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THE EFFECT OF A COMPETING VISUAL INFORMATION-PROCESSING TASK ON THE TEMPORAL CHARACTERISTICS OF SPONTANEOUS SPEECH

by

GEORGE FEIN

A dissertation submitted to the Graduate
Faculty in Psychology in partial fulfillment
of the requirements for the degree of Doctor
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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The notion of a central cognitive operator with limited capacities (Norman and Bobrow, 1975; Kahneman, 1973) provides the conceptual basis for the present experimental approach to the study of the information processing and the decision making processes underlying the production of unrehearsed speech. The research project attempts to pinpoint the temporal location within spontaneous speech during which the bulk of information processing and decision making takes place. To this end, two methods of investigating information processing in speech are brought together here: 1) the analysis of temporal patterning in speech and 2) the use of a competing (concurrent) information processing task to experimentally control the information processing capability available for the generation of unrehearsed speech.

In almost all models of speech generation, pauses are seen as times during which speech is planned. It is this assumption as well as certain corollary assumptions about information processing during speech that are tested in the experiment.

Survey of Relevant Empirical Literature

Lexical Model. The assumed relationship between pauses and decision making is clearly seen in one of the first models of speech generation (Lounsbury, 1954). Lounsbury's model linked behavioral models of language with an analysis of temporal patterns in speech. Lounsbury argued that speech events are mediated by complexes of internal stimuli and that these complexes have habit strengths which are a function of the frequency and/or contiguity of occurrence of the event in the speaker's previous experience. Pauses between words are seen as a measure of habit strength, measuring the latency between a stimulus (current word) and response (subsequent word). The stronger the habit strength, the shorter the pause should be.

It should be noted here that in order to use the pause as a measure of latency between associations, Lounsbury (1954) distinguished between two types of pauses: 1) short juncture pauses: pauses which fall between boundaries of higher level constituents and are made by the speaker to help the listener understand the grammatical structure of the sentence, and 2) longer hesitation pauses: pauses reflective of decision making processes in the speaker. It is important to point out that Lounsbury's model is a first-order lexical model. This first-order lexical model is opposed to hierarchical models (Johnson, 1965; Osgood, 1963; Yngve, 1960) in which the major encoding units are grammatical rather than lexical and which postulate higher level decisions at major constituent boundaries, relegating lexical decisions to a lower level. Between the first-order lexical model and the hierarchical syntactic models there is a higher-order lexical model in which decision processes relevant to word selection may take place one or two words before the chosen word instead of immediately preceding it. In this higher-order lexical model, it is still the word, rather than any higher order constituent, which is the major encoding unit.

In early tests of Lounsbury's model, Goldman-Eisler (1958a, 1958b) related a measure of information content of words (the Shannon guessing technique) to hesitation pauses in speech. Her results supported a lexical model wherein long pauses immediately preceded words with high information content and followed words with low information content. There have been a number of attempted replications and extensions of Goldman-Eisler's initial findings (Tannenbaum, Williams and Hillier, 1965; Goldman-Eisler,1961 a, b; Bernstein, 1962; Boomer, 1965). Rochester (1973) analyzed this experimental evidence gathered pertaining to the lexical decision model. In a careful and critical review of the literature on pauses, she found that Goldman-Eisler's results:

a) have not been proven reliable in that there has been no adequate replication and b) are not easily generalizeable because of the small and highly select speech and subject samples used. When comparisons across studies were made, the results of research in the field were found to be inconsistent and/or contradictory. These comparisons of results across studies are very difficult to make because neither the measures of pauses, the measures of information content of words, nor the samples used in the different studies are readily comparable.

There are two major technical biases in Goldman-Eisler's initial experiments that have been pointed out in Rochester's review. First, in the selection of speech samples, Goldman-Eisler used only grammatically correct, well-constructed sentences. In this way, Goldman-Eisler chose samples that were not only unrepresentative of spontaneous normal speech, but excluded utterances in which syntax was a problem for the speaker.

> Because the technique was biased against syntactically relevant pauses, few such pauses were seen. Thus, the technique chosen to investigate a lexical decision-making hypothesis was biased in favor of the hypothesis and against alternative (or complementary) hypotheses. This strategy is disturbing because the technical biases were not mentioned (either in 1958 or in Goldman-Eisler, 1968) in interpretations of the data (Rochester, 1973, p. 57).

