and the first sound is different from the second sound in Different trial.

b). Non-Verbal intelligence test

Non-verbal intelligence test was used to match subjects across language groups. This matching was done to ensure that the subjects in the Thai group (T) and in the Thai and English (TE) group which came from 2 different schools did not differ initially in intelligence.

The intelligence score was the number of items correct on the Raven's Coloured Matrices task.



2.1 SUBJECTS

Four classes of students who were students in Prathom one (Grade 1) and Prathom three (Grade 3) from Anubal Nakhorn Pathom school and Anubal Sutheethorn school participated in this experiment. Letters outlining the research were sent to the school principals, requesting that data could be collected from the students.

The subjects were first tested on the non-verbal intelligence test to match their intelligence and then they were selected to do the speech perception test. One hundred and forty-one subjects (T 6 years old, T 8 years old, TE 6 years old, TE 8 years old) were tested on the non-verbal intelligence test. (See raw scores of intelligence test in Appendix) The scores of all the subjects were tallied to find the mode of the scores. It was found that the score between 16 and 33 was the range of the mode: 16 to 23 scores were the mode

of the subjects age 6 years old and 25 to 33 were the mode of the subjects age 8 years old. The subjects with their scores lesser or more than the range of the mode were not used. The mode of the scores were converted to percentage by multiplying by 100 and divided by the number of the pictures completed by the subjects (36) which meant that the subjects age 6 years old acquire 44.4 % to 63.8 % and the subjects age 8 years old acquire 69.4% to 91.6 % of intelligence scores were selected to be tested on the speech perception experiment. Since the speech perception test need only 48 children to do the test, some of the children had to be excluded. It was found that the upper scores of the children age 6 years old were approximately between 50-70 % and of the children age 8 years old were 70-90%. Thus, the children age 6 years who acquired scores less than 50% were excluded and the children age 8 years who acquired scores less than 70 % were also excluded. The rest were 97: TE-8 = 32, T-8 = 26, TE-6 = 17, T-6 = 22. Out of this number only 48 children were randomly selected to do the speech perception test, 24 were from Anubal Nakhorn Pathom school and acted as the subject group which are exposed to only Thai and 24 were from Anubal Sutheethorn school and acted as the subject group which are exposed to both Thai and English. There were equal numbers of males and females in each sub-group. Mean ages of each age group were 6.5, 8.2 years. All subjects are Thai speaking children

and have normal hearing. The mean intelligence test scores of the selected children were 19.2 of the Thai 6 group and 19.4 of the Thai and English 6 group and 25.8 of the Thai 8 group and 27.5 of the Thai and English 8 group. The non-verbal intelligence scores of the selected subjects were presented in table 2.1.

2.2 APPARATUS AND MATERIALS

2.2.1 **Speech Perception Test:** The speech perception test was carried out in a quiet place in the subjects' school. The test was conducted using a Toshiba 3100E Laptop computer converted to allow digital to analogue (D-A) conversion. The programme controlling the experiment was written by the School of Psychology, The University of New South Wales. The apparatus attached to the computer is described below:

a) A response box : On the response box there were three transparent keys, the 'home' key and two 'response' keys, and also a set of reward lights. The 'home' key or 'ready' key allowed the subject to start trials. The 'response' keys were the 'same' and the 'different' key which the subject used to respond whether the sound pairs presented were the "same" or "different". Light globes were located under the keys and were used to illuminate the keys at different times throughout the procedure. The reward lights were small different coloured lights which would illuminate when the subject

made a correct response. All of the parts of the response box served as digital inputs to or outputs from the computer.

Table 2.1 Non-verbal Intelligence Scores of the Subjects

SUBJECT GROUPS			
Exposed to only Thai [T]		Exposed to both Thai and English [TE]	
6 yrs	8 yrs	6 yrs	8yrs
22	30	20	29
19	31	20	29
24	30	23	31
22	30	24	30
21	31	18	33
22	28	22	29
21	29	20	29
22	28	22	29
19	27	22	29
18	26	18	28
18	29	18	30
23	33	23	31
avg 19.2	25.8	19.4	27.5

b) A set of headphones: The speech stimuli were presented through a set of headphones attached to the A-D conversion board of the computer.

c) A control button: A separate input which enabled the experimenter to initiate each trial and to stop the experiment if the subject became tired or fussy was attached to the response box. The Toshiba 3100E controlled the presentation and timing of the speech stimuli, and the response box. Data was also recorded and stored by the computer on hard disk.

