METERED MEMORY SEARCH WITH CONCURRENT RESPONSE SWITCHING

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CHAPTER I

INTRODUCTION

The present paper is concerned with the individual's capacity to engage in two different verbal activities at the same time. Interest in simultaneous processing, while an old problem in experimental psychology (see Woodworth, 1938), has been revived in recent years (Treisman, 1969). Most of the literature concerned with the concurrent performance of verbal tasks has required the individual to attend to two different sensory inputs at the same time. In such cases, verbal tasks may be concurrently performed by switching attention back and forth between sensory inputs (Cherry, 1953; Broadbent, 1954; Treisman, 1969). However, such switching may not be necessary in the event that sensory discrimination is absent in one of the tasks (Peterson, 1969; Weber and Blagowsky, 1970a). Therefore, there are instances in which two verbal tasks can be processed at the same time. Paulhan, an early psychologist, reported that he could recite a poem and multiply at the same time (Woodworth and Schlosberg, 1954, p. 88). In addition there is Peterson's (1969) extemporaneous speaker who seems to be planning what he will say next while he is simultaneously speaking.

Peterson (1969) has attempted to classify verbal tasks in terms of attentional demands. He identifies three levels of tasks, each requiring differences in attention, and suggests that the capacity of an individual to engage in two independent verbal activities simultaneously is a function of the attention required by the tasks. Concurrent processing of verbal activities is disrupted only if severe attentional demands are placed on the cognitive capacity by one or both of the activities.

The present investigations are designed to provide additional information on the capacity to engage in concurrent verbal activities whenever attentional demands of the verbal tasks are taken into consideration. In addition, the present experiments are concerned with Peterson's (1969) suggested categories.

Review of the Literature

Much of the recent interest in concurrent processing of verbal tasks stems from the so-called shadowing experiments. The method of shadowing, originated by Cherry (1953), requires the individual to repeat a spoken message staying as "close behind" the passage as possible. In the initial experiments by Cherry (1953, 1954) the subject's task was to shadow a voice presented to one ear while another, unrelated message was presented to the other ear. Cherry found that the subjects could report back the primary (the shadowed message) passage, but that messages in the unattended ear were almost completely unrecognized. However, some information did get through the unattended ear. Subjects could determine if the rejected message was spoken in normal human speech, were able to discriminate between a male and a female voice, could identify a 4000 CPS tone, and observed that reversed speech sounded queer. These results suggested that dichotic verbal stimuli cannot be processed simultaneously by the individual. Cherry felt that attention had to be switched from one ear to the other in order to process parts of both messages. He theorized that there is a circumscribed reaction time for attention switching and that during this interval no information can be processed. Cherry (1954) periodically switched one message between the two ears at various time intervals. This alternation did not interfere with shadowing if it was very rapid (20 times per second) or very slow (once every second), but it had a marked effect at intermediate rates.

Other investigators have replicated Cherry's procedure with minor variations (Moray, 1959; Treisman, 1960) and obtained substantially the same results. When two messages are presented, each from a different source, subjects can repeat one back very efficiently, but can usually report nothing about the verbal content of the other apart from a few highly important or relevant words. If the subject is specifically asked to recall single target words presented to one ear, his ability to repeat the words presented to the other ear is completely disrupted at the times when the target word occurs (Mowbray, 1964).

Broadbent (1954) conducted a study aimed at shedding further light on the results of the shadowing experiments. Earlier studies by Poulton (1953) and Hirsh (1950) had suggested that perceived localization of messages was important. In Broadbent's (1954) experiment, the role of auditory localization in attention was investigated by separating the sources of information in space. It was found that a relevant message was better understood when it was presented simultaneously with an irrelevant one. Additional results indicated that separation of the information sources offered few advantages if rapid alternation between channels was required. These results could not easily be reconciled with Cherry's interpretations. Contrary to that implied on the basis of Cherry's interpretation, selectivity is not based on the ear at which the message arrives, but on the perceived location of the sound source. Furthermore, the same critical rate of interruption appears even when a single ear is involved.

Broadbent (1958) proposed that there is a filter which selects a message on the basis of characteristics toward which it has been biased and allows this message alone to proceed to the central analyzing mechanisms. In this way, messages with other characteristics are excluded and the total amount of discrimination which has to be performed by the nervous system is greatly reduced. He suggested that messages are initially processed in parallel, but that at some central stage lies a perceptual channel of limited capacity. The selective filter reduces the load on this bottleneck by blocking irrelevant messages before they reach it. Thus, whole complex messages can be rejected on the sole basis of possessing some simple quality, and no further analysis of them would need occur. Broadbent believed that the information content, defined as bits per second, would be critical in determining how many stimuli could be perceived (Broadbent, 1956).

However, there have been a number of studies that cannot be immediately explained by Broadbent's model. Although subjects can follow only one of two messages (Cherry, 1953), if a single passage is given at twice its normal rate it maintains its intelligibility (Fairbanks, Guttman, and Miron, 1957). Other experiments have yielded similar results. If the information concent of the passage is doubled by using a low-order approximation to English (Moray and Taylor, 1958; Treisman, 1965), subjects achieve shadowing scores considerably higher than 50% of their original performance. On this basis it would appear that the limit lies not in the overall information rate, but in the number of physically separate inputs that can be followed.

Another example of results which are not readily explained by Broadbent's models stem from studies which point out that often the selection of wanted from unwanted speech can be performed on the basis of highly complex characteristics. Peters (Deutsch and Deutsch, 1963) found that if an unwanted message is similar in content to the wanted one, it produces more interference in receiving the latter than if it is dissimilar to it. This seems to indicate that the content of the two messages is analyzed prior to the acceptance of one and rejection of the other. Gray and Wedderburn (1960) found that when speech was delivered to subjects in both ears simultaneously, so that a meaningful sequence could be formed by choosing syllables or words alternating from one ear, the subjects produced the meaningful sequence rather than simply the series of words or syllables presented to one ear or the other. Moray (1959) found that if a subject is listening selectively to one channel and ignoring the other, calling his name on the non-attended channel will on a certain number of instances cause him to switch his attention to this channel. He also found that when neutral material (i.e., digits) was used instead of the subjects' name it did not get through. As a result, Moray assumed that the block in dichotic shadowing occurs at a high level of analysis. His results have been confirmed by Oswald, Taylor, and Treisman (1960) in an experiment concerned with the intelligibility of an individual's name during sleep.

Deutsch and Deutsch (1963) have adopted a somewhat different view about where the limiting (serial) factor lies. They have suggested a model that places the limit in capacity for perceiving speech in the response side of the brain's central communication channel. They prefer the explanation that all stimulus inputs are fully analyzed and that selection is made only to determine responses and memory.

Treisman and Geffen (1967) conducted an experiment directed at resolving the controversy about where the limitation exists in selective attention. To test the extent to which attention is a feature of perception rather than of response, they compared the same response made to both the attended and the unattended message. In an attempt to establish the degree to which this limit lies on the response side, they investigated how much interference a second response to the same stimulus caused in the performance of a primary response. They combined these two problems in a single paradigm by presenting two messages and requiring two responses, one of each being given priority by the instructions. The primary message and response were chosen to occupy most of the limited capacity available to the subject. The primary response was made to the primary message only and the other response to both messages. Thus subjects were given two dichotic messages, one primary and one secondary, and had to make two different responses: the primary response was to shadow the primary message; the secondary response was to tap upon hearing certain target words in either message. The authors felt that since the secondary response was identical for the two messages, any difference in its efficiency between the two messages must be due to a failure in perception of the secondary message. Any interference between the primary and secondary responses (repeating and tapping) to target words in the primary message must be due to a limit in performing simultaneous responses, since if either was correctly performed the target word must have been perceived. Most of the tapping responses were performed to target words in the primary message while few tapping responses were made to target words in the secondary message. An analysis of the errors also suggests that the secondary message was not being perceived. Errors in the shadowing response increased to thirty percent when the tapping response was made to secondary message target words as compared to eleven percent for the primary message target words. The authors interpreted this difference as additional evidence for a perceptual rather than a response limitation.

Therefore, Treisman and Geffen (1967) viewed their results as favorable to the filter theory proposed by Broadbent (1958). However, they believed that Broadbent's model needed modification. It was necessary to theorize that the perceptual filter contains a lower threshold for significant information. This additional assumption is required to account for their finding that some information from the secondary message was perceived.

However, an experiment by Norman (1969) produced results which suggest that all sensory inputs undergo analysis before filtering. Subjects shadowed English words presented to one ear while two-digit numbers were presented to the unattended ear. Results indicate that the subjects had no memory for the digits if shadowing continued for 20 seconds before they attempted to recall the digits. However, they did remember some digits if tested immediately after presentation. Apparently these digits were stored in a short-term memory stage that quickly dissipates over time. Because short-term memory was shown to exist under these conditions, it seems likely that digits were undergoing analysis before filtering. In order to account for Norman's findings

Broadbent's filter would need additional elaboration and sophistication.

A further, somewhat different approach toward the problem of parallel and sequential processing has been put forth by Moray (1967). His model suggests that the limitations on processing information by the human operator is not because he acts as a single channel processor, but as a limited capacity processor. Moray states:

> The total capacity of the brain can be allocated to the separate aspects of the tasks, such as reception, recoding, emission, storing, etc. (Moray, 1967, p. 84)

According to this view, simultaneous processing is possible where the total capacity is not exceeded.

Peterson and Kroener (1964) conducted several experiments in which simultaneous processing seemed to occur. They found that if subjects were told they would be tested on material presented to the ear opposite the one shadowed, then performance was greatly improved. Moray's model also accounts very nicely for the result of another study (Moray and Jordan, 1966) performed to investigate a highly compatible two channel task. The experiment was a variant on a study that Broadbent emphasized in establishing his model.

Broadbent presented three pairs of digits to a subject. Each pair was presented simultaneously to the two ears. At presentation rates greater than one pair every 1½ seconds, subjects could only recall the messages ear by ear, not alternating between the ears. As mentioned earlier in this section, Broadbent theorized that if parallel inputs arrived faster than the switch could operate, then one message must be held up, and the messages passed sequentially through the system. In their 1966 experiment, however, Moray and Jordan obtained different results by providing the subjects with a means of parallel output matching the parallel inputs. They presented three pairs of digits in the same way as Broadbent (1954), however, in this case subjects typed their responses on a keyboard in which two keys could be pressed simultaneously. Ten keys were provided so that the subjects could type out the left ear message with their left hands, and the right ear message with their right hands. The results indicated that performance was much better with parallel modes of response.

In addition, there is other evidence that two verbal tasks can be processed at the same time. For example, there are the instances of virtually simultaneous translation of one language into another (Triesman, 1965). In a more recent article, Peterson (1969) adopted a similar conception couched in terms of the attentional demands that various verbal tasks require. He identified three levels of tasks, each requiring differences in attention, and suggested that the capacity of an individual to engage in two independent verbal activities at the same time is a function of the attention required by the tasks. He also placed a considerable emphasis on practice, implying that more attention is required for a newly organized activity than for an overtrained skill.

Peterson (1969) categorized the simplest type of activity such as counting and the reciting of the alphabet as emissive activity. Such tasks are seen as requiring very little attention for the adult. A second level of attention was postulated for activities dependent on uncertain external events for which production is required. An example of this kind of activity might be the shadowing experiments in which there is stimulus uncertainty and a direct correspondence between input and output is required. A third level of attention was suggested for activites with stimulus uncertainty which require some type of transformation of the input prior to the output, so that more than the simple reproduction of the second level is required. Examples of such activities are arithmetic computation, problem solving, etc.

Peterson investigated the subject's efficiency in performing two concurrent verbal activities with the above categories. In one case, the subject's task was to solve anagrams (a transformational task) while concurrently engaging in one of the following activities: counting (emissive), shadowing (reproductive), or addition (transformational). It was found that when an emissive activity was combined with anagram solution, both could be maintained with a minimal loss of efficiency indicating that actual simultaneous processing occurred. When reproductive or transformational activities were combined with anagram solution, however, performance as measured in terms of facility at anagram solution suffered in direct relation to position in the hierarchy. While Peterson's results from combining different tasks were probably generally correct, there were some possible problems of control. For example, changes in task level were confounded in many cases by simultaneous variation in stimulus and response complexity.

An experiment (Weber and Blagowsky, 1970a) made use of Peterson's categories but used a metered memory search task that held constant stimulus-response complexity. The memory task was originally developed as a procedure for measuring search time for a rule-specified target (Weber, Cross, and Carlton, 1968). Stimuli are presented and the target is rule-defined as a transformation a specified number of steps away from the stimulus. Transformations of various sizes (0, 1, 2 steps away from the stimulus) can be applied to the separate stimulus items of a circular sequence. The differing levels of the transformational task can be readily quantified based on the size of transformation, and corresponding response time. Therefore, it is possible to obtain a measurement of complexity. Moreover the memory search task relates readily to Peterson's (1969) classification: a 0-unit transformation is equivalent to Peterson's reproductive tasks, while one or more unit transformations classify as transformations in the Peterson scheme.

Weber and Blagowsky (1970a) investigated the effects that an emissive task (chanting letters or numbers) had on the performance of either a reproductive or transformational task (metered memory search). The results suggested that performance for the letter transformations in the memory task was decreased when subjects were required to concurrently chant either an incompatible letter chant or a neutral number chant. However, a subtractive method for viewing the data yielded strong evidence that actual simultaneous processing did indeed occur in some of the conditions. In general, concurrent processing was more efficient with the number sequence than with the letter sequence.

Peterson was aware of the possibility that differing tasks within one of his levels may differentially effect performance on another task. However, his experiment (1969) did not reveal any such differences that were due to what he termed class similarity (both tasks involving the same characters). Although the difference between the letter sequence and the number sequence found by Weber and Blagowsky (1970a) does not necessarily represent differences attributable to class similarity, it does indicate that two tasks within the same category can have differential effects on a concurrently performed task.

An additional finding of Weber and Blagowsky (1970a) indicated that simultaneous processing occurred to a greater extent when the chants were performed in conjunction with the 0-unit transformations rather than with the higher levels of transformational sizes. In all conditions, concurrent processing became more efficient with practice.

Summary

A considerable amount of effort has gone into the area of concurrent information processing. The shadowing experiments have resulted in evidence that actual simultaneous processing of verbal material is difficult or impossible. However, other evidence suggests that two verbal tasks can be processed at the same time. Perhaps the confusion results from problems of definition and interpretation. Peterson (1969) attempted to provide information on concurrent processing whenever attentional demands of the tasks are taken into consideration. It seems likely that such a classification of tasks would be helpful in interpreting work on concurrent processing. However, Weber and Blagowsky (1970a) conducted an experiment in which tasks within one of Peterson's levels had quite different effects on a concurrently performed task. Therefore, this series of studies will extend the research on simultaneous processing and relate it to Peterson's classification for attention tasks.

CHAPTER II

THE PROBLEM

Statement of the Problem

Prior studies have contributed some experimental evidence for distinguishing between three levels of attention. Experiments conducted by Peterson (1969) and Weber and Blagowsky (1970a) revealed differences in efficiency of performance on one verbal activity related to attentive level of the other task. The primary intention of this dissertation was to examine possible differential effects that various tasks within Peterson's emissive level may have for accompanying reproductive and transformational tasks. If different emissive tasks require a similar amount of attention as Peterson (1969) suggests, then they should have similar effects upon an accompanying task. However, there was some reason to believe that task difficulty within the emissive level can have differential effects on an accompanying activity (Weber and Blagowsky, 1970a). If this is the case, then Peterson's classification is incomplete at best. Thus it was considered profitable to examine Peterson's classification by investigating the extent to which a relatively wide range of emissive activities, differing in difficulty, disrupted the performance on reproductive and transformational tasks.

Experiments Conducted

Two experiments were conducted. The first experiment studied the consequences that various types of response switching have for emissive tasks. In the second experiment, emissive tasks that required response switching and emissive tasks which did not were performed concurrently with a primary task.