Second, as Boomer (1970) pointed out, in Goldman-Eisler's initial experiments the word counted as following a pause (the "p" word) was not always the first word after the pause. Rather, the "p" word was the first content word (nouns, verbs, adverbs, adjectives) following the pause. In fully one third of the cases (11/34), the "p" word was separated from the pause by from one to three function words (prepositions, conjunctions, pronouns, auxiliary verbs). Goldman-Eisler's justification for this was: "Introspection indicated that the utterance of such grammatical expressions is often delayed until the choice of the next content word is made" (Goldman-Eisler, 1958a, p. 100). This suggests that the lexical choice hypothesis may have determined an important experimental decision. In addition, it seems clear that Goldman-Eisler's experiments were not tests of a first-order lexical encoding model but of a higher-order lexical encoding model. As stated above, the higher-order lexical encoding models are closer to the grammatical hierarchical models than is the first-order lexical model.

The only original finding of Goldman-Eisler that has been consistently supported (according to Rochester's review) is that words immediately following long pauses are difficult to guess. However, this finding does not differentiate between the lexical and hierarchical models because long pauses tend to occur at grammatical constituent boundaries.

Hierarchical Model. Boomer (1965) tested the hierarchical model by analyzing pause lengths within a specified grammatical unit (the phonemic clause). He found that 40% of all hesitation pauses occurred after the first word of the phonemic clause. He did not include in his analysis pauses immediatedly preceding the phonemic clause because he assumed them to be juncture pauses rather than hesitation pauses. In a re-analysis of Boomer's data, Barik (1968) argued that Boomer's definition of juncture pauses was too loose in the case of long pauses (over 700 msec.) at syntactic junctures. He argued further that such long pauses are a combination of both juncture pauses (first 500 msec.) and hesitation pauses (latter 200 msec. or more), with the first part of the pause serving the listener-oriented function and the latter part reflecting decision making processes in the speaker. Barik reanalyzed Boomer's data, this time including pauses that are long enough to serve both juncture and hesitation functions and found that he could account for fully 51% of all pauses using a grammatical encoding hypothesis.

Taylor (1969) tested the hierarchical model by examining pauses as a function of sentence complexity. She argued that if structural complexity of a sentence is related to the complexity of speaker processes, then, the more complex the sentence, the longer the reaction time should be because more encoding operations were taking place. She found that subjects took the same time to begin sentences of widely varying syntactic complexity. These results did not support the syntactic encoding model posited by Boomer (1965) and Barik (1968). Reaction time did vary, however, with topic difficulty, offering support for a semantic model wherein pauses are associated with content rather than structure.

Proximal vs. Distal Function of Pauses. Boomer (1970) made the distinction that in both the lexical and the hierarchical models presented above, a proximal relationship is assumed between temporal patterning and local decision making in speech. This is compared with the later work of Goldman-Eisler and her colleagues (Goldman-Eisler, 1968; Henderson, Goldman-Eisler, and Skarbeck, 1965; Henderson, Goldman-Eisler, and Skarbeck, 1966) in which a distal function of pauses is presented. That is where pauses are thought to signal not only local but also temporally distant decision making. This distal model was developed to account for Henderson's observation of periods of fluency (long vocalizations with short pauses) alternating with less fluent periods. This observation was made on the basis of a post hoc analysis of cumulative pause histograms in which straight line periods of fluency and hesitancy were fit to the data by eye. Henderson saw these alternating periods as constituting single psycholinguistic units, wherein semantic decisions were being made during periods of hesitancy.

Schwartz and Jaffe (1968) have shown that Henderson's procedure has severe methodological flaws. They argue that with a sequence of random events, the kind of "runs" found by Henderson are likely to occur. They simulated Henderson's data with randomly generated binary computer series and using procedures similar to Henderson's, found periods of relative pause followed by periods of relative fluency. In extending this work, Jaffe, Breskin, and Gerstman (1970), using computer generated random series, simulated the further finding of Henderson et. al. (1966) wherein longer periods of hesitation were followed by longer periods of fluency. Clearly, Henderson's findings might be an artifact of the human perceiver when viewing random series rather than a function of the psycholinguistic events taking place in the speaker.

<u>Cognitive Variables.</u> There have been a number of studies examining the relationship between cognitive variables and pausing in speech. Goldman-Eisler (1961a) asked subjects to describe the content of cartoon stories and to formulate the essential point of each cartoon. She found that the frequency and duration of silent pauses increased in the formulation stage of the task. In

addition, she found that the proportion of pause time occupied by filled pauses remained constant throughout the task (Goldman-Eisler, 1961b).

Lay and Paivio (1970) presented subjects with three verbal response tasks (self-description; cartoon description; and evaluation of pairs of proverbs) requiring different levels of abstractness. Their results showed that both filled and silent pauses increased in frequency as the presumed level of abstraction required increased. In this experiment abstraction of the task was confounded both with the type of stimuli (verbal/visual) and with the degree to which the speech response required was overlearned. In a related experiment which did not have these difficulties, Reynolds and Paivio (1968) found that both filled and silent pauses are more frequent when subjects defined abstract as compared to concrete nouns.