2.2.2 Non-Verbal intelligence test: Raven's coloured Progressive Matrices (1977) (set A, Ab, B) were used to measure intelligence. The test consisted of several coloured pictures. In each picture a part was missing with the correct part being included in six choices under that picture. The procedure to test and score followed the accompanying Manual for Raven's Progressive Matrices (1977). See detail of Non-Verbal intelligence test in Appendix.

2.3 STIMULI

The speech stimuli were 4 voiceless English fricative sounds i.e. [f], [s], [θ], and [ʃ]. These sounds were constructed into 6 sound pairs namely (f-s), (f-θ), (f-ʃ), (s-θ), (s-ʃ), and (θ-ʃ). Although fricative sounds can be independently produced without vowels, this experiment has

chosen to use non- word syllables with initial fricative with the vowel [a:] following each consonant and with falling intonation i.e. [fa:ʰ], [sa:ʰ], [ɛa:ʰ], and [fa:ʰ]. These non- word syllables with falling intonation would make the stimuli more like English words and make the discrimination task more real to the children. The speech stimuli were spoken by a native English speaker and then digitised and stored in diskettes. Two examples of each sound were recorded, making a total of 8 speech sounds. The purpose of having various examples was to encourage a phonetic mode of processing rather than an acoustic mode. This is to ensure that phonetic features are used for perceptual discrimination and that possible idiosyncratic features of sounds do not provide clues for discrimination. The speech sounds were:

- a) Phonemic contrast: a phonologically relevant contrast in the Thai language ([fa:]-[sa:]);
- b) Non-phonemic contrast: a phonologically irrelevant contrast in the Thai language ([ɛa:]-[fa:]);
- c) Phonemic and Non-phonemic contrasts: pairs of phonologically relevant sounds and irrelevant sounds in the Thai language ([fa:]-[ɛa:], [fa:]-[fa:], [sa:]-[ɛa:], [sa:]-[fa:]). The computer was programmed to randomly select any of the examples of each sound for any particular contrast. Each contrast was presented in two types of interstimulus interval; the second sound was presented 500 or 1500 ms after the

first sound was presented.

The stimuli used in the practice phase were two Thai words: /mi:ʎ/ and /dek ʎ/ which were presented in two same and two different trials. As the words /mi:ʎ/ and /dek ʎ/ have different phonological structure i.e. open and closed syllables, different initial consonants: [m] and [d], different vowels: [i:] and [e], and different tones: [ʎ] and [ʎ]. The children would have no difficulty in discriminating them and will become accustomed to the speech perception test. An easy beginning task would help to encourage the children to do the test.

2.4 RUNNING THE TEST

All of the subjects were tested on the intelligence test for matching across language groups. The forty-eight subjects for the four groups were selected by determining their intelligence scores. Only selected subjects were then tested on perception test. Both tests were conducted at the subjects' schools.

2.4.1 Intelligence Test

The test consisted of several coloured pictures in which each picture one part was missing. The subject chose the correct cut out from the choices under that picture. The test took approximately 15 minutes to administer.