The basic purpose of the first experiment was to discover emissive tasks which differ in difficulty. Therefore response switching was manipulated in emissive tasks to see if it increased the level of difficulty. Such an approach appeared promising since several models of attention assume that there is some limit to the responses we can make. Deutsch and Deutsch (1963, 1967) and Reynolds (1964) have made the strong claim that all attention tasks can be explained in terms of selection of outputs.

The chief aim of the second experiment was to discover whether two activities within one of Peterson's levels of attention could have significantly different effects upon an accompanying activity. Accordingly, the second experiment examined the effects that emissive tasks (chanting) had upon a concurrently performed primary task (metered memory search). The effect of chant sequences which involved a form of response switching were compared with chant sequences which did not involve response switching. In addition, the effects for single and double chant grouping upon metered memory search were noted.

CHAPTER III

EXPERIMENT I: RESPONSE SWITCHING TIME

This first experiment was designed to accomplish several objectives. First it was directed toward the study of the effect of response intensity switching on response time. Response intensity switching involved comparisons among the response times for processing a string of characters by speaking, "mouthing" (subdued whispering), and switching between speaking and mouthing items in chant sequences. The second function was to study the effect of response class switching on response time. Subjects produced chant sequences that were composed of numbers, letters, or switched between numbers and letters. Finally, the effects of single chant grouping (e.g., 1,2,3,4,5,1,2, . . . 5) versus double chant grouping (e.g., 1 1, 2 2, 3 3, . . .) upon response intensity and response class switching times were studied.

Several hypotheses were examined: 1) There will be an effect due to response intensity switching, that is, speaking and mouthing will require more time than speaking only or mouthing only. 2) Chant sequences requiring class switching will have longer response times than uniform chant sequences. 3) Double chant groupings will have longer response times than single chant groupings. 4) Both response intensity switching and response class switching will improve with practice. In addition, some possible interactive effects were expected to be of interest. In particular, do the possible effects produced by response intensity switching change as a function of sequence composition?

METHOD

Subjects

The subjects (Ss) were undergraduate students at Oklahoma State University and received $1.50 for participation. There were 24 Ss, 12 for each between-Ss condition.

Experimental Design

The design had one between-Ss factor, chant grouping, at two levels (single versus double chant grouping), and two within-Ss factors both at three levels--response intensity (speak, mouth, or speak and mouth) and chant materials (numbers, letters, or numbers and letters). Twelve Ss each were randomly assigned to the single and double chant groupings. The design and the specific tasks are illustrated in Table I.

Instruction and Procedure

The three response intensities were performed for each of the chant materials. For the single chant grouping, the number (N) sequence was the first five numbers successively repeated "1, 2, 3, 4, 5, 1, 2, 3, 4, 5" and similarly the letter (L) sequence was the first five letters of the alphabet "a, b, c, d, e, a, b, c, d, e." In addition a third sequence, numbers and letters (N/L), alternated the first five numbers and letters "1, a, 2, b, 3, c, 4, d, 5, e."

The double chant grouping differed in that each character immediately repeated itself. Thus the N and L sequences were

TABLE I

APPROPRIATE RESPONSES FOR THE VARIOUS CONDITIONS[a]

	Single Grouping		
Chant sequences	Speak	Mouth	Speak and Mouth
Numbers (N)	1,2,3,4,5,1,2,3,4,5	(1)(2)(3)(4)(5)(1)(2)(3)(4)(5)	1(2)3(4)5(1)2(3)4(5)
Letters (L)	a,b,c,d,e,a,b,c,d,e	(a)(b)(c)(d)(e)(a)(b)(c)(d)(e)	a(b)c(d)e(a)b(c)d(e)
Numbers and Letters (N/L)[b]	1,a,2,b,3,c,4,d,5,e	(1)(a)(2)(b)(3)(c)(4)(d)(5)(e)	1(a)2(b)3(c)4(d)5(e)

	Double Grouping		
Chant sequences	Speak	Mouth	Speak and Mouth
(N)	1,1,2,2,3,3,4,4,5,5	(1)(1)(2)(2)(3)(3)(4)(4)(5)(5)	1(1)2(2)3(3)4(4)5(5)
(L)	a,a,b,b,c,c,d,d,e,e	(a)(a)(b)(b)(c)(c)(d)(d)(e)(e)	a(a)b(b)c(c)d(d)e(e)
(N/L)	1,a,2,b,3,c,4,d,5,e	(1)(a)(2)(b)(3)(c)(4)(d)(5)(e)	1(a)2(b)3(c)4(d)5(e)

[a]Mouthed, or silent, characters appear in Parenthesis; characters spoken aloud are not enclosed in parenthesis.

[b]The N/L sequences were the same for both groups for reasons explained in the text.

respectively "1 1, 2 2, 3 3, 4 4, 5 5" and "a a, b b, c c, d d, e e." However, the N/L chant remained the same as for the single-chant grouping. This was necessary in order that all sequences would contain an equal number (ten) of characters.

Before beginning the experiment, the Ss were given appropriate instructions (Appendix A) and practice on performing the three response intensities for each of the three different chant materials. For the Speak task the S was instructed to say the sequence (composed of numbers, letters, or both numbers and letters) aloud without stopping. For the Mouth task the S was instructed to say the sequence silently, talking to himself but using exaggerated lip and mouth movements, so that E could objectively determine that the S was in fact engaged in silent processing. In the Speak and Mouth task the S was instructed to switch between speaking and mouthing the characters. The instructions and procedure were the same for the single and double chant groupings except that the chant sequences differed as previously discussed.

There were nine conditions for the single and double chant groupings. The conditions and their appropriate responses are illustrated in Table I. The characters not enclosed in parentheses were spoken aloud and those in parentheses were mouthed.

For each trial of two passes through the sequence, the experimenter (E) placed a cue card with one of the instructions, Speak, Mouth, or Speak and Mouth, before the S. The cue card also contained the appropriate sequence of characters with spoken and mouthed characters differentiated as in Table I. When the S had finished studying the cue card, he turned it over and activated a Standard Electric Clock's remote switch at the onset of each trial and stopped the clock remotely when he finished the sequence. He was not allowed to see the clock face, nor was he given information on his response times.

Data was collected for ten blocks, each block comprised of the nine conditions, with each S receiving a different random order of conditions. There was an interval of about 20 seconds from the end of one trial to the beginning of another; during this time the E reset the clock and wrote the time for the trial on a data sheet. The entire session comprised approximately 50 minutes.

RESULTS

The chant material factor did not receive complete representation in the experiment. The N/L sequence for the double chant grouping was the same single sequence that was used for the single chant grouping (Table I). A double N/L sequence would have required 20 characters (1 1, a a, 2 2, b b, 3 3, c c, 4 4, d d, 5 5, e e) whereas all others contained 10 characters. Therefore, the data for the single chant grouping and the double chant grouping received separate analyses. After separate analyses, the data for both groupings were pooled (data for N/L sequence were omitted) to provide information on single versus double chant grouping.

Single Chant Grouping

Descriptive statistics for response time (RT) in seconds as a function of response intensity and the chant material are presented in Table II. Mean RT's were determined by averaging over number of trials and number of Ss.

Figure 1 and Table II suggest that both response intensity and

TABLE II

TIME (SECS) TO PRODUCE 10 CHARACTERS AS A FUNCTION OF RESPONSE INTENSITY AND CHANT MATERIALS FOR THE SINGLE CHANT GROUPING[a]

Speak			
	Numbers	Letters	Numbers/Letters
Means[a]	2.09	2.07	2.63
SEM	.48	.45	.60

Mouth			
	Numbers	Letters	Numbers/Letters
Means	1.95	1.94	2.46
SEM	.54	.56	.61

Speak and Mouth			
	Numbers	Letters	Numbers/Letters
Means	4.69	4.93	4.28
SEM	.99	.91	.84

[a]Means determined by averaging over number of Ss (N=12) and number of trials (10 trials).

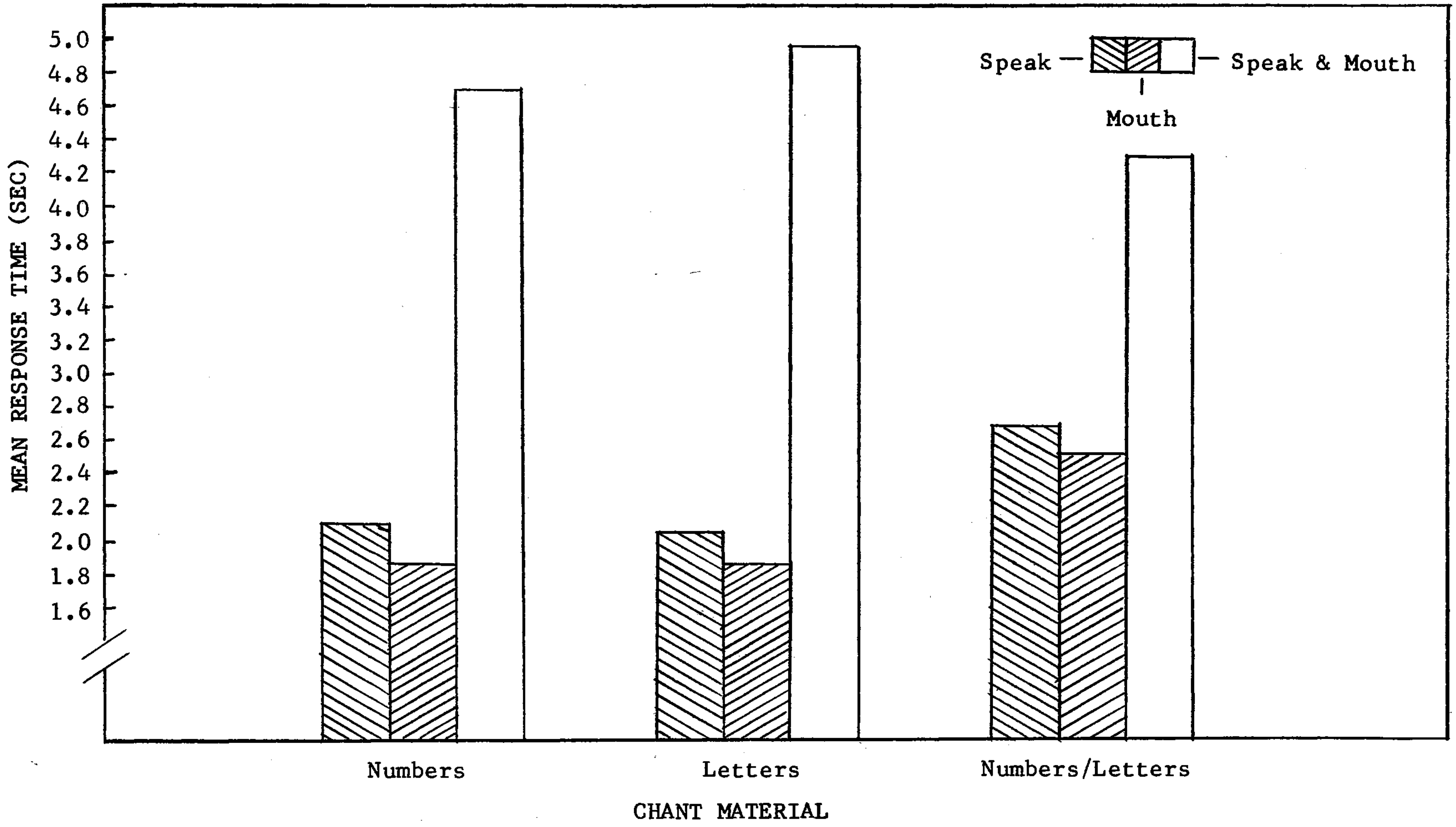

Figure 1. RT for Response Intensity and Chant Material for the Single Chant Grouping

chant material were effective variables. Significance tests for the means of Table II confirm this. The .05 level was adopted as the minimal level for an effect to be considered significant in all statistical analyses. In addition, the Greenhouse and Geisser procedure (Winer, 1962) was conducted with reduced degrees of freedom for the conservative test recommended for repeated measures designs. The main analysis (Table III) was an analysis-of-variance performed on the mean RTs for each S at each condition. The main effects for response intensity and chant material were significant ($p < .01$). Figure 1 also indicates that the effects of response intensity varies as a function of chant material. This suggestion was also confirmed (Table III) as the Intensity x Chant material interaction was significant ($p < .01$).

In view of the interactions tests on simple main effects were in order. Table IV provides evidence that response intensity was significant for each chant material ($p < .01$). Comparisons were made among the subgroup means of response intensity for each chant material by the Neuman-Kuels procedure (Winer, 1962). Switching between speaking and mouthing took significantly longer than either speaking or mouthing ($p. < .05$). This was true for each chant material. However, as suggested by Figure 1, there was no significant difference between speaking and mouthing for any of the chant materials.

Table V demonstrates that chant material was significant at each level of response intensity ($p < .01$). Comparisons using the Neuman-Kuels procedure were performed on the subgroup means of chant material for each level of response intensity. As suggested in Figure 1, speaking or mouthing the number and letter sequence required significantly longer RTs than that required by the number sequence or letter

TABLE III

ANALYSIS-OF-VARIANCE FOR TABLE II MEANS

Source	df	SS	MS	F
Total	107	201.657		
Ss w group	11	40.5472		
Chant Material (C)	2	1.1760	.588	10.69 ($p < .01$)
C x Ss w group	22	1.2124	.055	
Response Intensity (I)	2	143.8593	71.930	217.31 ($p < .01$)
I x Ss w group	22	7.2735	.331	
C x I	4	5.9491	1.481	40.19 ($p < .01$)
C x I x Ss w group	44	1.6332	.037	

TABLE IV

ANALYSIS-OF-VARIANCE FOR RESPONSE INTENSITY AT EACH CHANT MATERIAL FOR THE SINGLE CHANT GROUPING

Numbers

Source	df	SS	MS	F
Total	35	74.9964		
Ss w group	11	13.6169		
Intensity (I)	2	57.3789	28.6895	157.81 ($p < .01$)
I x Ss w group	22	4.0006	.1818	

Letters

Source	df	SS	MS	F
Total	35	83.9866		
Ss w group	11	12.4325		
Intensity (I)	2	68.2218	34.1109	225.15 ($p < .01$)
I x Ss w group	22	3.3323	.1515	

Numbers/Letters

Source	df	SS	MS	F
Total	35	41.5274		
Ss w group	11	15.7108		
Intensity (I)	2	24.3206	12.1603	178.82 ($p < .01$)
I x Ss w group	22	1.496	.0680	

TABLE V

ANALYSIS-OF-VARIANCE FOR CHANT MATERIAL AT EACH RESPONSE INTENSITY FOR SINGLE CHANT GROUPING

Speak

Source	df	SS	MS	F
Total	35	11.4804		
Ss w group	11	8.2884		
Chant material	2	2.4178	1.2089	34.34 ($p < .01$)
Chant x Ss w group	22	.7742	.0352	

Mouth

Source	df	SS	MS	F
Total	35	13.9608		
Ss w group	11	11.1976		
Chant material	2	2.1193	1.0597	36.17 ($p < .01$)
Chant x Ss w group	22	.6439		

Speak and Mouth

Source	df	SS	MS	F
Total	35	32.3521		
Ss w group	11	28.3366		
Chant material	2	2.5899	1.2950	19.98 ($p < .01$)
Chant x Ss w group	22	1.4256	.0648	

sequence ($p < .05$). However, in the case of switching between speaking and mouthing, the letter sequence had significantly longer RTs than did the number and letter sequence ($p < .05$). (The difference between the sequence and the number and letter sequence was significant at the .10 level.) This reversal is illustrated in Figure 1 and helps to gain a better understanding of the significant Modality x Chant material interaction that was reported in Table III.