In recent work, Yngve (1973) had subjects doing a signal detection task while they were speaking. In his experiment, a white or yellow light came on while the subject was talking. The subject was instructed to tell the experimenter verbally which color the light was. Yngve found that when subjects responded to the light signal, they very often forgot what they were going to say. They would backtrack, repeat the last few words they had spoken, and then in many cases they would be at a loss. In addition, he found that when the subjects repeated themselves, they spoke faster and with fewer syllabic stresses than they had initially.

In Yngve's experiment, the detection task required both the use of central cognitive operators to detect and identify the light and the use of the verbal apparatus (and its corresponding cognitive operators) to make a verbal response. The relative contributions of these cognitive and verbal requirements of his detection task are confounded. Yngve interpreted his results in terms of the interference of the cognitive (short-term memory) requirements of his detection task on the speech task. He is not justified in making this interpretation because he cannot rule out the possibility that it is really the verbal reporting requirement of his response task that is disrupting his subjects' speech. In order to make a more appropriate test of the short-term memory interference model, he would need to have a detection task requiring short-term memory processing, but not requiring a verbal response. It should also be pointed out that the subjects in Yngve's experiment were not naive with respect to the experimental hypotheses and might have been biased in favor of his hypotheses.

In reviewing the literature on the relationship between cognitive variables and pauses in speech, Rochester (1973) concluded that the frequency and duration of pauses increase as a function of increases in the presumed difficulty (complexity and/or abstractness) of the speech task. She found that the research in this area "demonstrates repeatedly that pauses are relevant to cognitive processing". The main evidence supporting a relationship between pauses and information processing in speech can be summarized as follows: 1)pauses are closely related temporally to words of high information content and 2) pauses increase as the complexity and/or abstractness of the speech task increase. In both cases speech is observed and the incidence of pauses is correlated with complexity of the speech task or information content of words. In neither case is the cognitive process taking place during a specific pause measured or experimentally manipulated. The present research project is just such an attempt to experimentally examine the temporal patterning of information processing and decision making in speech.

Rationale for the First Experiment and the Present Experiment

The experiments to be presented are based on a model wherein a speech task and a concurrent perceptual-motor task make use of some of the same limited capacity central cognitive operators. The idea of using two competing tasks to investigate information processing in speech grew out of the work of Antrobus(1968) on the relationship between task-irrelevant-thought (mindwandering or daydreaming) and the information presentation rate of a concurrent visual-perceptual task. Antrobus found that the frequency of reporting stimulus-independent-thought (at the end of 15 second intervals) was a negative linear function of stimulus information rate. Although speech tends to be more deliberate and more strongly goal determined than task-irrelevant thought, both have in common the characteristic of being relatively novel sequences of meaning.

A task can be shown to use central cognitive operators if it is susceptible to interference by another task (Norman and Bobrow, 1975). The extensive research on multiple task performance indicates that material in short-term memory, recently learned material, and events of which one is consciously aware are most susceptible to interference. Overlearned responses are highly resistant to interference. Because of the small amounts of interference present and the noise inherent in most experimental situations, it has so far been impossible to determine whether the highly learned responses are processed outside a central cognitive operator (they are not interfered with), or whether they simply use an experimentally indistinguishable portion of the central operator's capacity (the interference is there, but it is smaller than the noise present in the experiment). Regardless of how this issue is settled, it is clear that the highly learned phonological and syntactic features of speech should be more resistant to interference by a perceptual-motor task than the semantic and meaning qualities. If longer pauses are concerned exclusively with semantics and meaning, then these pauses should lengthen as a function of increased task information rate more than should the shorter pauses which are associated with highly learned syntactic operations. A preliminary experiment (Antrobus and Fein, unpublished manuscript) constituted a test of this deduction.

Before describing this early experiment in detail, let us first examine some of the ramifications of the deduction as well as of deductions based on slight variations of the stated assumptions. If an index of pausing (mean pause time or slope of the regression of log-frequency on pause duration - see Jaffe and Feldstein, 1970) is a function of the information rate of an interfering task, then if the interfering task were removed, the index of pausing would provide, by inference, an index of the amount of the speaker's internal information processing required to generate the speech. Such an index would be a measure of the speaker's information processing in generating his speech and would therefore be a more appropriate measure of the speaker's rate of cognitive processing than would methods (such as the Cloze procedure) based on the information processing of the speaker's speech by a second party.