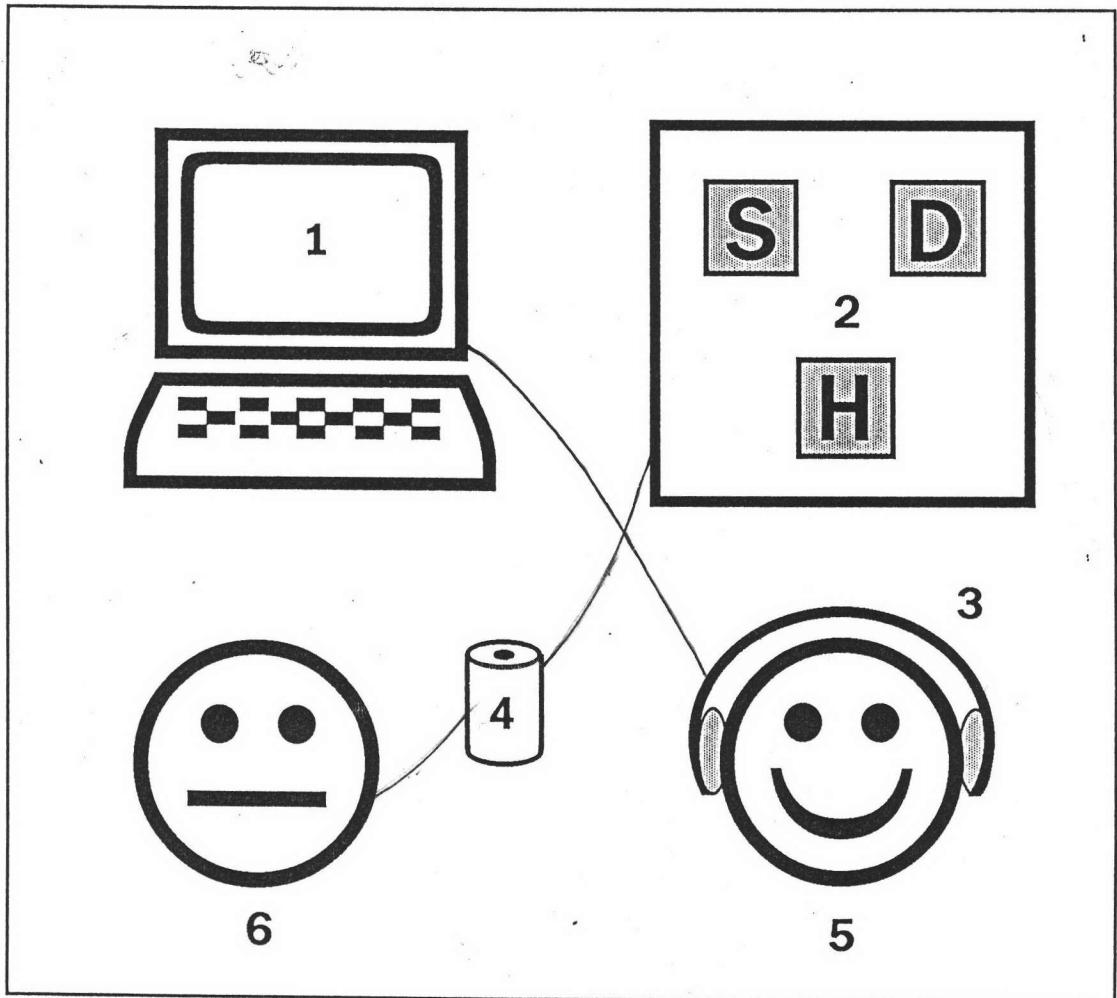
2.4.2 Fricative Perception Test

The experimenter took the child into the quiet place and seated the child as shown in Figure 2.1

a) Experimental phases

The speech perception test consisted of a practice phase followed by the test phases.

The practice phase was included to demonstrate the children knowledge of 'same' and 'different' sounds. There were two Thai words: /mi:/ and /dek/ which were presented in 2 Same and 2 Different trials. These trials enabled the child to become accustomed to the procedure and allowed the experimenter to help them if they were having difficulties. The child had to pass the practice phase (3 out of 4 correct) before progressing to the test phase. The test phase had six blocks, one block for each of the six contrasts: one phonemic contrast, one non-phonemic contrast, and four phonemic and non-phonemic contrasts. Each block consisted of 2 practice trials and 4 test trials. For each contrast, there were an equal number of presentations of Same and Different trials. All of the lights on the response box lit up and flashed to signal the end of each block. The experimenter could stop the experiment at the end of each completed block if it was necessary. Testing occasion would then recommence on a new testing. On this next occasion, the experimenter would choose to keep or abandon the practice phase (/mi:/-/dek/) before

Figure 2.1 Test Room Layout

1. Computer
2. Response Box :
 - 2.1 S : Same Key
 - 2.2 D : Different Key
 - 2.3 H : Home Key
3. Headphones
4. Control Button
5. Child
6. Experimenter



continuing the test phases.

b) Preliminary instructions

The experimenter asked about the child's knowledge of 'same' and 'different'. If the child did not know exactly and was confused with 'same' and 'different' concepts, the experimenter cited a few instances of 'same' and 'different' pictures, and some minimal pairs of simple Thai words to illustrate these concepts to them. The experimenter continued with this procedure until she was sure that the child understood the concept.