Double Chant Grouping

Descriptive statistics for RT as a function of the three response intensities and the two chant materials (N/L omitted) are shown in Table VI. Mean RTs were determined by averaging over number of trials and number of Ss.

Figure 2 indicates that response intensity was an effective variable for the double chant grouping. Significance tests (Table VII) for the means of Table VI confirmed this. The main effect for response intensity was significant ($p < .01$). Comparisons were made among the subgroup means of response intensity by the Neuman-Kuels procedure. The response intensity switching task (switching between speaking and mouthing) took significantly longer than the conditions in which the sequences were spoken or mouthed alone ($p < .05$).

A Comparison of Single and Double Chant Grouping

In order to gain an understanding of the effects of single versus double chant grouping, the data for the two chant groups were pooled (data for N/L sequences, although presented in Figure 3, were excluded from any statistical analysis). Figure 3 suggests that differential

TABLE VI

TIME (SECS) TO PRODUCE 10 CHARACTERS AS A FUNCTION OF RESPONSE INTENSITY AND CHANT MATERIAL FOR THE DOUBLE CHANT GROUPING[a]

Speak		
	Numbers	Letters
Mean	2.27	2.28
SEM	.38	.35

Mouth		
	Numbers	Letters
Mean	2.30	2.30
SEM	.40	.44

Speak and Mouth		
	Numbers	Letters
Mean	3.84	4.05
SEM	.82	.86

[a]Means determined by averaging over number of Ss (N=12) and number of trials (10 trials).

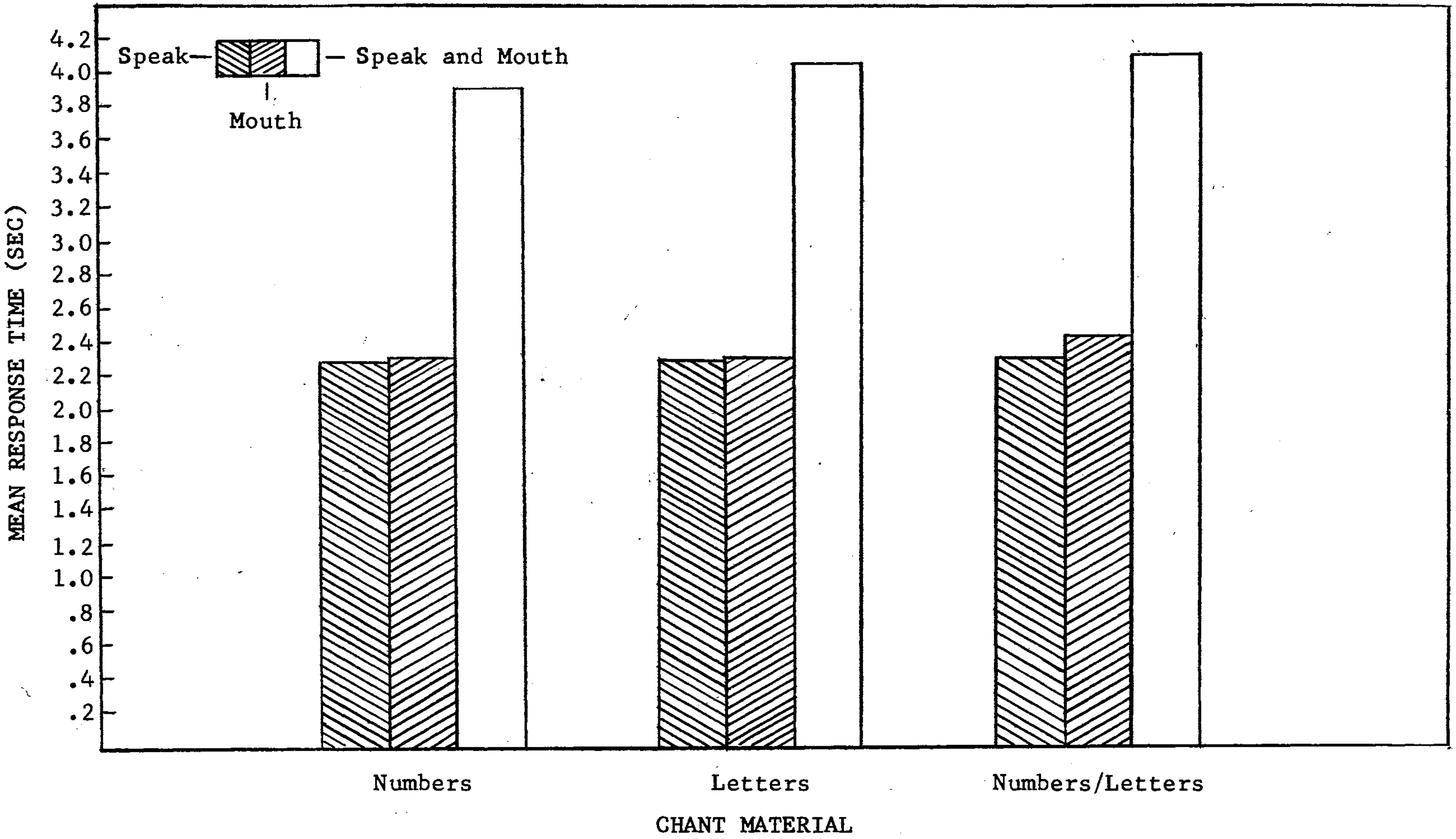

Figure 2. RT for Chant Response Intensity and Chant Material for the Double Chant Grouping

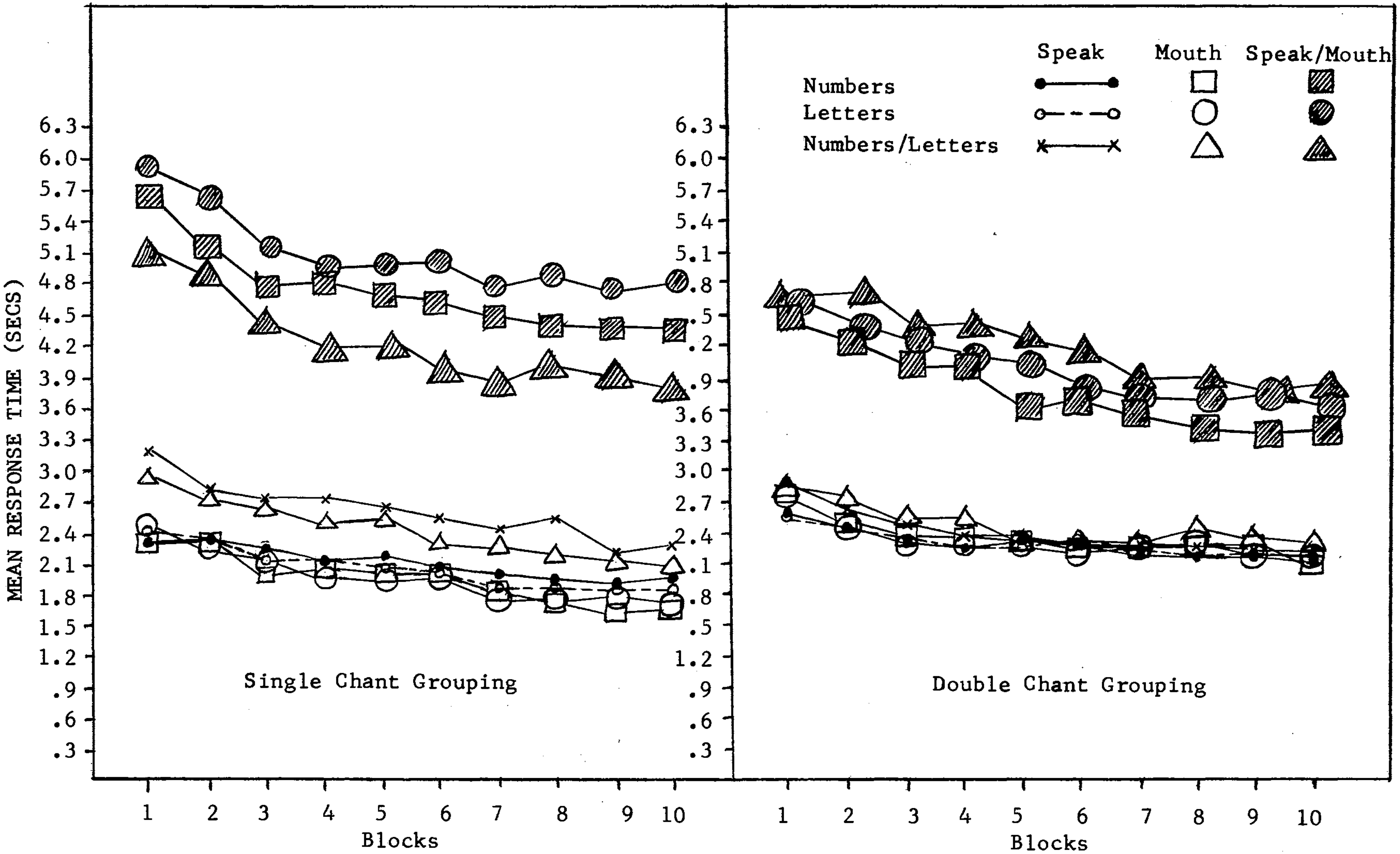

Figure 3. RT as a Function of Chant Response Intensity, Chant Material, Chant Grouping, and Trials

TABLE VII

ANALYSIS-OF-VARIANCE FOR TABLE VI MEANS OF THE DOUBLE CHANT GROUPING

Source	df	SS	MS	F
Total	71	68.0802		
Ss w group	11	17.8526		
Chant materials (C)	1	.1197	.1197	1.232
C x Ss w group	11	1.0688	.0972	
Intensity (I)	2	43.7258	21.8629	108.987 ($p < .01$)
I x Ss w group	22	4.4132	.2006	
C x I	2	.1772	.0886	2.693
C x I x Ss w group	22	.7229	.0329	

intensity effects existed for the single chant and double chant grouping: the response intensity switching effect was less pronounced for the double grouping. An analysis-of-variance (Table VIII) performed on the pooled data demonstrates that the Intensity x Grouping interaction was significant ($p < .01$). Even so, response intensity switching took significantly longer than speaking or mouthing for both single and double groupings (Tables V and X). Practice effects are evident in Figure 3. Although conditions involving intensity switching improved at faster rates, there was an overall reduction in RT across blocks for all conditions.

Discussion

Some of the results have important implications insofar as Peterson's (1969) attentional categories are concerned. Apparently, additional processing time is needed for emissive tasks which require either intensity or class switching at the response level. Applying Peterson's criteria, all the tasks included in the present experiment were emissive in nature. The following is Peterson's definition for emissive tasks:

> At the lowest level (of attention) there is identified a class of activities which is self-guided and independent of cues from peripheral sources. It has been labeled emission. (Peterson, 1969, p. 377)

In the present experiment all of the tasks, including those which required either response intensity or response class switching, were of a predictable self-maintained nature. The RTs for response intensity switching were much longer than were those for speaking alone or mouthing alone; consequently, it seems certain that tasks within one of Peterson's levels may vary considerably in processing rate. Furthermore,

TABLE VIII

POOLED ANALYSIS-OF-VARIANCE FOR SINGLE AND DOUBLE CHANT GROUPINGS[a]

Source	df	SS	MS	F
Total	143	227.8450		
Between Ss	23	44.2975		
Grouping	1	.4006	.4006	.20
Subject s grouping	22	43.8969	1.9953	
Within subjects	120	184.1228		
Intensity (I)	2	158.7771	97.3886	285.376 ($p < .01$)
Grouping x I	2	10.6309	5.3155	19.116 ($p < .01$)
I x Subjects	44	12.2394	.2782	
Chant material (C)	1	.1267	.1267	2.87
Grouping x C	1	.0966	.0966	2.19
C x Subjects	22	.9733	.0442	
I x C	2	.0977	.0489	2.20
Grouping x I x C	2	.2182	.1091	4.91 ($p < .05$)
IC x Subjects	44	.9776	.0222	

[a]Data for producing the N/L sequence were excluded for both chant groupings.

the RTs for the number and letter sequence were greater than were those for either the number sequence alone or the letter sequence alone.

Several different interpretations may be advanced to account for the increased processing times encountered in either response intensity or response class switching. Perhaps the most economic view would simply consider the increment in processing time as reflecting an additional time required for switching back and forth between response classes. Thus an interpretation is proposed in which response switching shares many characteristics with Broadbent's (1957) mechanical model for the selection of stimulus inputs, except that the selection here would be for response outputs. In addition it should be noted that most of the literature on switching time has been concerned with receptive attention, that is, where the individual attends to two different sensory inputs at the same time (i.e., Cherry, 1953; Broadbent, 1954, Treisman, 1969). Switching time in this context refers to that time interval required for switching attention rapidly back and forth from one input to the other. In contrast, the present experiment is concerned with switching time for what may be termed productive attention (Weber and Blagowsky, 1970a) in which multiple tasks are performed at the same time.

An alternative explanation would be that the additional processing time required for the switching tasks could have been the result of a heavier memory load, i.e., remembering to change from one response class to another. But it is reasonable to assume that both class and intensity switching tasks required similar demands upon memory load. There does not seem to be any credible basis for supposing that response intensity switching produced more oppressive demands upon memory than did response class switching. However, the additional processing time needed for response intensity switching was considerably more pronounced than it was for response class switching. Therefore, an explanation based simply on a heavier memory load does not seem too feasible.

A third possible approach emphasizes the role of response competition. As previously noted, response intensity switching required additional processing time for all three character sequences. Response class switching, also produced an increment in processing time when the sequences were entirely spoken or mouthed. An interpretation which employs response competition appears compatible with the above results.

A traditional S-R view would explain the present results in terms of chaining and feedback. That is, pronounciation of each successive character served as both a response and a stimulus for the next response in a simple S-R chaining fashion (Hull, 1943). Thus a situation analagous to classical response competition (Hull, 1943) could have been created for the conditions in which the subjects had to switch between speaking and mouthing. That is, each successive response served as a stimulus which evoked excitatory tendencies for both a spoken response and a mouthed response. Even if the two responses were very similar (both the spoken response and the mouthed response involved the <u>same</u> character), it is clear that they would be incompatible with one another in the sense that they could not be executed simultaneously. Thus the two response intensities gave rise to a competition between themselves. It seems plausible that the response competition could have been responsible for the increased response times that were found for response intensity switching in which subjects alternately spoke and mouthed successive characters.

Response competition was probably produced in a similar fashion for the sequences that required what has been termed response class switching. Verbal processing of number and alphabet sequences are everyday requirements in our society and are therefore strongly overlearned. In these sequences, each number (letter) elicits a strong tendency to respond with the next number (letter). When the two sequences were combined into one sequence, response competition most likely resulted. That is, each successive character (regardless of whether it was a number or a letter) acted as a stimulus for both a number and a letter response.

An interpretation based on response competition is even more appealing when the respective effects for response intensity switching and response class switching are compared. The results indicate that response intensity switching required more processing time than did response class switching. Perhaps such a relationship would be expected if it is recalled that response competition increases as a function of response similarity (Hull, 1943). Intuitively, it would appear that two competing intensity responses for the <u>same</u> number (or letter) would be more similar than would two competing class responses, that is, a number response and a letter response. If this were the case, then the level of response competition would have been greater for intensity switching than for class switching. The result of this increased response competition is the additional processing time that would be required for intensity switching as compared to class switching.

Figure 3 illustrates that the effect for intensity switching was less for the double chant grouping than it was for the single chant grouping. Once again, an explanation based on response competition and incorporating the concept of response similarity seems to be warranted. It seems likely that, during intensity switching, the competing responses (spoken versus mouthed) were more similar for the single grouping than for the double grouping. That is, two competing intensity responses for the same number (or letter) would be more similar than the case where two different numbers (or letters) were involved. For example, consider the number sequences (that involved intensity switching) for both the single and double groupings. The second response in each sequence represented the first point of response competition. For the single chant grouping, the competing responses were a spoken "2" and a mouthed "2". In the case of the double chant grouping, the competition was between a spoken "2" and a mouthed "1". Consequently, the two competing responses involved the identical character for the single sequences and were thus more similar. The result was a higher level of response competition for the single chant grouping which produced longer RTs. Thus the evidence once again suggests that processing time increases as response similarity increases.