Obviously, the speaker has additional ways of coping with a simultaneous perceptual-motor task. He may fill his pauses with "ahs", "ums", "you knows", and "I means". He may repeat the ends of sentences and stutter on the beginnings. He may even stretch out the consonants and vowels within words. The speaker may also simplify his speech as the task information rate increases. He may use simpler words or simpler sentence construction. Some of these behaviors are presumably devices to keep the listener from taking over the conversation and may, therefore, be reduced by studying monologues within a solitary environment. Variability in these speech characteristics which is systematically associated with the task information rate must be measured and considered jointly with pause time in a multivariate statistical model.

The Preliminary Experiment

Subjects. In the preliminary study, eight paid subjects served four one-hour sessions each. Each subject served as his own control, going through all treatment conditions.

Apparatus. The subject's display and manipulanda consisted of a vertical panel 12 in. wide X 7 in. high. Five telegraph finger plates, with centers separated by 2 in. intervals were arranged in a row one inch above a table top. A red pilot light was positioned 2 in. above each key. Depressing the key below an illuminated light constituted a detection. The one bit/sec. condition was achieved by setting the probability of illumination of the center light at the onset of each one sec. interval = 0.5. The three and five bit/sec. conditions were established by assigning the same probability to the center three or all five lights, respectively. The illumination of the lights was fixed so that the probability of correct detection at a presentation rate of one bit/sec. = 1.0.

The random sequence of signals was recorded on paper tape. The presentation of instructions and stimuli and the recording and scoring of all responses was entirely automated. Speech was recorded on magnetic tape @ 7 and a half in./sec., with a Tandberg, model 80 tape recorder.

Subject cubicle. Subjects were seated alone at a 2 X 3 ft. table upon which the visual task apparatus was placed. The cubicle was constructed as a room within a room separated by cork and free air space. The interior of the cubicle measured 5 X 6 X 8 ft. high and was illuminated indirectly by a 60 watt bulb.

Speech conditions. There were two speech conditions: Past Events and Future Events. Each of the two speech conditions were divided into two parts of one 44 min. session each. The instructions to the subjects may be summarized as follows:

Past Events - Day one: describe a book you have read
Day two: describe a movie or play you have seen
Future Events - Day one: plan a story
Day two: plan a day

Order of the instructions was counterbalanced across subjects. Subjects were given a 10 min. break in the middle of each session.

The two contrasting instruction conditions were employed as an additional or supplementary test of the general pause model. In the Past Events condition, subjects simply retrieved events from long term memory more or less in the order they were originally stored. In the Future Events condition, subjects were required to construct novel sequences of events. It was expected that the greater amount of cognitive processing thought to be required in the Future condition would yield a higher frequency of long pauses.

The rationale for employing two different instructions within each of the two conditions was to insure that the difference between the two conditions would not be an artifact of the difference between two specific sets of instructions. That is, specific instructions were treated as nested within conditions.

Visual Encoding Task. Four stimulus rates were employed: 0,1,3,5 bits/sec. Subjects spent 11 min. on each session. The order of the rates was counterbalanced between sessions, within each subject. The detection task was always introduced after the subject had begun to speak.

Design. The experiment was a 4 (information rate) X 2 (Past vs. Future Events with 2 instruction conditions nested under each) X 8 (subjects), randomized block design. One may also treat the design as a 4 (information rate) X 4 (instruction conditions) X 8 (subjects), randomized block design. There were, therefore, sixteen 11 min. speech samples recorded on magnetic tape for each subject. Final analysis was carried out on the 10 min. sequence following the first spoken word at least 30 sec. subsequent to the start of the visual detection task or to a change in the stimulus rate of the task. This ten minutes of tape recorded speech in each condition was analyzed for the temporal patterning of the speech.

Results. The ten minutes of speech was sampled at 300 msec. intervals using the AVTA system. This system is described extensively by Jaffe and Feldstein (Appendix A, 1970). The output from the AVTA analysis of the taped monologues consisted of a series of approximately 2000 binary bits of information denoting whether AVTA had discerned a pause or a vocalization in the corresponding 300 msec. interval. The AVTA binary output was then analyzed on an IBM 360/50 computer so that for each ten minute speech sample a histogram of the frequencies of pause and vocalization strings of different durations was computed. In addition, the following statistics were computed on each ten minute speech sample: 1) mean pause length; 2) number of pauses greater than 7 sec. in duration (long pauses); 3) the conditional probability of having a pause in a 300 msec interval given that there was a pause in the previous 300 msec interval; and 4) the conditional vocalization probability (defined similarly to the conditional pause probability in 3 above).

