

CHAPTER III  
EXPERIMENT II



Method

Subjects

Twenty four students at Chulalongkorn University served in Experiment II. They were randomly assigned to condition.

Apparatus

1. A digital stop watch
2. A synchronizer
3. A set of 6 touched-switches
4. A tape recorder (stereo system)
5. A slide projector and a day-light-screen
6. A set of 24 To-Be-Perceived Items (TBPI)
7. A set of 24 Examining Pictures (EP)
8. A microphone with stop circuit connection

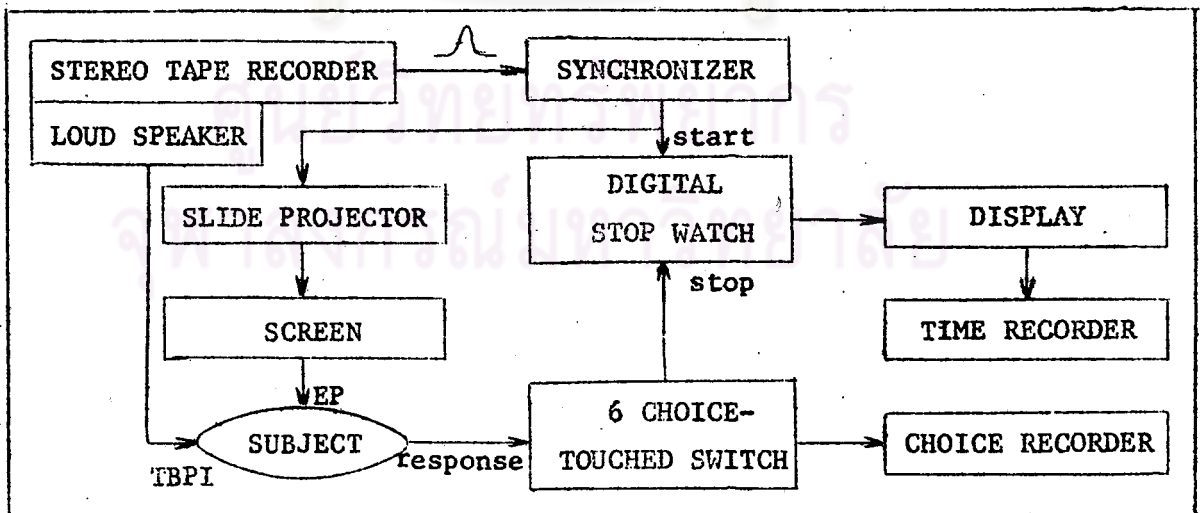


Fig. 3. A synchronized system and apparatus used in experiment II.

### Experimental design and procedure

To measure the time taken by the Ss in the internal processing period of speech perception in relation to the modifier positions, a synchronized system was designed in order to eliminate all intervening variables. Electronic circuits were specially designed and connected for the task. The To-Be-Perceived-Items (the lists of noun-modifier item used in Experiment I) were presented to Ss via a loud speaker of a tape recorder. The speed of presentation was up to the normal speaking condition, about 100 two-syllable words per minute. At the end of the last syllable in each TBPI, an electrical pulse about 50 cps. from the tape was sent to startup the digital stop watch and simultaneously project the slide via a synchronizer. Ss were assigned to select one of the pictures, that corresponded to the TBPI, out of the six pictures presented on the screen. The resulting distance between the screen and Ss' eyes was approximately 250 cm. and the cluster of the six pictures was distributed in a circular form with the radius of approximately 25 cm. so that the solid angle sustained by the Ss' eyes was in the order of average visual span and all pictures would be perceived simultaneously, thus, eliminated the orderly searching characteristic of the Ss reading habit which could be one of the intervening variables that affected reaction time. Only one of the six pictures corresponded to the TBPI from the tape, the other four pictures were only one-character-wrongly drawn so that if any one of them was wrongly selected by the Ss, the error of speech perception could be definitely

identified; the sixth picture was a question mark in which Ss were told to choose for the response when they were not sure or could not select the corresponding picture, thus, eliminated the guessing effect. Ss were trained to respond to the stimuli by touching the touched-switch under the number that corresponded to the number of the selected picture which, in turn, corresponded to the TBPI. In summary, the variety of the modifier positions of the TBPI would effect the duration of encoding process and hence, express in the differential reaction time. The paradigm can be presented in a diagram as follows :