An interpretation based upon response competition is an interesting possibility. If it is appropriate, then response switching should lose its effect with practice. According to traditional S-R theory, the associative strengths for the two competing responses would change as a consequence of practice. That is, the associative tendency for the correct response would become stronger after each trial whereas the tendency to emit the incorrect response would become correspondingly weaker. However, reference to Figure 3 illustrates that the switching effect holds after a fair amount of practice.

The idea that our limited capacity arises in response organization had received considerable attention (Deutsch and Deutsch, 1963; Reynolds, 1964; Treisman and Geffen, 1967; Deutsch, Deutsch, Lindsay, and Treisman, 1967). However, the role of response organization has previously been limited to a debate concerned with where our limited capacity exists while concurrently processing verbal tasks. That is, does our limited ability arise primarily because of limitations in perceptual or in response organization? Therefore, the function of response switching has been studied in situations in which two or more stimulus inputs are simultaneously presented at the peripheral level (the shadowing experiments, for example). In contrast, the present study seems to be unique in that the effects of response switching were examined for activities which were self-guided and independent of cues from peripheral sources.

CHAPTER IV

EXPERIMENT II: EMISSIVE TASKS AND METERED MEMORY SEARCH

The basic aim of experiment II was to determine whether different emissive activities can have significantly different effects upon an accompanying activity. Therefore the experiment examined the effects of chanting upon concurrently performed reproductive and transformational tasks. The effects of chant grouping that involved response intensity switching were compared with chant grouping that did not involve response intensity switching. In addition, the effects for single and double chant grouping upon metered memory search were noted. The reproductive and transformational tasks were the same as those used by Weber and Blagowsky (1970a), and result in a serial search process as first shown by Weber, Cross, and Carlton (1968). A further study (Weber and Blagowsky, 1970b) was conducted in order to gain a better understanding of these search processes. The primary purpose of the study was to compare the effects of implicit and explicit scanning on search time. Explicit scanning required overt verbalization while implicit scanning probably required implicit speech since the two scanning rates were approximately the same (Landauer, 1962; Weber and Bach, 1969). It was therefore concluded that internal speech forms the basis for transformations of various sizes applied to the separate stimulus items of a circular sequence. The speech process apparently operates such that sequence items, starting with the stimulus, are generated one at a time until an appropriate "meter reading" is reached (corresponding to required size of transformation). At this time, the subject overtly responds with the last item generated. Thus, this would be a serial, self-terminating, metered search process in which successive items are not just scanned from memory, but actually generated.

Therefore the metered memory search task should provide an almost completely objective method for the study of concurrent verbal activity. It would allow the subject to perform overtly a verbal subsidiary (emissive) activity and at the same time implicitly perform 0- and 1-unit transformations that respectively satisfy Peterson's definitions for reproductive and transformational tasks.

Seven hypotheses were offered: 1) There will be an effect due to transformation (T) size, a 1-unit transformation (T_1) requiring more time than an 0-unit transformation (T_0). 2) The concurrent performance of a subsidiary task (chanting) will decrease performance on metered memory search (MMS). 3) Performance of chants requiring intensity switching will decrease performance on MMS to a greater degree than the performance of chants not requiring intensity switching. 4) Single and double chant grouping will have different effects upon MMS. 5) All chant sequences will have a more pronounced effect upon T_1 than T_0. 6) Concurrent processing of chants and transformations will improve with practice, but to a lesser extent for intensity switching chants than for class switching chants. 7) The RTs for the chant sequences and transformations will not be strictly additive whenever the two are performed concurrently (some simultaneous processing will occur).

METHOD

Subjects

The Ss were all right-handed (left-handed Ss tend to cover adjacent stimuli) and undergraduate students at Oklahoma State University. Ss were given extra credit points for one of the four hours in which they served as Ss. In addition, they were paid $1.50 for each of the last three hours. There were 14 Ss, 7 for each between-S condition.

Experimental Design

The design had one between-Ss factor (chant grouping--single chant grouping and double chant grouping), and two within-Ss factors, one at two levels (transformation size--0- or 1-unit) and one at three levels (chant response intensity--no chant, number chant, and switch number chant). Seven Ss were randomly assigned to each chant grouping. The design and the specific tasks are illustrated in Table IX.

Materials and Procedure

The same circular sequence of letters was used for all of the Ss in making their transformations. It consisted of the first five letters of the alphabet, "a, b, c, d, e,; a, b, . . .". Besides the no chant (-C) condition, Ss chanted either numbers (NC) or numbers switched in intensity (SNC). For the single chant grouping, Ss spoke the first five numbers "1, 2, 3, 4, 5,; 1, 2 . . .". The SN chant required Ss to switch between speaking and mouthing the numbers as in Experiment I "1, (2), 3, (4), 5, (1), 2, (3), 4, (5)." Also as in Experiment I, the NC and SNC for the double chant grouping were "1 1,

TABLE IX

APPROPRIATE RESPONSES FOR THE VARIOUS CONDITIONS

Single Chant Grouping

Stimuli	No Chant (-C) T Size 0	No Chant (-C) T Size 1	N Chant (NC) T Size 0	N Chant (NC) T Size 1	SN Chant(SNC) T Size 0	SN Chant(SNC) T Size 1	N Chant Alone	SN Chant Alone
b	b	c	b 1	c 1	b 1	c 1	1	1
d	d	e	d 2	e 2	d(2)	e(2)	2	(2)
e	e	a	e 3	a 3	e 3	a 3	3	3
a	a	b	a 4	b 4	a(4)	b(4)	4	(4)
c	c	d	c 5	d 5	c 5	d 5	5	5
d	d	e	d 1	e 1	d(1)	e(1)	1	(1)
"	"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"	"
(15 items)								

Double Chant Grouping

Stimuli	No Chant (-C) T Size 0	No Chant (-C) T Size 1	N Chant (NC) T Size 0	N Chant (NC) T Size 1	SN Chant(SNC) T Size 0	SN Chant(SNC) T Size 1	N Chant Alone	SN Chant Alone
b	b	c	b 1,1	c 1,1	b 1(1)	c 1(1)	1,1	1(1)
d	d	e	d 2,2	e 2,2	d 2(2)	e 2(2)	2,2	2(2)
e	e	a	e 3,3	a 3,3	e 3(3)	a 3(3)	3,3	3(3)
a	a	b	a 4,4	b 4,4	a 4(4)	b 4(4)	4,4	4(4)
c	c	d	c 5,5	d 5,5	c 5(5)	d 5(5)	5,5	5(5)
d	d	e	d 1,1	e 1,1	d 1(1)	e 1(1)	1,1	1(1)
"	"	"	"	"	"	"	"	"
"	"	"	"	"	"	"	"	"
(15 items)								

2 2, 3 3, 4 4, 5 5, 1 1, 2 2, . . ." and "1, (1), 2, (2), 3, (3), 4, (4), 5, (5), 1, (1), 2, (2), . . ." respectively.

There were eight within-S conditions for both the single chant grouping and the double chant grouping. The eight conditions and their appropriate responses for each group are illustrated in Table IX. The letters represent written transformational responses and the numbers represent spoken or mouthed chant responses. In the case where transformations were performed with -C only the terminal response corresponding to the required size of transformation was written by the S. In the case where trials required both transformations and chants, the S was instructed to synchronize the chant response with the transformational response. That is, he would write the terminal response and, at the same time, speak the chant.

As an example, consider the first row to illustrate the Ss tasks for a 1-unit transformation. If he were in the single chant group, then a 1-unit transformation with -C would just involve the S writing a "c". If the condition involved a 1-unit transformation and NC, his response would be to write "c" and simultaneously speak "1". The Ss in the double chant group performed in the same manner except the chant sequences differed as shown in Table IX.

The experiment began with the presentation of a 4½ x 11 inch sheet of paper with a column of fifteen typed, lower case letters. The letters a, b, c, d, and e occurred in internally randomized blocks of five. In chant alone as well as in other conditions, the chant sequence was performed three times for each trial. Thus the number of chant and/or transformation items per trial was always 15. In a space beside each letter the S wrote in his normal script handwriting the appropriate transformation responses from the top to the bottom of the 15-letter page. He was instructed to go as rapidly as he could, but that he could not make more than two or three errors on the 15-line page.

Each S was run over a four-day period. The first day consisted of instructions and four blocks of practice. On the first day, all Ss were told that the object of the experiment was to see how quickly they could process certain kinds of information (instructions presented in Appendix B). For the transformation instructions each S was shown a 3 x 5 inch card with the letters a, b, . . . e shown in a circular sequence. They were told to note that it was a circular sequence, and that for any letter shown to them, it should be possible for them to provide without hesitation the next letter in the sequence. Examples were then given for each of the five letters. The circular sequence was then placed so that it could be viewed by the Ss for the entire experiment.

Next the S was presented 3 x 5 inch cue cards with either a 0, or 1 on them, signifying size of transformation. Each S performed fifteen such transformations after each of these two cards was presented. Three other cue cards were also presented to all Ss. For the Ss in the single chant group, the cards contained the word "NONE" (-C) or the numbers 1, 2, 3, 4, 5, (NC), or 1, (2), 3, (4), 5 (SNC). Ss were instructed to speak (or speak and mouth) the chants three times in rapid succession (corresponding to the fifteen lines of the column). Hence, the number of chant items and the number of items to be transformed were equal. In addition to the "NONE" card, Ss in the double chant group were shown cards with either 1 1, 2 2, 3 3, 4 4, 5 5 (NC), or

1, (1), 2, (2), 3, (3), 4, (4), 5, (5) SNC) on them.

Then each S was presented the chant and transformation cue cards in combinations. The Ss were shown the chant cue cards and after about two seconds they were shown the cue card with the required transformation on it. The E demonstrated a 0-unit transformation and NC, and a 0-unit transformation and SNC for each S, stressing that they were to synchronize their verbal and written responses. This was easily done by all Ss.

After presentation of instruction, each S received four blocks of trials for practice. These were given to insure that the S understood what each of the eight conditions required and to encourage the S to synchronize his responses. A block of trials consisted of a booklet of eight pages, one page for each condition.

The experiment proper consisted of thirty blocks for each S over an additional three-day period. Ten blocks were presented each day for three consecutive days (with few exceptions). The eight conditions were randomized for each block so that each S had a different order than other Ss in each block. A restriction on randomization was that the same condition could not appear at both the end of one block and at the beginning of the next block.

A trial of fifteen transformations started with the cue card(s) depicting the condition, the E saying "start" and ended with the S saying "stop". The time interval between "start" and "stop" constituted the response time (RT) for a trial, and was recorded on a stopwatch. The entire session comprised about fifty minutes each session for the three sessions. Between each block of eight pages there was an approximate 30-second rest period. Between pages within a block there was a period of about 10 seconds while the E recorded RT on a prepared sheet. For each S, the RTs for blocks 10 and 20 were recorded on a tape recorder. These tape recordings were later used in computing a reliability measure that examined the accuracy of the RTs.

In order to provide time measures for individual chant and transformational responses, additional apparatus were utilized on blocks 29 and 30 for each S. A modified Grason-Stadler voice operated relay (model E 7300A-1) with one microphone registered RTs for each one of the 15 chant responses on a Rustrak event recorder (model 229-4) running at a tape speed of ½ inch per second. In order to measure individually the 15 concurrently performed transformational responses, the event recorder was included in an additional circuit with a 24 inch x 34 inch aluminum sheet and the S performed trials of 15 transformations by writing with a soft number pencil his responses directly on the metal beside the stimuli. When the pencil was in contact with the metal, the circuit was complete thus operating the event recorder and providing a measurement of the RT for each of the individual transformations. The RTs for the 15 individual chant responses and transformations were measured to an accuracy of approximately 1/16 sec. by measuring the tape to the nearest 1/32 inch.

Results

Descriptive statistics for RT as a function of chant grouping, transformation size, and chant response intensity are presented in Table X. Mean RTs were determined by averaging over 28 trials and the 14 Ss. The last two trials were considered separately because they involved additional apparatus. Figure 4 shows RT as a function of

TABLE X

RT DESCRIPTIVE STATISTICS AS A FUNCTION OF CHANT GROUPING, TRANSFORMATION SIZE AND CHANT RESPONSE INTENSITY

Single Grouping

Condition	0 -C	1 -C	ON	1N	OSN	1SN	NC Alone	SNC Alone
Mean[a]	6.99	10.68	7.60	11.77	12.56	18.44	2.39	5.116
S.E.M.	.81	1.24	1.02	1.74	2.39	2.97	.14	.80

Double Grouping

Condition	0 -C	1 -C	ON	1N	OSN	1SN	NC Alone	SNC Alone
Mean	7.49	10.93	8.82	12.53	11.35	14.79	6.18	9.10
S.E.M.	1.02	.75	.88	.89	1.21	1.89	1.00	1.12

[a]Means determined by averaging over number of Ss (N = 7 for each group) and number of trials (28 trials).

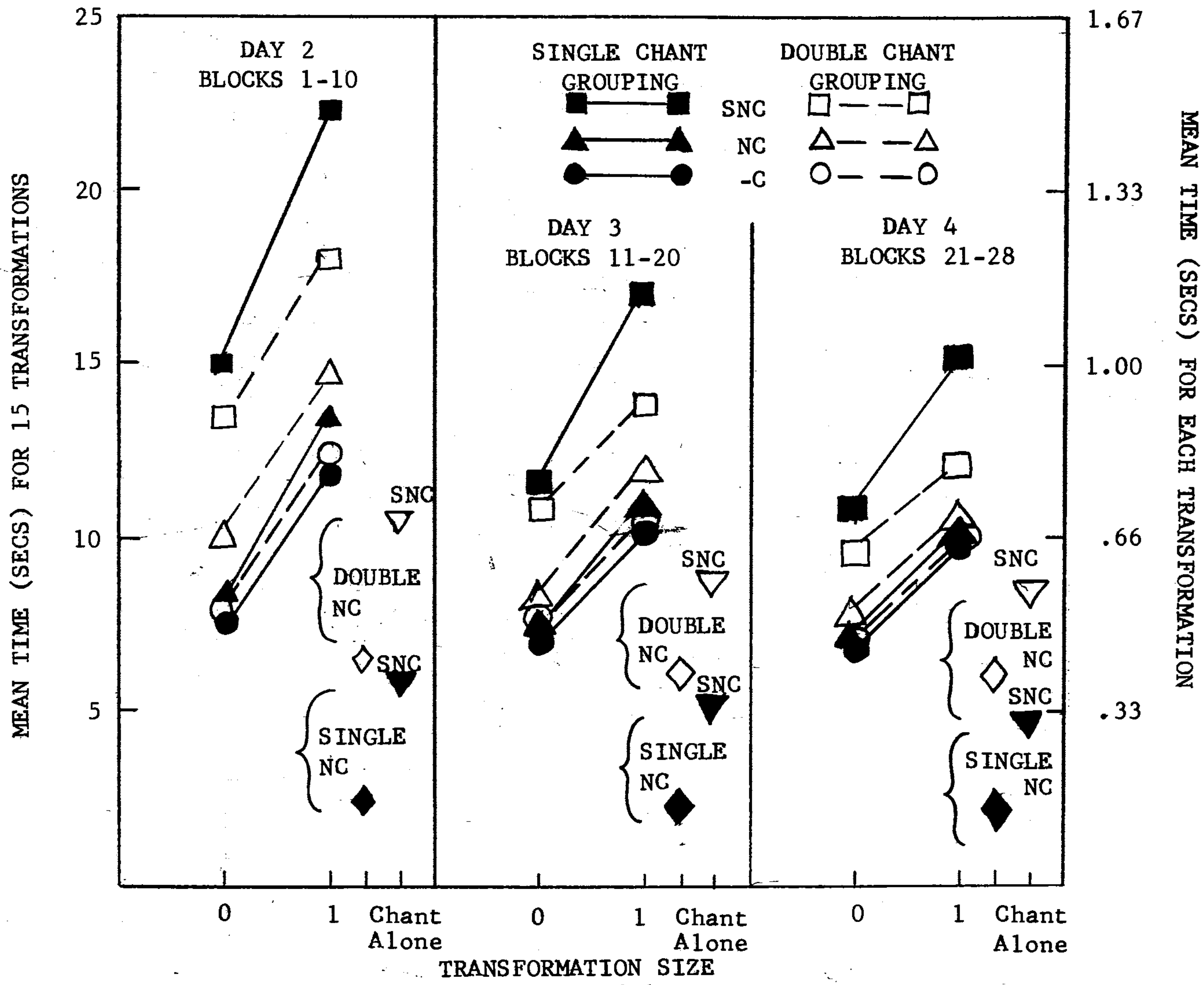

Figure 4. RT Shown as a Function of Chant Response Intensity, Transformation Size, Chant Grouping

transformation size, with chant grouping and chant response intensity as the parameters. The left ordinate shows RT for the 15 transformations on a page, and the right ordinate shows the same information expressed as time per transformation. The successive panels in Figure 4 represent different stages of practice. The lower right-hand corner of each panel shows Chant Alone times for the Number Chant (NC) and the Number Switched Chant (SNC) for both single and double chant groupings.