The experimenter explained to the children that they would listen to the pairs of sounds through the headphones. The experimenter pointed to three keys on the response box and then explained the different functions of those keys. The experimenter told the child that he or she was to press firstly the 'home' key to start the test, then the light on that key would go off and they would hear the two sounds. The sounds were either same or different. Their task was to press one of the two 'response' keys. The 'same' key was coded with two 'same-coloured' figures while the 'different' key was coded with 'different-coloured' figures. The child was asked to press the 'response' key to examine their understanding. For example, if the sounds were the same, the experimenter asked the child which key they think they should press if the sounds were the same. If the child pointed to the 'same' key, the experimenter would respond " Yes, that's right , because they

are the same colour...and if the sounds were different, which key should you press ?" The experimenter then pointed the 'different' key and asked "is this one correct? " The child should respond "Yes" but if the child pointed to the incorrect response key the experimenter would respond " No" and explained what the difference was; " This key is correct because it has different colours on it, you have to press it when you think the sounds are different ". The experimenter then continued "and if you think the sounds are the same you press this key (the experimenter presses the 'same' key) because it has the same colour". The children were trained to press the keys until they made correct decisions on the 'same' and 'different' keys. They were also instructed that they press the keys as quickly as possible after the second sound was presented. In order to prevent error responses (for example, pressing the 'home' key with one hand and the response key with the other hand), the child was instructed to use the same hand (their preferred hand) to press all the keys.

c) Procedure

The speech perception experiment used a discrimination procedure to examine the subjects' discrimination ability. A pair of either same or different sounds was presented to the child, whose task was to press the appropriate 'response' key as quickly as possible after hearing the second sound. Each child was tested twice, once with each of the ISI conditions (500

ms or 1500 ms). All children were tested on all 6 sound pairs in each of the ISIs i.e. (e-f), (f-s), (f-e), (f-f), (s-e), and (s-f) which were randomly assigned to one of six stimuli except non-phonemic sound pair (e-f) which was presented on the selected order. The computer was programmed to run the second ISI condition for each child automatically. After putting on the headphones, the child started the experiment by pressing the 'home' key when it lighted up. Then the light on this key went off. The experimenter then also pressed the control button to initiate the trial when the experimenter judged the child to be ready. This enabled the experimenter to be sure that the child was attending when the trial began. The two sounds were then presented. After the second sound was presented, the 'same' and 'different' keys became illuminated indicating that a response could be made. The child had to decide to press either the 'same' or 'different' key as quickly and accurately as possible. They had 3 seconds to make a decision each time then the illuminated 'response' keys went off. The reward lights flashed on if the child's response was correct but if the child made an error such as lifting the hand before the second sound was presented, making a decision by using more than 3 seconds after the second sound was presented, or making an incorrect response, then the reward lights would not light up. In the case when no response was being made, the trial

was repeated later in the same phase and the result was recorded. However, trials were not repeated when incorrect response were made. A new trial was started when the 'home' key lit up again. At the end of each of the six blocks, all of the lights lit up together to indicate the end of the block. The experimenter had to press any key on the computer to run the next test block and the child then restarted the experiment. Children were given some cartoon stickers after the test trials.

2.5 DATA ANALYSES

2.5.1 Measurements of the Tests

a) Non-verbal intelligence test: The accompanying Manual for Raven's Progressive Matrices (1977) was used for measuring intelligence scores. There were 36 pictures in the Raven's Coloured Progressive Matrices (set A, Ab, B). The child was given 1 score for each correct answer. See raw data in Appendix A.

The mean scores of the 48 selected subjects were 19.2 of the Thai 6 years old group (T-6 group) and 19.4 of the Thai and English 6 years old group (TE-6 group). And the mean scores of the Thai 8 years old group (T-8 group) were 25.8 and 27.5 of the Thai and English 8 years old group (TE-8 group). The subjects' scores of the non-verbal intelligence test were presented in Table 2.1. (See the selection of 48 subjects to

do the speech perception test in 2.1 page 25.)

b) Speech perception test:

A discrimination index for different trials was used to measure the subject's ability to discriminate whether two sounds were different when they were indeed different. It is given by the number of correct responses on different trials (i.e. a subject replied 'different' on 'Different trials') minus the number of incorrect responses on same trials (i.e. a subject replied 'different' on 'Same trials'), divided by the number of different trials.

$$\frac{\text{No. of 'different' on Different trial} - \text{No. of 'different' on Same trial}}{\text{No. of Different trial}}$$

There were 2 different trials. The discrimination indices (DIs) were calculated for each subject and for each of the six contrast types, at each of the ISI levels. A mean DI of +1 indicated perfect discrimination; a score of 0 indicated chance discrimination. A score between +1 to 0 indicated varying degrees of discrimination with scores closer to +1 indicating better discrimination than scores closer to 0. A negative score indicated erroneous responding. DI is a better measurement of speech perception than percentage of correct responses as it takes into account subjects' chance probability of responding 'different' on both same and

different trials.