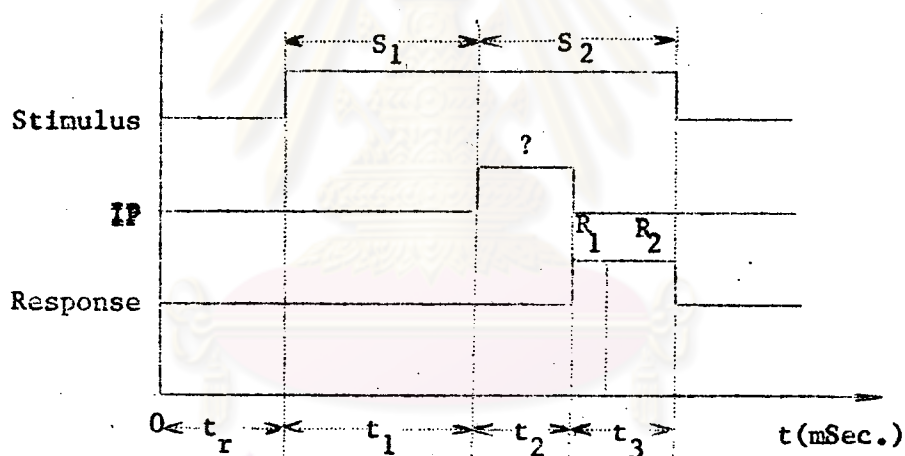


Fig. 4. Prototype paradigm

- $S_1$  -- To-Be-Perceived-Item from loud speaker
- $S_2$  -- Examining Picture from screen
- IP -- Internal Information Processing
- $R_1$  -- Key selection response
- $R_2$  -- Key touching response
- $t_1$  --  $S_1$  presentation interval (fixed)
- $t_2$  -- Internal reaction time (unknown)
- $t_3$  -- External reaction time (fixed)
- $t_r$  -- Resting time (fixed)

When a set of trails was tested, it was found that the precision and sensitivity of the designed system and instruments detected another intervening variable which, of course, must be eliminated for correction of the data. Owing to the variation of the duration in the movement of S's hand to the touched-switch in each trial, the data of reaction-time could not be statistically processed for the comparison of the duration of encoding process in relation to modifier positions in the TBPI. The discovery of such intervening variable changed the paradigm to be as shown in the following diagram.

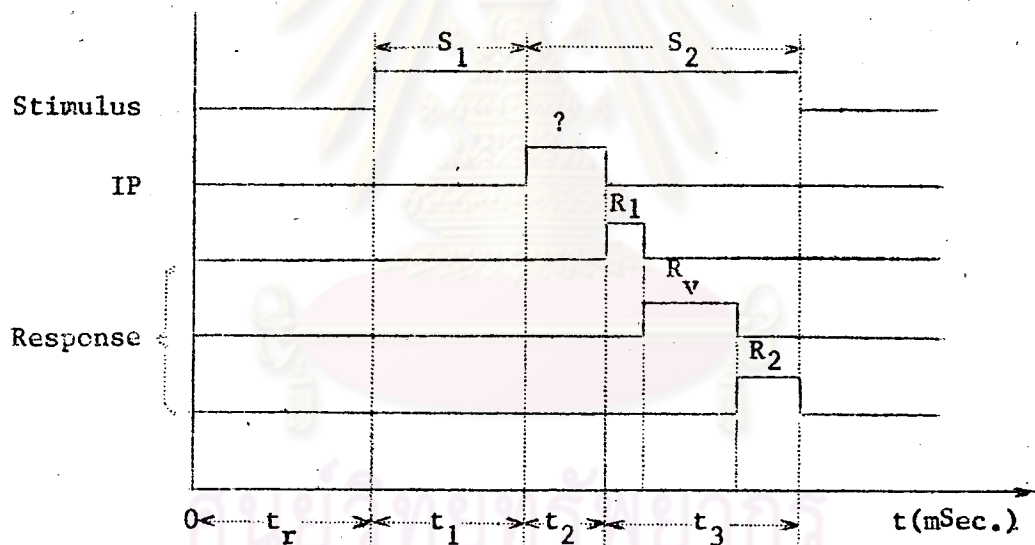


Fig. 5. Finding of intervening variable  
 $R_v$  -- Intervening variable

Finally, modified system and instruments were constructed. In order to eliminate the complexity of the response in the preceding paradigm, Es were assigned to perform oral response immediately after

the selection of the corresponding picture by stating out the ordinal number of the picture and the choice would be recorded by the experimenter. Some parts of electronic circuit were changed; the touched-switch in the preceding system of equipments was replaced by a microphone with a stop-signal - circuit connection. When S performed an oral response, speech sound was detected by the microphone and converted into an electrical pulse which stopped the digital stop watch, i.e., stopped by sound. The reaction time was recorded by the experimenter.