Figure 4 and Table X suggest that both transformation size and chant response intensity were effective variables. Significance tests for the conditions of Table X confirmed this. The main analysis (Table XI) was an analysis-of-variance performed on the mean RTs for each S at each condition. The main effects for transformation size and chant response intensity were significant ($p < .01$). It is apparent from Figure 4 that RT increased for both chant groupings as transformation size increased. It is alo apparent that chant response intensity had an effect on the concurrently performed transformations. That is, the RTs for both groups increased as chant response mode changed from -C to NC to SNC.

Figure 5 helps clarify the Grouping x Chant response intensity interaction that was significant ($p < .01$) in Table XI. Figure 5 indicates that chant response intensity had a somewhat smaller effect for the double chant grouping than it had for the single chant grouping. In order to determine if chant response intensity was an effective variable for both chant groupings, two separate analyses-of-variance were performed on the data (Table XII). The first analysis considered the data for the single chant grouping and the second analysis concerned the data for the double chant grouping. Table XII demonstrates

TABLE XI

ANALYSIS-OF-VARIANCE FOR TABLE X MEANS

Source	df	SS	MS	F
Total	83	1032.9763		
Between Ss	13	122.5980		
Grouping	1	2.5636	2.6636	.27
Ss w group	12	119.9344	9.9945	
Within Ss	70	910.3783		
Transformations (T)	1	345.2711	345.2711	157.0871 ($p<.01$)
Grouping x T	1	5.7367	5.7367	2.61
T x Ss w group	12	26.3776	2.1981	
Chant Response Intensity(I)	2	428.5388	214.2694	116.4318 ($p<.01$)
Grouping x I	2	46.4799	23.2399	12.6383 ($p<.01$)
I x Ss w group	24	44.1672	1.8403	
T x I	2	4.3776	2.1880	12.0617 ($p<.01$)
Grouping x T x I	2	5.0762	2.5381	13.9917 ($p<.01$)
T x I x Ss w group	24	4.3532	.1814	

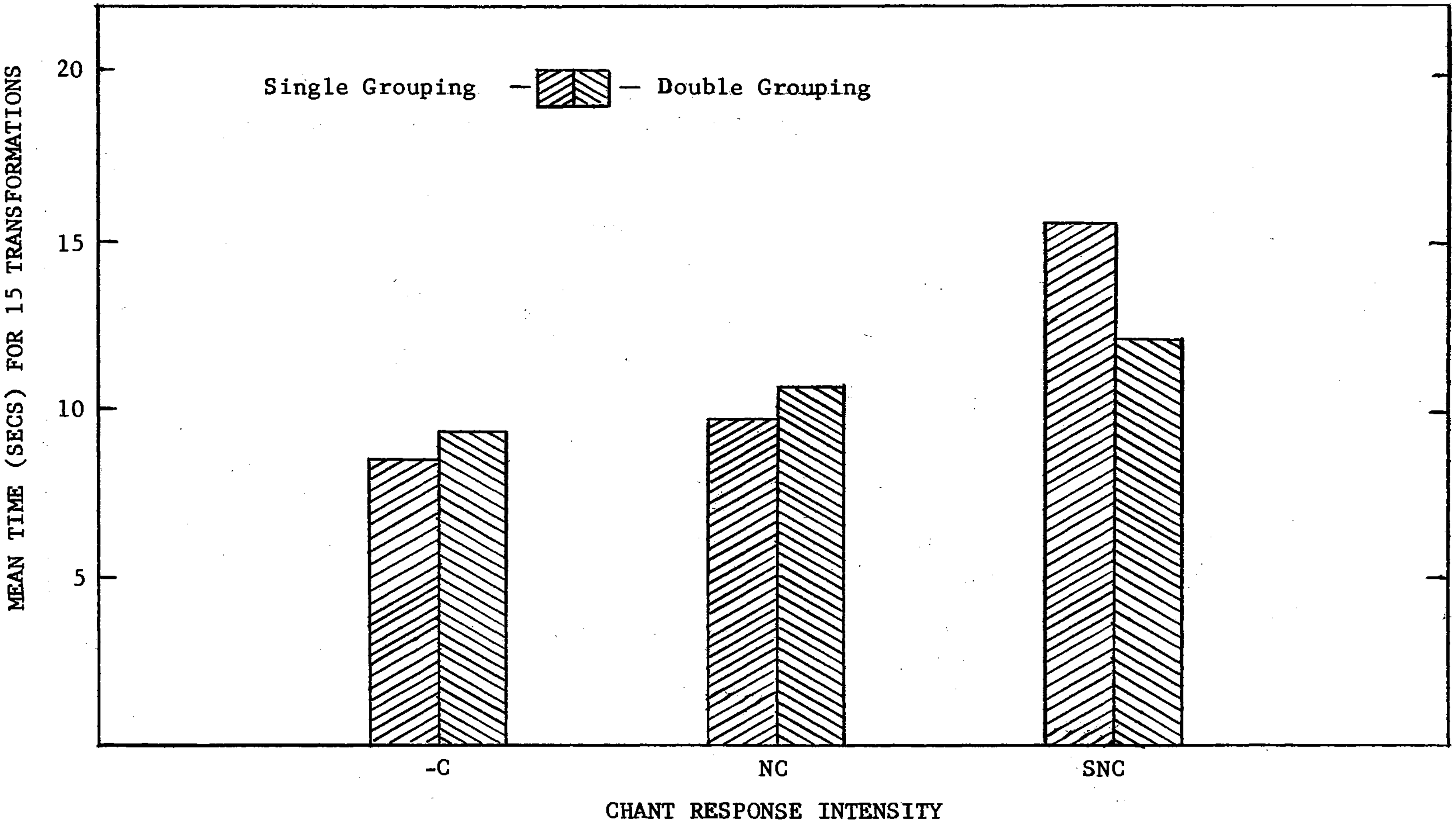

Figure 5. Illustration of Interaction Between Chant Grouping and Chant Response Intensity

TABLE XII

ANALYSES-OF-VARIANCE FOR SINGLE AND DOUBLE CHANT GROUPING

Single Chant Grouping

Source	df	SS	MS	F
Total	41	735.1296		
Ss w group	6	87.5681		
Chant Response Intensity	2	368.5515	184.2758	73.99 ($p < .01$)
Chant Response Intensity x Ss w group	12	29.8866	2.4906	
Tran.	1	220.0096		73.25 ($p < .01$)
Tran. x Ss w group	6	18.0203	3.0034	
Chant Response Intensity x Tran.	2	9.2839	4.642	30.78 ($p < .01$)
Chant Response Intensity x Tran. x Ss w group	12	1.8096	.1580	

Double Chant Grouping

Source	df	SS	MS	F
Total	41	295.1832		
Ss w group	6	32.3664		
Chant Response Intensity	2	106.4674	53.2337	44.73 ($p < .01$)
Chant Response Intensity x Ss w group	12	14.2804	1.1900	
Tran.	1	130.9984	130.9984	94.05 ($p < .01$)
Tran. x Ss w group	6	8.3571	1.3929	
Chant Response Intensity x Tran.	2	.1696	.0848	.40
Chant Response Intensity x Tran. x Ss w group	12	2.5439	.2120	

that chant response intensity was indeed an effective variable for both chant groupings ($p < .01$).

Table XII also provides information relevant to the Chant grouping x Transformation x Chant response intensity interaction that was significant ($p < .01$) in Table XI. This interaction may be seen in Figure 6 which suggests that the effects produced by chant response intensity were differential when transformation size is considered for the single chant grouping, but not for the double chant grouping. Such a suggestion is confirmed by Table XII which reveals that the Chant response intensity x Transformation interaction was significant only for the single chant grouping ($p < .01$).

In view of the Transformation x Chant response intensity interaction ($p < .01$) in Table XI, tests on the simple main effects were conducted. An analysis-of-variance was performed for each one of the three chant response intensities (Table XIII). As suggested by Figure 6, the effect for transformation size was significant for all three chant response intensities ($p < .01$). Additional information on the Transformation x Chant response intensity interaction results from two analyses-of-variance conducted for each one of the two transformation sizes (Table XIV). Chant response intensity was significant for both of the transformation sizes ($p < .01$).

Although an effective variable for both transformation sizes, the effects of chant response intensity were examined at each level of transformation for each chant grouping. These additional tests were conducted because of the Chant grouping x Transformation x Chant response intensity interaction that has been previously discussed. An analysis-of-variance performed at each transformation size for each

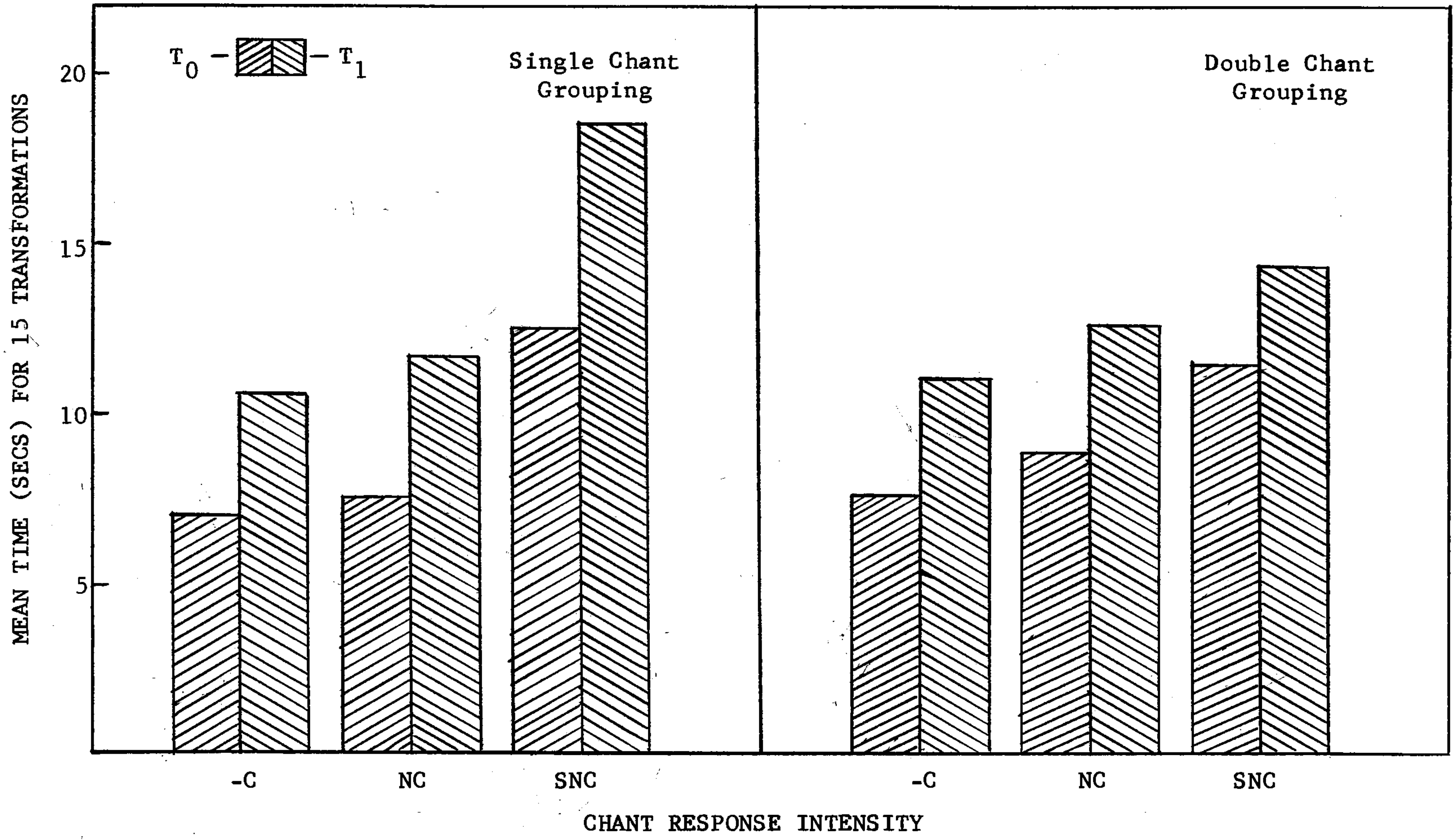

Figure 6. Illustration of the Effects of Chant Response Intensity Upon Transformation Size for Both Chant Groupings

TABLE XIII

ANALYSIS-OF-VARIANCE ON TRANSFORMATION SIMPLE MAIN EFFECTS FOR EACH CHANT RESPONSE INTENSITY

No Chant

Source	df	SS	MS	F
Total	27	116.5591		
Between Ss	13	17.4397		
Grouping	1	.9732	.9732	.71
Ss w group	12	16.4665	1.3722	
Within Subj.	14	99.1194		
T	1	88.7793	88.7793	104.10 ($p < .01$)
Grouping x T	1	.1069	.1069	.13
T x Subj. x group	12	10.2332	.8528	

Number Chant

Source	df	SS	MS	F
Total	27	146.5410		
Between Ss	13	29.0435		
Grouping	1	6.8409	6.8409	3.70
Ss w group	12	22.2026	1.8506	
Within Subj.	14	117.4975		
T	1	108.7203	108.7203	155.14 ($p < .01$)
Grouping x T	1	.3676	.3676	.52
T x Subj. w group	12	8.4096	.7008	

Switch Number Chant

Source	df	SS	MS	F
Total	27	341.3364		
Between Ss	13	166.7620		
Grouping	1	41.3295	41.3295	3.95
Ss w group	12	125.4325	10.4527	
Within Subj.	14	174.5744		
T	1	152.1491	152.1491	151.05 ($p < .01$)
Grouping x T	1	10.3383	10.3383	10.26 ($p < .01$)
T x Subj. w group	12	12.0870	1.0073	

TABLE XIV

2 x 3 ANALYSIS-OF-VARIANCE FOR EACH LEVEL OF TRANSFORMATION

T_0

Source	df	SS	MS	F
Total	41	259.9809		
Between Ss	13	56.5172		
Grouping	1	.2912	.2912	.06
Ss w group	12	56.2260	4.6855	
Within Subj.	28	203.4637		
Chant Response Intensity	2	173.5442	86.7721	109.63 ($p<.01$)
Grouping x Chant Response Intensity	2	10.9243	5.4622	6.90 ($p<.05$)
Chant Response Intensity x Ss w group	24	18.9952	.7915	

T_1

Source	df	SS	MS	F
Total	41	427.7233		
Between Ss	13	98.1951		
Grouping	1	2.9303	2.9303	.37
Ss w group	12	95.2648	7.9387	
Within Ss	28	329.5282		
Chant Response Intensity	2	259.3723	129.6862	127.86 ($p<.01$)
Grouping x Chant Response Intensity	2	45.8105	22.9052	22.58 ($p<.01$)
Chant Response Intensity x Ss w group	24	24.3454	1.0143	

chant grouping (Table XV) demonstrates that chant response intensity was significant ($\underline{p} < .01$) at each transformation size for each chant grouping. Comparisons, using the Neuman-Kuels procedure were made on the effects of chant response intensity at each level of transformation size for both chant groupings. The SNC was significantly longer than the -C or NC in all comparisons ($\underline{p} < .01$), however, NC was significantly longer than -C only for the comparisons in the double chant grouping.