2.5.2 Statistics Used in the Experiment

In the experiment which has many subject's group and many variables and is aimed to compare the subjects' performances, it is possible that the experiment will have both difference and no difference among those performances. And those differences may be significant or nonsignificant. If the significant difference was found, it rejects the null hypothesis that there is no difference between means in the experiment. There are various statistical methods to seek the significant difference between means i.e. z test, t test, and analysis of variance (ANOVA). The analysis of variance (ANOVA) is conducted to examine whether the differences between the comparisons are significant. It is similar to 't test' which is used to test the significant difference between means but 't test' is limited to test only 2 means each time. ANOVA has developed to examine more means, separate effects and also interactions of a number of treatment variables. (the detailed description of ANOVA is given in Appendix C.) In the experimental research, it always be hypothesized before the experiment that the population means are different rejecting the null hypothesis (Fallik and Brown, 1983).

In ANOVA, F ratio value is used to test the null hypothesis by comparing the obtained F value* with the critical F ratio** in the F table*** for the .05 level or the .01 level of the significance (or some other specified level). If the obtained F exceeds that value, it rejects the null hypothesis.

* Obtained F is the result of our ANOVA calculation.

** The critical F ratio is the critical ratio from the F table required for significance at a given level.

*** The F table is a two-dimensional table and we look up the critical F ratio in terms of its degrees of freedom (df) for numerator (which is the df for the mean square between the groups) and its degrees of freedom for demoninator (the df for the meansquare within the groups). We look down the column for degree of freedom for numerator to its intersection with the row for degree of freedom for the denominator mean square. We find the value for the 0.5 level in light face type and value for the 0.1 level in boldface type.

(F Table is shown in appendix D.)

The present experiment examines the speech perception of 4 subject groups; differ in language experience and age on discriminating 6 sounds pairs in 2 ISI levels. The data were analysed via a 2 x 2 x (6 x 2) mixed ANOVA. The factors were between-subjects factors and within-subjects factors in which between-subjects factors were two language groups, exposed to Thai only group (T group), exposed to both Thai and English group (TE group); and two age groups, 6 and 8 years old. The within-subjects factors were sounds pairs (f-s, e -f, f-e , f-f , s-e and s-f); and two ISI levels, 500 ms and 1500 ms. The analyses of the two factors were shown in Table 2.2: Hypothesized DI scores in Between-Subjects Analysis and Table 2.3: Hypothesized DI scores in Within-Subjects Analysis below. The hypotheses of the tables were explained at page 40. Abbreviations and terms used in the tables are:

1. Subject Group

- a. Exposed to only Thai language : T group
- b. Exposed to both Thai and English language : TE group

2. Sounds Pairs

- a. Phonemic sound pair : P sound pair
- b. Non-phonemic sound pair : NP sound pair
- c. Phonemic and Non-phonemic sound pair : PNP sound pair
- d. Sound pair : sp1 = (f-s), sp2 = (f-e), sp3 = (f-f),
sp4 = (s-e), sp5 = (s-f), sp6 = (e - f)

a. language : To compare the effect of language experience on the perception ability of T- group and TE- group, it was hypothesized that the discrimination ability of the TE group would be better than the T group.

b. age : To compare the performances of children age 6 and 8 years old, it is hypothesized that the 8 year olds should have better discrimination ability than the 6 year olds.

c. language x age : the interaction of language experience and age on the perception ability.

Table 2.3 Hypothesized DI scores in Within-Subjects Analysis: the discrimination ability of each sound pair and the effect of ISI on those discrimination abilities were compared. There were 11 rows as follow:

i. ISI : To compare discrimination ability at 2 different ISIs: between ISI 500 ms and 1500 ms, it is expected that the discrimination ability in the ISI 500 ms would be better than in the ISI 1500 ms.

ii. c1 or contrast 1 : To compare the discrimination ability of NP sound pair versus P and PNP sound pairs, it was hypothesized that the discrimination ability of the P and PNP sound pairs would be better than the NP sound pair.

iii. c2 or contrast 2 : To compare the discrimination ability of P versus PNP sound pairs, it was hypothesized that subjects should discriminate P sound pair better than PNP sound pairs.