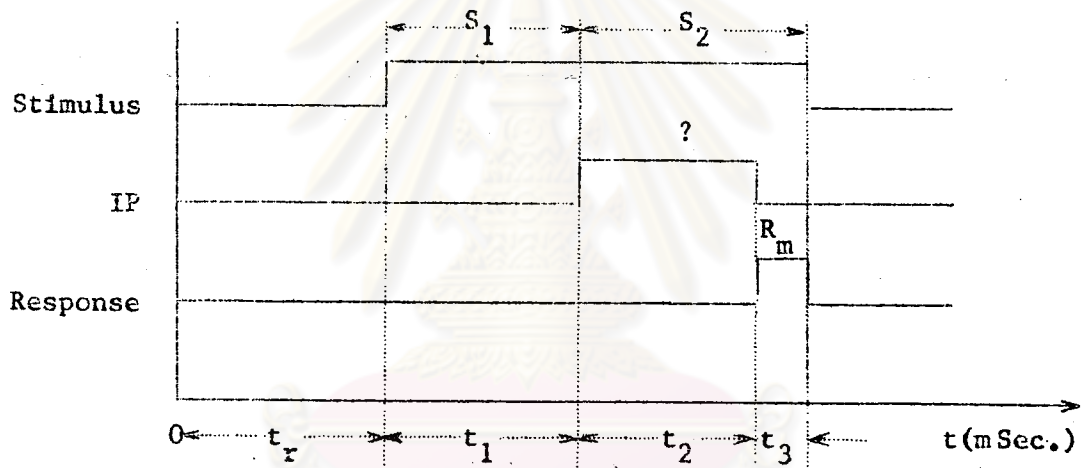


Fig. 6 Modified paradigm

$R_m$  -- Modified response

Each S performed for 24 trials, each trial took only approximately 10 seconds with a resting and resetting the instrument period of approximately 5 seconds, therefore, S's sensory-receptor-sensitivity would not decrease and S's attention would not be lost by fatigue. The resting period also functions as an intermittent period between trials which eliminated interference of the encoded TBPIs. Each S served in the experiment II for approximately 5 minutes. No reward was given to the S.

Results of Experiment II

Reaction Time Analysis

The data of reaction time in the experiment II were reorganized and analyzed in the form of fixed-N-position in order to show the differential internal processing time of each pattern of varied-M-position TBPI. The mean of reaction time of each pattern are presented in table 8.

TABLE 8  
REACTION TIME OF TBPI PERCEPTION

Number of M prior to N	Mean reaction time
0	2.48
1	3.55
2	3.97
3	4.38

The differences between the means of reaction time were tested for significance by means of ANOVA for single factor experiment with repeated measures on the same elements.<sup>1</sup> The results are summarized in table 9.

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<sup>1</sup>B.J. Winer, Statistical Principles in Experimental Design, (Tokyo: McGraw Hill Kogakusha, 1971), pp. 261-296.



TABLE 9  
ANALYSIS OF VARIANCE

Source of variation	SS	df	MS	F
Between people	31.92	23	1.39	
Within people	64.24	72	0.89	
Treatment	47.96	3	15.97	66.54*
Residual	16.28	69	0.24	
Total	96.16	95		

The  $F_{.99}(3,69) < 4.13$ , thus the overall differences of means of reaction time are significant at a .01 level test due to the effect of the treatment.

Tests on differences between pairs of means are performed by means of Newman-Kuels method<sup>1</sup>. The results are summarized in table 10.

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<sup>1</sup>B.J. Winer, Statistical Principles in Experimental Design, (Tokyo: McGraw Hill Kogakusha, 1971), pp. 261-296.

TABLE 10  
TESTS ON DIFFERENCES BETWEEN PAIRS OF MEANS

Number of M prior to N	Total	0	1	2	3
		59.56	85.23	95.26	105.13
0	59.56	-	25.67	35.70	45.57
1	85.23		-	10.03	19.90
2	95.26			-	9.87
3	105.13				-
$q_{.99}(r, 60)$			3.76	4.28	4.60
$\sqrt{nMS_{res}} q_{.99}(r, 60)$			9.02	10.27	11.04
$q_{.95}(r, 60)$			2.83	3.40	3.74
$\sqrt{nMS_{res}} q_{.95}(r, 60)$			6.79	8.16	8.98
		0	1	2	3
0		-	**	**	**
1			-	*	**
2				-	*
3					-

TABLE 11  
TEST FOR TRENDS

T	0	1	2	3	$\sum c^2$	$n\sum c^2$	C	MS	F
Total	59.56	85.23	95.26	105.13					
Linear	-3	-1	1	3	20	480	146.74	44.86	186.91**
Quadratic	1	-1	-1	1	4	96	-15.80	2.60	10.83**
Cubic	-1	3	-3	1	20	480	15.48	.50	2.08



The mean of reaction time of each pattern of TBPI is plotted in figure 7.