In order to examine the efficiency of concurrent verbal processing, Table XVI was constructed. It represents a summary or derived scores that are the result of a subtraction process. For example, if comparisons desired are those of performing an SNC and a 1-unit transformation separately with the above tasks performed concurrently, the Table would be entered by reference to the summed 1 + SNC and the concurrent column 1 SNC respectively. Presumably, concurrent processing was more efficient in those instances where the summed RTs for transformations and chants, performed separately, exceeded RTs for the two tasks performed concurrently. An inspection of Table XVI reveals that the summed RTs were longer than the concurrent RTs in 1260 of the 1568 possible comparisons. Two more findings were, first, that summed RTs exceeded concurrent RTs more frequently in the case of NC and transformations (654) than for SNC and transformations (525), and, second, that summed RTs exceeded concurrent RTs more often for the double chant grouping (762) than for the single chant grouping (498). In the case of the single chant group the summed RTs exceeded the concurrent RTs 351 times out of a possible 392 when NC was performed and 147 times when SNC was performed. For the double chant grouping, the corresponding frequencies were 384 and 378 respectively. It may also be seen that the summed RTs

TABLE XV

ANALYSIS-OF-VARIANCE FOR EACH TRANSFORMATION SIZE AND CHANT GROUPING

Single Grouping, T_0

Source	df	SS	MS	F
Total	20	182.8281		
Ss w group	6	39.6801		
Chant Response Intensity	2	130.6869	65.3435	62.93 ($p < .01$)
C x Ss w group	12	12.4611	1.0384	

Single Grouping, T_1

Source	df	SS	MS	F
Total	20	332.2920		
Ss w group	6	65.9084		
Chant Response Intensity	2	247.1485	123.5743	77.09 ($p < .01$)
C x Ss w group	12	19.235	1.6029	

Double Grouping, T_0

Source	df	SS	MS	F
Total	20	76.8617		
Ss w group	6	16.5460		
Chant Response Intensity	2	53.7818	26.8909	49.39 ($p < .01$)
C x Ss w group	12	6.5339	.5445	

Double Grouping, T_1

Source	df	SS	MS	F
Total	20	87.3221		
Ss w group	6	24.1775		
Chant Response Intensity	2	52.8553	26.4277	30.82 ($p < .01$)
C x Ss w group	12	10.2893	.8574	

TABLE XVI

DIFFERENCES BETWEEN RTs FOR CHANTS AND TRANSFORMATIONS PERFORMED CONCURRENTLY AND THE SUM FOR EACH PERFORMED SEPARATELY

Group								
Single Chant	0+N	ON	1+N	1N	0+SN	0SN	1+SN	1SN
Mean[a]	9.388	7.604	13.073	11.774	12.113	12.566	15.798	18.444
T+C>TC[b]	0+N>0N=190		1+N>1N=161		0+SN>0SN=106		1+SN>1SN=41	
T+C-TC[c]	(0+N)-0N=1.784		(1+N)-1N=1.299		(0+SN)-0SN=-.453*		(1+SN)-1SN=-2.646*	
Double Chant								
Mean	13.682	8.822	17.119	12.533	16.602	11.352	20.039	14.798
T+C>TC	0+N>0N=195		1+N>1N=189		0+SN>0SN=195		1+SN>1SN=183	
T+C-TC	(0+N)-0N=4.860		(1+N)-1N=4.586		(0+SN)-0SN=5.250		(1+SN)-1SN=5.241	

[a]Means determined by averaging over number of Ss (N=7 for each group) and 28 trials 7x28=196.

[b]Number of times out of possible 196 that RTs for transformations and chants performed separately but added together exceeded RTs for the same two tasks performed together.

[c]The mean difference between the summed separate RTs and the concurrent RTs.

*Evidence of a loss in efficiency when the two tasks are performed concurrently.

exceeded the concurrent RTs more times for the 0-unit transformation (686) than for the 1-unit transformation (574).

Mean differences for the summed separate RTs and concurrent RTs varied considerably for chant grouping, chant response intensity, and transformation size. Subtraction of the concurrent RTs from the summed RTs yielded the largest mean differences for the double chant grouping and for the NC. Most important in this respect, however, was the finding that the summed RTs were actually less than the concurrent RTs in the case of the SNC (at both transformation sizes) for the single chant grouping, indicating that there was a loss in efficiency when the two tasks were performed concurrently.

Practice effects are clearly evident in Figure 4. There was an overall reduction in RT across blocks. It is also clear from Figure 4 that many of the conditions improved at different rates. However, the primary interest was the concurrent conditions. Table XVII presents the frequency with which summed RTs speeded concurrent RTs as a function of blocks.

Since RTs for the various conditions were monitored with a stopwatch, a reliability measure was performed to insure that the RT measurements were reasonably accurate. The reliability was determined by measuring the RTs a second time through utilization of the tape recordings. The RTs for 16 trials (blocks 10 and 20) for each group were recorded on a tape recorder and then remeasured from the tape with a stopwatch. The original RTs were then correlated with the second RTs from the tape. The following product-moment coefficients were obtained: $r = .96$ for the single chant group and $r = .98$ for the double chant grouping, indicating the method for measuring RTs in the experiment was

TABLE XVII

FREQUENCY WITH WHICH SUMMED RTs EXCEEDED CONCURRENT RTs AS A FUNCTION OF PRACTICE

Single Chant Grouping

T + C TC	Blocks			
	1-7	8-14	15-21	22-28
NC				
0+N>0N[a]	45	48	49	48
1+N>1N	31	37	42	49
SNC				
0+SN>0SN	10	23	30	37
1+SN>1SN	5	11	8	11

Double Chant Grouping

T + C TC	Blocks			
	1-7	8-14	15-21	22-28
NC				
0+N>0N	48	49	49	49
1+N>1N	46	49	47	49
SNC				
0+SN>0SN	48	49	49	49
1+SN>1SN	38	47	49	49

[a]Number of times out of possible 49 that RTs for transformations and chants performed separately but added together exceeded RTs for the same two tasks performed together.

satisfactory.

As indicated in the method section, the 15 transformations and/or chants for each trial were individually measured in blocks 29 and 30. It was intended to examine the data in order to determine whether chant response intensity increased the response duration for transformations or the intervals between the transformation responses. However, observation of the Ss' behavior suggested that there were certain inadquacies in the procedure. That is, the S often tapped the metal with his pencil between successive responses. The result of these activities was a false inflation of the true response duration. Thus any conclusions about the effects of chanting on either response duration or the interval between response would be misleading if based on an analysis of the present data. However, since the method would seem to hold promise, the preliminary findings are presented in Appendix C.

Discussion

The results indicate that different tasks within the emissive level can have differential effects upon the efficiency with which an accompanying task is processed. That is, switching between speaking and mouthing the numbers (response intensity switching) produced significantly greater decrements upon the performance of MMS than did simply speaking the numbers. Peterson was aware that differing tasks within one of his levels may differentially effect performance on another task although his experiment (1969) did not reveal any such differences. This may have been the result of an inadequate sampling of tasks at the same level of attention in his classification. In any event, there seems to be little doubt that MMS can be concurrently performed more efficiently with a spoken number chant than with numbers switched in intensity.

That chant response intensity had an extremely pronounced effect upon MMS performance is very evident when one considers the previously mentioned subtraction method. It will be recalled that when the chants were simply spoken, the summed RTs for chants and transformations performed separately exceeded the concurrent RTs. In marked contrast, when the numbers were switched between the two intensity levels the concurrent RTs exceeded the summed RTs (only for the single-grouped chants, however). Thus time switching was evidently involved when the numbers were switched for the single-grouped chants. Accordingly, it seems likely that concurrent verbal processing was much more efficient where the numbers were spoken.

The use of subtraction methods has received criticism (Woodworth, 1938; Johnson, 1955). However, the subtraction process utilized in the present experiment differs from the classical subtraction methods in both purpose and method and is not subject to the same criticisms. The purpose of classic subtraction methods has been to study stages of information processing (Sternberg, 1969a). This approach assumes that the interval between a stimulus and a response is composed of several stages that do not overlap (components within a stage may be either serial or parallel). It is further assumed that the different stages can be individually studied by a method similar to the one described by Sternberg:

> To use the subtraction method one constructs two different tasks in which RT can be measured, where the second task is thought to require all the mental operations of the first, plus an additional inserted operation. The difference

> between mean RTs in the two tasks is interpreted as an estimate of the duration of the inserted stage . . . (Sternberg, 1969b, p. 421).

This interpretation depends on the validity of the assumptions previously mentioned and an assumption which Sternberg (1969b) refers to as pure insertion which states that changing from one task to another does not alter any of the processing stages. In contrast to the above approach, the present utilization of subtraction was not directed at the study of stages within a task.

The present finding that different tasks within the emissive level can differentially effect performance on an accompanying task agrees with the results of a study discussed earlier (Weber and Blagowsky, 1970a). In that study it was found that a forward number chant could be concurrently processed more efficiently with MMS than could a backward letter chant. Yet, the degree of difference between the effects upon MMS for the above two chants was not nearly so large as the present difference between chant sequences with and without responses intensity switching. That is, although performance for MMS was decreased when subjects concurrently chanted a backward letter chant or a forward number chant, the summed RTs for transformations and chants, performed separately, exceeded the concurrent RTs in some conditions for both chants. Consequently, the different effects produced by the two chants in the Weber and Blagowsky (1970) investigation were not nearly so dramatic as are the present differential effects produced by intensity switching.

The evidence that has been considered demonstrates that two verbal activities within one of Peterson's levels of attention (emissive level) can have significantly different effects upon an accompanying activity. It therefore is concluded that different tasks within the emissive level may require different levels of attention. Accordingly, Peterson's categories need revision in order that an appropriate allowance may be made. Insofar as the present study is concerned, it is concluded that additional attention is needed for emissive tasks which entail response intensity switching. Yet the question remains as to why response intensity switching requires increased attention. In considering such a question it may prove beneficial to view the chant behavior as a type of search or scan through memory. This approach yields the interesting speculation that degree of attention may in some manner be related to the particular scan mechanism that is utilized for a specific chant sequence.

Figure 7 presents potential scanning models for the memory representation of each one of the chant sequences that were employed in the present investigation. Mouthed numbers appear in parentheses; spoken numbers are not enclosed in parentheses. In addition, the solid lines represent scan that end in an overt response (may be <u>either</u> spoken or mouthed) whereas the dotted lines do not culminate in an overt response, but rather in hypothetical deleted stages. It should be mentioned at this point that one could reasonably argue that Figure 7c is unnecessarily elaborate. That is, that 1 should "lead to" (2) rather than (1). This added step was motivated by the need to get at least as many steps (30) in single grouping as double grouping. In addition, the added step aids the development of ideas that follow concerning "deletion" and "re-cycling."

Attention is first directed at the two chant sequences that did <u>not</u> involve intensity switching (Figures 7a and 7b). In the case of

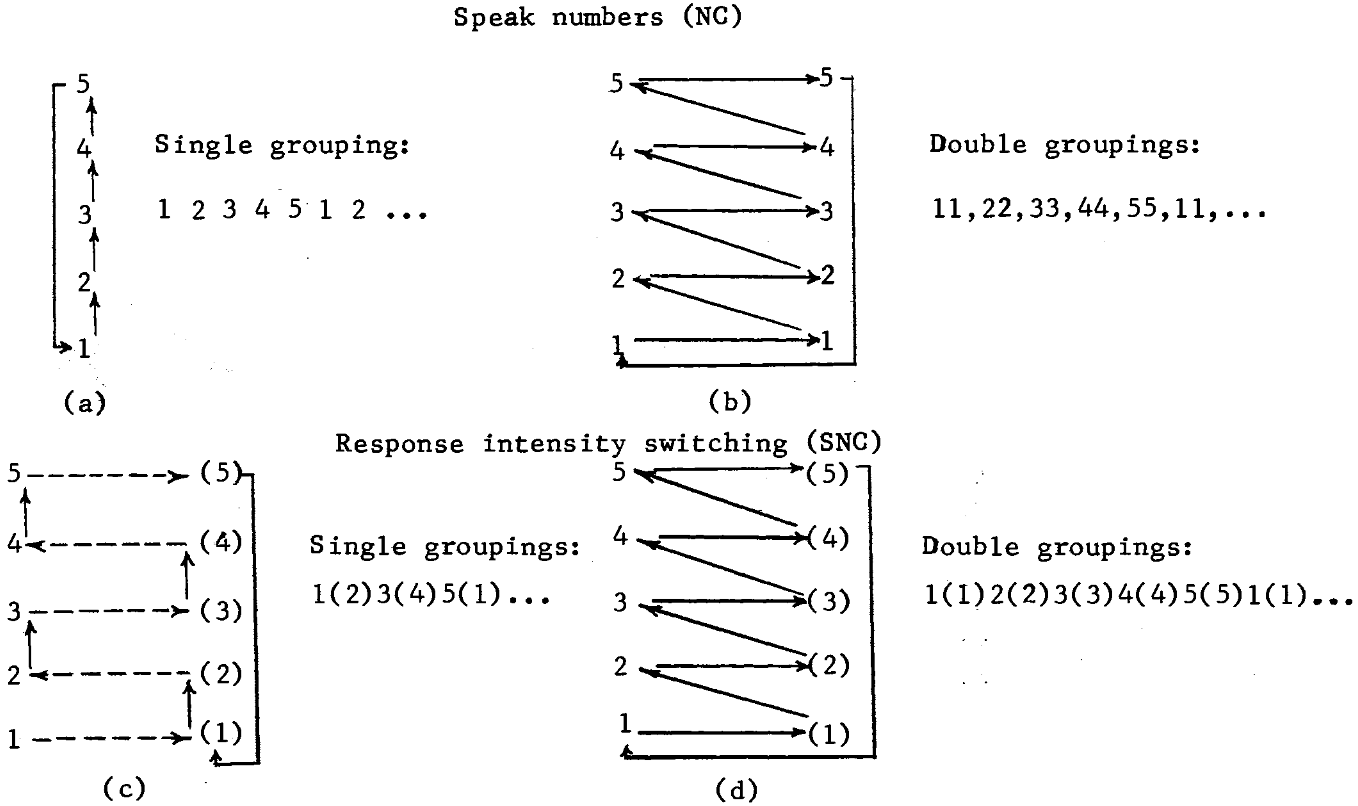

Figure 7. Models for the memory scan mechanisms that could have been employed for the chant sequences

single grouping, the most economic scan would consider the numbers in the highly overlearned routine discussed in Experiment I. As indicated in Figure 7a, the numbers would be scanned in a forward fashion. If the numbers were to be recalled in any other order the scanning procedure must altered, which is difficult, just as it is difficult to rearrange an ordinary list of numbers and say them backwards.