Table 2.2 Hypothesized DI Scores in Between-Subjects Analysis-

Variables	Exposed to Thai only		Exposed to Thai and English	
	6 yrs	8 yrs	6 yrs	8 yrs
Language	-1	-1	1	1
Age	-1	1	-1	1
Language x Age	1	-1	-1	1

Table 2.3 Hypothesized DI Scores in Within-Subjects Analysis-

ISI Level	ISI 500 ms						ISI 1500 ms					
	sp1	sp2	sp3	sp4	sp5	sp6	sp1	sp2	sp3	sp4	sp5	sp6
ISI	1	1	1	1	1	1	-1	-1	-1	-1	-1	-1
KP vs P and PKP (c1)	-1	-1	-1	-1	-1	5	-1	-1	-1	-1	-1	5
P vs PKP (c2)	4	-1	-1	-1	-1	0	4	-1	-1	-1	-1	0
within PKP (c3)	0	-1	1	1	-1	0	0	-1	1	1	-1	0
f- θ vs s- \int (c4)	0	-1	0	0	1	0	0	-1	0	0	1	0
f- \int vs s- θ (c5)	0	0	1	-1	0	0	0	0	1	-1	0	0
ISI x c1	-1	-1	-1	-1	-1	5	1	1	1	1	1	5
ISI x c2	4	-1	-1	-1	-1	0	-4	1	1	1	1	0
ISI x c3	0	-1	1	1	-1	0	0	1	-1	-1	1	0
ISI x c4	0	-1	0	0	1	0	0	1	0	0	-1	0
ISI x c5	0	0	1	-1	0	0	0	0	-1	1	0	0

To reject the null hypothesis that there is no difference between the subject's performances, the hypothesis of the experiment had to be made before calculating the analysis of variance. Table 2.2: Hypothesized DI scores in Between-subjects analysis and Table 2.3: Hypothesized DI scores in Within-subjects analysis were made to compare the different performances between each subject group which differ in various variables i.e. language experience, and age. Therefore, it was made to examine the effect of ISI on discriminating each sound pair. A numeral indicated subject's performance; positive and negative numeral indicated comparable discrimination and 0 indicated whatever is not compared. (Those performances mean the subjects' performances as hypothesizing in the present experiment. After calculating and comparing obtained F with critical F ratio, the results may be similar to the hypotheses or different from that was hypothesized.)

Table 2.2 Hypothesized DI scores in between-subjects analysis: the discrimination abilities of the 4 subject groups were compared. It is hypothesized that there will be better discrimination ability of the group which is exposed to both Thai and English languages than the group which is exposed to only Thai language. And the discrimination ability of the 8-year-old group will be better than the 6-year-old group. Table 2.2 comprised of 3 rows as follow;



iv. c3 or contrast 3: This contrast is to compare the discrimination ability within the 4 pairs of PNP sound pairs.

v. c4 or contrast 4: To compare the discrimination ability of sp2 (f-ə) versus sp5 (s-f), it was hypothesized that it should be easier to discriminate the sound pair which has (f) as a member.

vi. c5 or contrast 5: To compare the discrimination ability of sp3 (f-f) versus sp4 (s-ə), it was hypothesized that the discrimination ability of the (f-f) which has (f) as a member should be better than the (s-ə) sound pair.

vii-xi. are the interactions of the discrimination ability at 2 ISIs and the discrimination ability of sound pairs.

Finally, the interaction between the two analyses above was calculated to find the significant difference. There were a total of 47 interactions. The significant differences from the 2 analyses are grouped into 12 types. There are 3 significant difference types in the Between-Subjects Analysis (1 to 3) and 9 significant difference types in the Within-Subjects Analysis (4 to 12) as follow:

1). The significant difference of the subjects' perception ability between the Thai language group and the Thai and English language group.

2). The significant difference of the subjects' perception ability between the 6-year-old group and the 8-year-old group.

3). The significant difference of the subjects' perception ability between the 4 subject groups: the T- 6, the T- 8, the TE- 6, and the TE- 8.

4). The significant difference of the subjects' performances at the 2 ISI levels: ISI 500 ms and ISI 1500 ms.

5). The significant difference between the perception of each sound pair.

6). The significant difference between the perception of each sound pair effected by language experience.

7). The significant difference between the perception of each sound pair effected by age.

8). The significant difference between the perception of each sound pair effected by ISI.

9). The significant difference between the perception of each sound pair effected by language experience and age.

10). The significant difference between the perception of each sound pair effected by language experience and ISI.

11). The significant difference between the perception of each sound pair effected by age and ISI.

12). The significant difference between the perception of each sound pair effected by language experience, age and ISI.