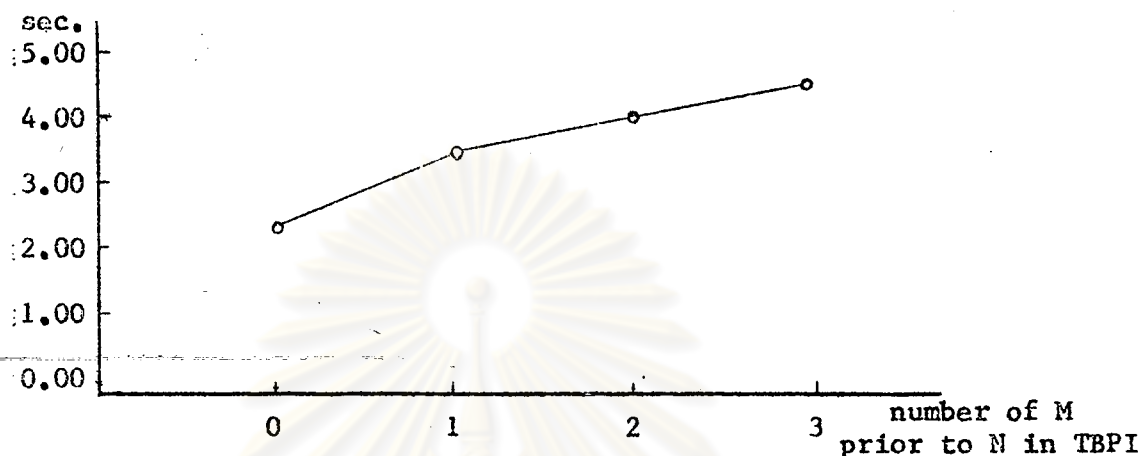


Fig. 7. Reaction time of verbal-visual matching of TBPI

#### Discussion on the Results of Experiment II

In Experiment II, it was hypothesized that modifier positions in TBPIs would effect speed of perception of speech in the way that encoding process would take differential internal processing time because the mechanism is serial and delayed where modifiers precede noun, but where modifiers follow noun the mechanism is instantaneous. As for a quantitative verification in verbal-visual matching reaction time, the hypothesis predicted the following quantitative result.

The increment of reaction time of verbal-visual matching varies as a linear function of the number of modifiers prior to noun in the TBPIs, or in a mathematical statement,

$$T_{vvm} \propto n_m$$

where  $T_{vvm}$  = verbal-visual matching reaction time  
 $n_m$  = numbers of modifiers prior to noun

The result of reaction time analysis, as shown in table 8,9,10 and figure 7, indicates a differential effect of modifier positions in the TBPIs. The test for trends indicates a much more linear variation, thus, supports the hypothesis that modifier positions in the TBPIs effect the internal processing time because of the mechanism which is serial and delayed where modifiers precede noun but it is instantaneous where noun precedes modifiers.

Combining the results of the experiment I and II, the differential effect of modifier positions in the TBPIs upon speech perception and STM is due to a process of reorganizing the speech codes. Particularly, the string of acoustic codes, which does not match to the internal semantic codes\* for the chunking process, must be impeded into the reorganization loop and may circulate for a number of times\*\* until the sequence of those acoustic codes is compatible to the internal semantic codes. Thus the reaction time in verbal-visual matching increases approximately in a linear function of the number of modifiers prior to noun because of the order of reorganization.

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\* The internal semantic code is the unit of learned material which a person obtained in the past experience. If the propagating neural network in the brain is assumed to be responsible for the storage of memory, it can be concluded that the internal semantic code is nothing but neural circuit which can be operated by the appropriate pattern of neural signals.

\*\* The circulation of acoustic codes in the reorganization loop is compatible to rehearsal which was narrated by the subjects in the interview.

Due to the variable control in the verbal-visual matching paradigm, it can be specified that the previously cited loop of operation must take place between the acoustic encoding process and semantic encoding process. Chunking occurs at the output of the latter process. Taking into account that the memory span is  $7 \pm 2$  perceptual codes at a time. This implication is supported by evidences illustrated in the results of the experiment I.

A complete model for the explanation of the findings of the present experiment will be proposed and discussed relatively to the contemporary theories of speech perception and human memory in the next chapter.



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