For immediate purposes it will be assumed that each number is stored and retrieved in relation to other numbers; in the retrieval of a particular number there is a minimum number of operations involved in its retrieval. Accordingly, the operations involved in going from one number to another help outline the route for the scanning process. These operations would be relatively simple in the case of simply speaking the single grouping (Figure 7a). The first few scan operations and their respective responses (from a total of 15) would be "start, 1, up, 2, up, 3, up, 4, up, 5, down four numbers, 1, up, 2, . . .". Using these operations and the arrows illustrated in Figure 7a, it is relatively easy to trace the scan pattern that is being suggested.

If the numbers are to be spoken in any other manner--for example, as in the double chant grouping--then a different strategy must be employed. How might an individual go about this task? One of several possibile scans is presented in Figure 7b. Its corresponding operations (from a total of 30) and scan responses would be "start, 1, right, 1 up + left, 2, right, 2, up + left, 3, right, 3, up + left, 4, right, 4, up + left, 5, right, 5, down four numbers and left, 1, right, 1, . . ." In comparison to Figure 7a, it may be seen that the search plan in Figure 7b requires added scanning. Consequently, the additional processing time that was needed for speaking the double grouping compared to the single grouping may be partially a reflection of this increased scanning. Of course, double grouping also requires twice as many responses as when the chants were simply spoken. This is not the case, however, when the chants are spoken and mouthed. (Note that a larger sample of responses was presented for the scan represented in 7b than for the one represented in 7a. In order to avoid possible confusion it should be mentioned that speaking numbers in the case of single grouping results in 15 total overt responses. In contrast, speaking numbers in the case of double grouping eventuates in a total of 30 overt responses). However, the double grouping at every stage of practice requires more than twice as much time as the single grouping. Thus, the fact that there are twice as many responses for the double chant grouping only partially accounts for the difference between speaking the two groupings.

There are apparently some search plans that the individual can execute more readily than others. As established in the results, it is difficult to switch between speaking and mouthing an ordinary list of numbers: the operations representing simple spoken associations are evidently more convenient or more reliable than the operations that combine spoken and mouthed associations. The results also demonstrate that the search plan for response intensity switching is more demanding in the event that chants are single grouped rather than double grouped. Inspection of Figures 7c and 7d suggests several reasons that could account for this relationship.

First, response intensity switching likely involves two types of scanning in the case of the single chant grouping, whereas only one type of scanning seems likely for the double chant grouping.

Considering response intensity switching for the single chant grouping first (Figure 7c), it is noted that some scans represented by solid lines, culminate in an overt response (either spoken or mouthed) and some scans, displayed by dotted lines, lead to no response. In contrast, all scans for the double chant groupings (Figure 7d) eventuate in overt responses. It seems entirely feasible that scans ending in overt responses might be executed more competently than scans ending in mixed overt and covert responses.

Secondly, response intensity switching for single grouping involves another hypothetical component, deletion, that is absent when response intensity switching is performed with double grouping. That is, ½ of the numbers are not overly responded to (either spoken or mouthed) during three passes through the sequence. Consider the first several operations and their corresponding responses (from a total of 30) for intensity switching with single grouping. "Start, 1, right+deletion, (1), up, (2), left+deletion, 2, up, 3, right+deletion, (3), up, (4), left+deletion, 4, up, 5, right+deletion, (5), down four numbers, (1), left+deletion, 1, up, 2, . . ." The numbers that are underlined represent overt responses (may be either spoken or mouthed); those not underlined are hypothetical deleted stages. (Numbers which are underlined and appear in parentheses were mouthed; numbers which are underlined only are spoken.) It may be seen that every other number has to be deleted (that is, neither spoken or mouthed). Thus, 15 numbers are responded to (either spoken or mouthed) and 15 numbers are deleted during 3 passes through the sequence. However, this additional operation was not needed for response intensity switching in the case of the double grouping in which all 30 numbers were either spoken or mouthed. Presumably, the added operation of deletion could have increased execution time for the scanning process.

Finally, there exists a third alternative that is perhaps responsible for the increased processing time that single grouping incurred for response intensity switching. When response intensity was switched in the case of the single grouping (Figure 7c), there had to be some provision for avoiding, on the second pass through the numbers, those numbers that were responded to on the first. That is, numbers that were either spoken or mouthed on the first pass must then be deleted on the second pass in a manner depicted in the above sequence of scan operations and responses for intensity switching with single grouping. That is, directly opposed numbers are underlined (representing overt responses) during the second pass through the sequence as compared to the first pass. It is as if the search plan had to be "recycled" with the operations accordingly rearranged in order that the necessary deletion and correct kind of scans were executed during the second pass. In contrast, and as demonstrated in Figure 7d, the search plan for intensity switching in the case of double grouping remained the same and was identical for all passes through the sequence.

The added necessity of rearranging the search is viewed as the most likely candidate for the increment in response time that accrued for response intensity switching in the case of single chant grouping compared to response intensity switching for double chant grouping. If deletion and/or different kinds of scan (and not rearrangement of the search plan) were responsible for the increment in processing rate, then execution of the search plan exemplified in Figure 8 should take just as long as two passes through the search plan illustrated in

Figure 7c. That is, both search plans contain 10 overt responses (5 spoken and 5 mouthed), require deletion of 10 numbers, and entail two kinds of scanning. The only obvious difference between the search plans (aside from specific numbers) is that the search plan in Figure 7c has to be rearranged before the second scan pass. Personal data (N = 1) indicates that processing for the task shown in Figure 8 is the more rapid. If this is the case, then affixing the correct deletion and scan type operations to a particular number evidently increases processing time. Consequently, response intensity switching has a larger effect for single grouping than it does for double grouping.

The finding that RT increased as a function of transformation size is not surprising (Weber, Cross, and Carlton, 1968; Weber and Blagowsky, 1970a). Neither is the finding that chants produced greater decrements in MMS for 1-unit transformations than for the 0-unit (Weber and Blagowsky, 1970b). Such an interaction indicates that a 1-unit transformation size demands more attention than does a 0-unit. It is probable that performance of 0-unit transformations merely required "reproductive" activity (Peterson, 1969; Weber and Blagowsky, 1970a). All that was necessary, accordingly, was a direct correspondence between input and output. However, the 1-unit transformation did involve a transition in the input, prior to the output, so more than simple reproduction was involved. As a result, these operations placed a greater demand on available capacity, hence, less spare capacity was available for scanning in the concurrently performed chant sequences.

The subtractive method suggests that an overlapping of the two tasks occurred for all conditions except two (the two exceptions were

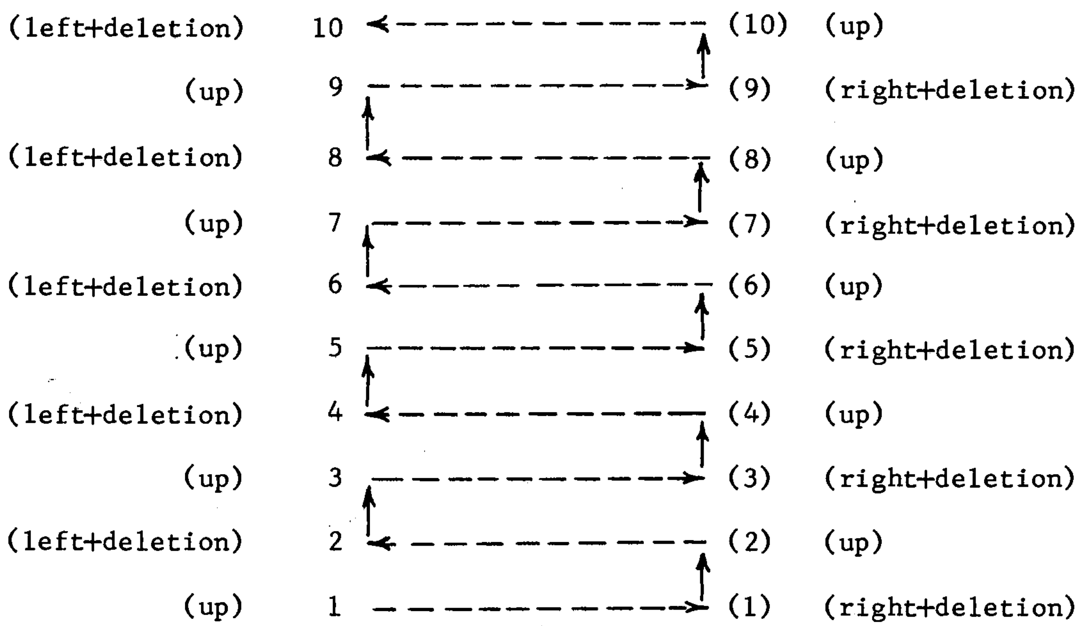

Figure 8. A scan plan incorporating both deletion and different scan types but not rearrangement for the overt response sequence 1 (2) 3 (4) 5 (6) 7 (8) 9 (10)

for response intensity switching in the case of the single chant grouping and has already received extensive discussion. Such overlapping probably reflects simultaneous performance of motor tasks and/or verbal tasks. Simultaneous performance of motor tasks would be involved to the extent that both processes, writing transformations and speaking chants, contain motor components. However, if only motor components were involved in overlapping, then the same relationship between summed RTs and corresponding concurrent RTs should have existed for the various combinations of chant sequence and transformation size. For example, the motor components for NC and 0-unit transformations were identical, or so it seems, to the motor components involved for NC and 1-unit transformations. Thus the same degree of overlap (or lack of overlap) should have existed for both situations. However, there was more overlapping in the case of NC and 0-unit transformations than there was for NC and 1-unit transformations. Furthermore, it has previously been found (Weber and Blagowsky, 1970a) that more overlap existed between a forward number chant and MMS than between a backward letter chant and MMS. Yet, it would seem that both chants involved very similar motor components. Consequently, if simply motor components were involved in the overlap, then the degree of overlap should have been very nearly the same for MMS and both chants. Thus it seems necessary to suppose that something in addition to motor components was involved in determining degree of overlap between the two tasks. Insofar as both processes involved either implicit or explicit speech (Weber and Blagowsky, 1970a; 1970b) there must have been an overlapping of verbal processing. If this were the case, then the question seems to be what kind of memory trace system would be required to produce verbal overlapping.

Figure 9 presents several models for concurrent processing (Weber and Blagowsky, 1970a). The following discussion is directed only at those concurrent tasks in which the subtraction method suggests verbal overlapping occurred.

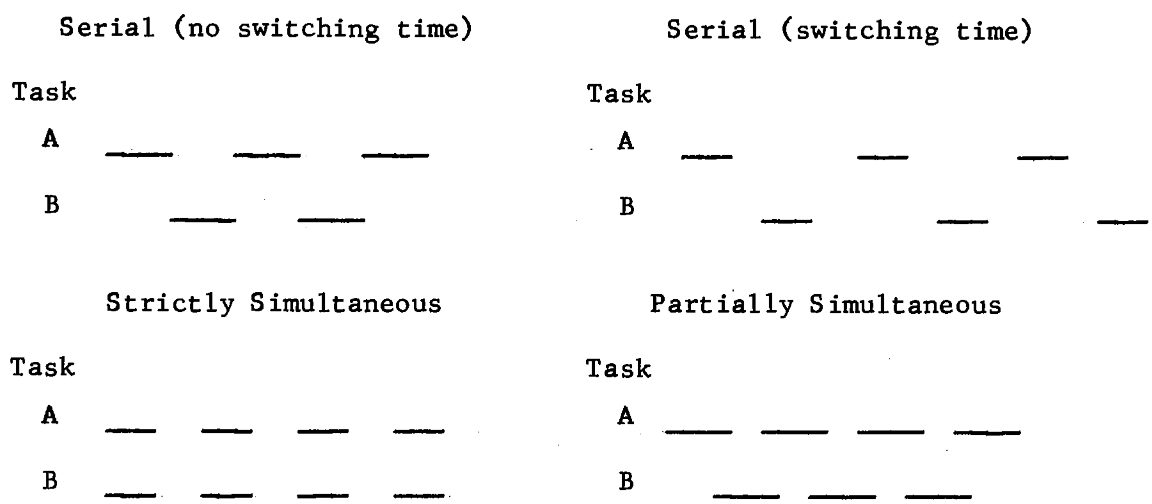

Figure 9. Concurrent processing models

First, consider the models with overt responses in mind. It would seem that both serial models are inadequate at the overt level for two reasons. One, the S's overt written and spoken responses were simultaneous, and, second, the fact that the summed RTs for transformations and chants performed separately exceeded the concurrent RTs. The partially simultaneous model is somewhat more satisfactory in that it takes into consideration the time savings score mentioned above. However, the strictly simultaneous model seems most appropriate at the overt level, since the Ss were instructed to synchronize the chant responses with the MMS task responses. Observations of the Ss suggest that they did perform the responses simultaneously (at least for response onset).

Next consider the models at a central level. It is apparent that the strictly simultaneous model is not appropriate. Concurrent performance of the chants and transformations was slower than performance of the chants and transformations alone. The strictly simultaneous model suggests that the rate of doing two yoked tasks (chants and MMS) would be as fast as the slower of the two tasks when done alone (MMS). Thus, the strictly simultaneous model is not adequate (unless the switching time is increased during concurrent processing). Of the three remaining alternatives, the partially simultaneous model seems most congruent with empirical observation. However, if the central scanning time was considerably more rapid than implicit speech then either of the serial models might also be adequate.

At this point it is appropriate to ask what kind of trace system is involved in concurrent processing. At least three ways have been suggested (Wickelgren, 1969) to account for how verbal trace systems are represented. Their representation may be acoustic, kinesthetic, or abstract. In addition, visual imagery has been suggested by several workers (Brooks, 1967, 1968; Paivio, 1969; Weber and Bach, 1969) as a possible means of representation. If either of the serial models are appropriate at the central level, then it would seem that the verbal trace systems would be of an abstract form. This seems necessary in view of the very rapid serial scanning processes that would be needed. The verbal trace system would have to be very much faster than implicit or explicit speech (Weber and Blagowsky, 1970a). Any form of visual representation also seems to be much too slow (Weber and Bach, 1969), and would suffer considerable interference when the S looked at the printed list of stimuli (Brooks, 1967).

An abstract trace system also seems to be required in considering either of the simultaneous models. On the basis of both introspective and empirical grounds, it is doubtful that either kinesthetic or acoustic traces can operate in a simultaneous fashion. Kinesthetic traces seem unlikely because it is hard to imagine saying a letter and a number at the same time. A trace system in the form of acoustic images seems inappropriate because there is considerable evidence (Cherry, 1953; Moray, 1959; Treisman, 1960) that we cannot hear two verbal stimuli at the same time. Again, visual images can be ruled out because of their extremely slow rates. Thus, regardless of which model is appropriate, it seems necessary to posit an abstract verbal trace system in which two or more traces can operate at least semi-independently of one another. Consequently, it seems likely that MMS with chanting (which does not involve intensity switching) draws on an abstract set of verbal traces, neither acoustic, kinesthetic, nor visual in nature.

Finally, practice effects were evident for the tasks performed concurrently. The improvement in MMS when performed alone provides an explanation for the finding that stimulaneous processing became more efficient as training increased. As performance on the MMS became over-learned, less attention (Peterson, 1969) was needed for its various components, such as reception, recoding, mapping, storing, emission, etc. As a result, there was an increasing accumulation of spare capacity that could be utilized for simultaneous processing.

CHAPTER V

SUMMARY AND CONCLUSIONS

The primary intention of this thesis was to examine Peterson's (1969) classification for attention tasks. Two experiments were conducted. The first experiment studied the consequences that various types of response switching have for emissive tasks. In the second experiment, emissive tasks that required response switching were performed concurrently with a primary task.

The basic purpose of the first experiment was to discover tasks within Peterson's emissive level that differed in difficulty. Therefore, response switching was manipulated in emissive tasks to see if it increased difficulty. The study was designed to accomplish several objectives. First it was directed toward the study of the effect of <u>response intensity switching</u> on response time. Response intensity switching involved comparisons among the response times for processing a string of characters by speaking, "mouthing" (subdued whispering), and switching between speaking and mouthing the items in the chant sequences. The second function was to study the effect of <u>response class switching</u> on response time. Subjects produced chant sequences that were composed of numbers, letters, or numbers and letters. Finally, the effects of single chant grouping (e.g., 1,2,3,4,5,1...) versus double chant grouping (e.g., 1,1,2,2,3,3,...) upon response intensity and response class switching times were studied.

The principal findings of the first experiment were as follows. 1) There was a significant effect due to response intensity switching, with speaking and mouthing requiring more time than speaking only or mouthing only. 2) Chant sequences requiring response class switching had larger response times than uniform chant sequences. It was therefore concluded that additional processing time is needed for emissive tasks which require response intensity or class switching. Several interpretations were considered to account for this increased processing time. Briefly, it was suggested that the increment in processing time could have been the outcome of switching back and forth between responses, increased memory load, or response competition.

The chief aim of the second experiment was to discover whether two activities within one of Peterson's levels of attention could have significantly different effects upon an accompanying activity. Accordingly, the second experiment examined the effects that emissive tasks (chanting) had upon a concurrently performed primary task (metered memory search). The effect of chant sequences which involved response intensity switching were compared with chant sequences which did not involve response intensity switching. In addition, the effects for single and double chant grouping upon metered memory search were noted.

The more important findings were as follows. 1) As the transformation size for metered memory search increased so did response time. 2) Performance for the metered memory task was decreased when subjects were required to concurrently perform a subsidiary task (chanting). 3) Chants which required response intensity switching decreased performance on metered memory search to a significantly greater degree than did chants which did not require response intensity switching. 4) The effects upon metered memory search were very similar for single and double chant grouping. 5) All chant sequences had a more pronounced effect upon the 1-unit transformation size than upon the 0-unit size. 6) Concurrent processing improved with practice. 7) With but two exceptions (in cases where response intensity switching was concurrently performed with metered memory search), the RTs for the chant sequences and transformations showed evidence of overlapping.

It was concluded that task difficulty within the emissive level can have differential effects upon the efficiency with which an accompanying task is performed. This conclusion stemmed from the demonstration that switching between speaking and mouthing the numbers produced significantly greater decrements upon the performance of metered memory search than did simply speaking the numbers. In addition, it was shown that emissive and transformational tasks in some cases produced a savings score when done concurrently and in some cases did not. Consequently, since different tasks within the emissive level may require different levels of attention, it was further concluded that Peterson's (1969) classification is incomplete and needs further elaboration. An explanation was attempted as to why response intensity switching increases the attentional demands of an emissive task. It was suggested that execution of the memory scan mechanism utilized for response intensity switching requires more attention or processing space than the scan mechanism employed for speaking only.

Since the subtraction method yielded evidence that verbal overlapping may have occurred for all but two of the concurrent conditions, an explanation was suggested to account for how the simultaneous processing could have occurred. It was hypothesized that metered memory search with chanting draws on an abstract set of verbal traces that may operate simultaneously.

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A P P E N D I C E S

APPENDIX A

INSTRUCTIONS FOR EXPERIMENT I

Single Chant Grouping

I am interested in how fast people can process information. In particular, I want to find out how fast you can go through the first five numbers twice.

Speak Numbers (SN): I would like you to say these numbers out loud (show cue card) two times without stopping. For example 1, 2, 3, 4, 5, 1, 2, . . . 5 (E demonstrates). Do it as fast as you can and do not skip any numbers. When I say start, push this button on the clock. When you finish, push the button the other way so the clock will stop and I can tell how long you have taken. Remember, go as fast as you can without skipping any numbers. Let's try a practice trial. Any questions? O.K. When you are ready, turn the card over and begin.

Mouth Numbers (MN): Now let's try something different. I would like you to repeat these numbers twice as you have done. [(1), (2), (3), (4), (5), (1), (2), (3), (4), (5) E demonstrates]. Once again, I want you to go as fast as you can without skipping any digits. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Alternate Numbers (AN): Now let's try something different. Again I want you to go through these five numbers twice. This time, however, I want you to alternate back and forth between saying the numbers aloud and mouthing them (show cue card). That is, [1, (2), 3, (4), 5, (1), 2, (3), 4, (5) E demonstrates]. Remember to go as fast as you can without skipping any numbers. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Now we are going to repeat these practices using the first five letters of the alphabet.

Speak Letters (SL): I want you to begin by saying these letters out loud two times without stopping (show cue card). For example a, b, c, d, e, a, b, . . . e (E demonstrates). Go as fast as you can without skipping any letters. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Mouth Letters (ML): O.K. Now I want you to mouth these letters (show cue card). That is [(a), (b), (c), (d), (e), (a), (b), . . . (e) E demonstrates]. Go as fast as you can without skipping any letters. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Alternate Letters (AL): Now let's try alternating between speaking and mouthing the letters (show the cue card). That is [a, (b), c, (d), e, (a), b, (c), d, (e) E demonstrates]. Remember to go as fast as you can without skipping any letters. Now for a practice trial. Any questions? Ready? Turn the card over and begin.

Now we are going to repeat these processes with the combination of digits and letters.
Speak Numbers and Letters (SN/L): First of all, I want you to say aloud the numbers and letters (show cue card). That is 1, a, 2, b, 3, c, 4, d, 5, e, (E demonstrates). O.K. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.
Mouth Numbers and Letters (MN/L): O.K. Now I want you to mouth the numbers and letters (show cue card). That is (1), (a), (2), (b), (3), (c), (4), (d), (5), (e) (E demonstrates). Remember to go as fast as you can without skipping any letters or numbers. Now for a practice trial. Any questions? Ready? Turn the card over and begin.
Alternate Numbers and Letters (AN/L): Now let's try alternating between speaking and mouthing the numbers and letters (show cue card). That is 1, (a), 2, (b), 3, (c), 4, (d), 5, (e) (E demonstrates). Remember to go as fast as you can without skipping any of the numbers or letters. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Double Chant Grouping

I am interested in how fast people can process information. In particular, I want to find out how fast you can go through the first five numbers twice.
Speak Numbers (SN): I would like you to say these numbers out loud (show cue card) two times without stopping. For example 1, 1, 2, 2, 3, 3, 4, 4, 5, 5 (E demonstrates). Do it as fast as you can and do not skip any numbers. When I say start, push this button on the clock. When you finish, push the button the other way so the clock will stop and I can tell how long you have taken. Remember, go as fast as you can without skipping any numbers. Let's try a practice trial. Any questions? O.K. When you are ready, turn the card over and begin.
Mouth Numbers (MN): Now let's try something different. I would like you to repeat these numbers twice as you have done. However, this time I want you to only mouth the numbers (show cue card). [(1), (1), (2), (2), (3), (3), (4), (4), (5), (5) E demonstrates]. Once again, I want you to go as fast as you can without skipping any numbers. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.
Alternate Numbers (AN): Now let's try something different. Again I want you to go through these five numbers twice. This time, however, I want you to alternate back and forth between saying the numbers aloud and mouthing them (show cue card). That is, [1, (1), 2, (2), 3, (3), 4, (4), 5, (5) E demonstrates]. Remember to go as fast as you can without skipping any digits. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Now we are going to repeat these processes using the first five letters of the alphabet.
Speak Letters (SL): I want you to begin by saying these letters out

loud two times without stopping (show cue card). For example a, a, b, b, c, c, d, d, e, e (E demonstrates). Go as fast as you can without skipping any letters. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Mouth Letters (ML): O.K. Now I want you to mouth these letters (show cue card). That is (a), (a), (b), (b), (c), (c), (d), (d), (e), (e) E demonstrates. Go as fast as you can without skipping any letters. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Alternate Letters (AL): Now let's try alternating between speaking and mouthing the letters (show cue card). That is a, (a), b, (b), c, (c), d, (d), e, (e) (E demonstrates). Remember to go as fast as you can without skipping any letters. Now for a practice trial. Any questions? Ready? Turn the card over and begin.

Now we are going to repeat these processes with the combination of numbers and letters.

Speak Numbers and Letters (SN/L): First of all, I want you to say aloud the numbers and letters (show cue card). That is 1, a, 2, b, 3, c, 4, d, 5, e (E demonstrates). O.K. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

Mouth Numbers and Letters (MN/L): O.K. Now I want you to mouth the numbers and letters (show cue card). That is (1), (a), (2), (b), (3), (c), (4), (d), (5), (e) (E demonstrates). Remember to go as fast as you can without skipping any letters or numbers. Now for a practice trial. Any questions? Ready? Turn the card over and begin.

Alternate Numbers and Letters (AN/L): Now let's try alternating between speaking and nouthing the numbers and letters (show cue card). That is 1, (a), 2, (b), 3, (c), 4, (d), 5, (e), (E demonstrates). Remember to go as fast as you can without skipping any of the numbers or letters. Let's try a practice trial. Any questions? Ready? Turn the card over and begin.

APPENDIX B

INSTRUCTIONS FOR EXPERIMENT II

For All Subjects

Alphabetical sequences: The object of this experiment is to see how quickly you can process certain kinds of information.
Transformations: Look at the sequence of letters on this card (show cue card). Please note that it is a circular sequence. This means that for any letter I give you, it should be possible for you to provide without hesitation the next letter in the sequence. E.g., if the letter "c" is shown to you, then you should be able to give me "d" because it is the letter next to "c", and if "d" then "e".
One-Unit Transformations: Now here is a card explaining what you are to do. The "one" implies that you are to fill-in the blank beside each stimulus letter with the letter one step away in the sequence. E.g., if the letter "e" is shown to you, then write "a". I want you to go as fast as you can and you should not make more than 2 or 3 errors. Please write the letters in script and say "Stop" when you have finished. Ready? Start. . . Please turn the page.
Zero-Transformations: This card represents a zero shift. You respond by copying the same stimulus item. E.g., if the letter "d" is shown to you, then write "d" in the blank. I want you to go as fast as you can and you should not make more than 2 or 3 errors. Please write the letters in script and say "Stop" when you have finished. Ready? Start . . . Please turn the page.

For Single Chant Grouping

Speak Numbers (SN): This card represents a number chant. You are to respond by saying the numbers 1, 2, 3, 4, and 5 for each set of 5 stimulus letters. Repeat saying the numbers until you have finished the column. (E demonstrates). Go as fast as you can without skipping any of the numbers. Ready? Start. . .
Alternate Numbers (AN): Now let's try something different. Again, you are to respond by going through these first five numbers for each set of five stimulus letters. However, I want you to alternate back and forth between saying the numbers aloud and mouthing them (show cue card). That is, 1, (2), 3, (4), 5, (1), 2, (3), 4, (5), 1, (2), 3, (4), 5 (E demonstrates). Remember to go as fast as you can without skipping any numbers. Ready? Start. . .

For Double Chant Grouping

Speak Numbers (SN): This card represents a number chant. You are to respond by saying the numbers 1, 1, 2, 2, 3, 3, 4, 4, 5, 5 for each set of five stimulus letters. Repeat saying the numbers until you have finished the column. (E demonstrates). Go as fast as you can without skipping any of the numbers. Ready? Start. . .
Alternate Numbers (AN): Now let's try something different. Again, you are to respond by going through these first five numbers for each set of five stimulus letters. However, I want you to alternate back and forth between saying the numbers aloud and mouthing them (show cue card). That is, 1, (1), 2, (2), 3, (3), 4, (4), 5, (5) (E demonstrates). Remember to go as fast as you can without skipping any numbers. Ready? Start. . .

The 8 Experimental Conditions

Now I am going to show you these cards again and you are to begin making the shifts or chants when I say "Start." There will also be some combinations of the shifts and chants. When this is the case, you will find it easier to synchronize the chants with the shifts. (E demonstrates the procedure using S's practice test booklet with 0 transformation and number chant or the double-number chant.) After you have finished the column say "Stop", and then please turn the page. I will repeat what the cards represent as I show them to you.

Order of Presentation

Single Chant Grouping

	0	
	1	
Present chant	ON	(demonstrate)
cards in	1N	
advance	OAN	(demonstrate)
	1AN	

Double Chant Grouping

	0	
	1	
Present chant	ON_2	(demonstrate)
cards in	$1N_2$	
advance	OAN_2	(demonstrate)
	$1AN_2$	

Real Trial

Now I am going to show you a cue card or cards (in the case of concurrent condition, the chant card is shown first followed by the transformation card about 3 seconds later) with one of the conditions we've talked about. Begin making the required shifts and chants as rapidly as you can. Don't look back at your earlier work unless it's necessary because this will slow you down. Any questions? (Show the cue cards according to the order of the particular block saying "start" with each presentation of a card and "please turn the page" before presenting the next card. When the shifts and chants are combined for a trial, present the chant card first followed by the shift cue card 3 seconds later.

A P P E N D I X C

SUMS FOR THE WRITTEN RESPONSE DURATIONS (SECS) AND INTER-RESPONSE INTERVALS (SECS)

FOR ONE TRIAL (BLOCK 30) AS DETERMINED FROM EVENT RECORDER

Single Chant Grouping

	0		ON		OSN		1SN		OSN		1SN	
Subj.	Dur.	Int.	Dur.	Int.	Dur.	Int.	Dur.	Int.	Dur.	Int.	Dur.	Int.
1	4.25	2.74	4.64	2.69	4.38	2.89	6.19	4.44	6.56	3.56	5.29	4.13
2	5.56	3.00	5.94	5.38	5.81	6.19	7.00	6.44	6.06	10.50	7.31	8.94
3	3.06	3.69	3.38	4.38	4.13	6.88	5.19	8.13	6.88	8.94	7.06	12.38
4	4.25	3.31	4.56	4.19	8.00	12.19	6.63	8.63	7.94	11.44	7.00	12.81
5	2.31	3.00	4.31	4.06	6.94	3.94	4.88	3.88	5.38	5.19	6.89	6.23
6	3.50	3.94	3.00	3.50	2.19	2.75	5.75	7.88	5.44	8.56	4.38	9.31
7	6.50	3.44	6.88	2.63	12.00	11.50	6.81	5.56	7.25	4.06	10.19	8.94
Total	29.43	23.12	32.71	26.83	43.45	46.34	42.45	44.96	45.51	52.25	48.12	62.74
$\bar{X}$	4.20	3.30	4.67	3.83	6.20	6.62	6.06	6.42	6.50	7.46	6.87	8.96

Double Chant Grouping

	0		ON		OSN		1SN		OSN		1SN	
Subj.	Dur.	Int.	Dur.	Int.	Dur.	Int.	Dur.	Int.	Dur.	Int.	Dur.	Int.
8	5.69	2.13	5.69	2.38	6.25	2.75	6.38	4.56	6.00	5.94	5.88	5.44
9	3.75	1.94	4.06	2.00	4.19	2.25	5.00	3.25	4.95	3.38	5.69	3.44
10	6.06	1.88	6.88	3.69	6.63	2.56	6.69	2.69	7.00	3.10	8.06	3.75
11	4.44	3.31	4.19	3.81	4.88	6.13	6.44	6.94	4.94	5.44	5.25	7.06
12	3.38	3.56	3.88	4.31	4.50	4.44	3.44	5.88	4.75	5.10	4.38	6.44
13	4.81	2.69	5.00	4.06	5.50	4.20	5.25	7.06	5.13	2.88	5.19	6.44
14	4.19	1.81	4.63	2.69	4.88	4.38	4.88	6.06	4.75	3.81	4.63	6.00
Total	32.32	17.02	34.33	22.88	36.83	26.71	38.08	36.44	37.52	29.83	39.08	38.57
$\bar{X}$	4.62	2.43	4.90	3.27	5.26	3.82	5.44	5.21	5.36	4.26	5.58	5.51

VITA[3]

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