Each of the above four statistics was then subjected to a two-way randomized block analysis of variance (information rate by speech task) with the total number of binary bits sampled used as a covariate. The covariate was used because the total sampling time was not exactly ten minutes for all speech monologues and we wished to control for this in our analysis of variance. In the analysis of variance, the information rate was partitioned into orthogonal (linear, quadratic and cubic) polynomial contrasts.

There were no significant speech task differences on any of the variables, nor were there any trends evidenced.

There were also no interactions between speech task and information rate evidenced.

Mean values over the eight subjects for each dependent variable at each information rate are presented in Table 1 together with F tests of linear, quadratic, and cubic polynomial contrasts. The linear information rate effect was highly significant for all of the pause statistics. Mean pause length was significant at the .01 level while the number of pauses greater than 7 sec. and the conditional pause probability were significant at greater than the .001 level. In all cases, the results were in the direction where indices of pausing were greatest during the higher task information rates. The linear effect of information rate was not significant with respect to the conditional vocalization probability measure.

The only significant quadratic or cubic effect of information rate was a quadratic effect whereby the conditional vocalization probabilities were higher on the intermediate information rate (F=12.5,p<.005). This is an effect whereby the vocalization - vocalization conditional probability is higher for the three task information rates than it is for the zero information rate condition. This increase is strongest for the one and three bit/sec information rate conditions.

Table 1

Pause and Vocalization Measures for the Four Information Rates of the Detection Task and Polynomial Contrast F Values

A)Mean Values of Pause and Vocalization Measures

INFORMATION RATE bits/sec	Mean Pause Length (sec)	Number Pauses Over 6 Sec.	Conditional Probabilities	
			Pause	Vocalization
0	1.04	2.03	.696	.715
1	1.22	2.91	.715	.742
3	1.20	3.03	.726	.751
5	1.42	4.63	.776	.732

B)Polynomial Contrast - F Values

Linear	9.12**	14.12**	28.73***	1.73
Quadratic	1.36	.57	1.55	12.51**
Cubic	4.38	.83	.36	2.22

* p<.05
** p<.01
*** p<.001

Discussion. The above results demonstrate that the concurrent signal-detection task does affect the temporal characteristics of self-generated speech. The effect of the perceptual-motor task manifests itself in a very specific way. Increasing the information rate in the perceptual-motor task increases the pause-pause conditional probability. The same kind of effect is evident for the frequency of long pauses that the subject produces.

These results are evidence that the concurrent perceptual-motor task is in fact a competing task. That is, it is competing for the use of the same limited capacity central cognitive operators.

The increase in the conditional vocalization probabilities in the intermediate task information rate conditions suggests one of several possibilities: The duration of phrases, or vocalizations, can become longer either by an increase in the number of syllables per phrase or by an increase in the duration of the syllables themselves with the number of syllables remaining constant or even decreasing. In the first case, speech output is increased when there is a vocalization, indicating a sort of activation or arousal. In the second case, speech output is decreased, indicating a depression of activation of the speech system. From the data gathered in this first experiment, there is no way of determining which of these two possibilities explains the increased vocalization lengths. In the second experiment, syllable counts per phrase will be taken and this question will be answered.

Further Rationale for the Present Experiment

The initial experiment and the model it supports provides us with an effective tool for assessing the fine temporal grain of the central cognitive demands of self-generated speech. The competing information processing task, when its demand load is controlled in real-time, will enable us to examine the central cognitive processes operative during speech. We have already shown that the increase in the pause-pause conditional probability is a positive linear function of an increased cognitive load in the competing information processing task. This can also be seen as a negative linear function of the availability of the central cognitive operator for the generation of speech. In the first experiment we did not look at the changing information processing demands of the speech generating task. Let us assume that because of competing task demands we have a limited central cognitive availability for generating speech. Our model states that the consequence of this limited central cognitive availability on the characteristics of speech will be greatest at those times that the fluctuating short term demands of speech generation on the central cognitive operator are maximal. As an example, let us assume that there are two specific events in speech generation: event A and event B. Let us further assume that event A makes very limited use of the central cognitive operators and that event B makes abundant use of the operators, at times approaching the limits of their capacities. If we interposed the same perceptual-motor task, sometimes during event A and sometimes during event B, we would expect that the evidence of interference between the perceptual-motor task and the speech generating processes would be much greater during event B than during event A. In this experiment, by interposing our competing task at different points in the self-generated speech and examining its effect on the subsequent speech we can examine the cognitive processes taking place at the moment when we interpose our competing task.

For the purpose of the present experiment, four different speech events were chosen at which to interpose the perceptual-motor task. They are: 1) x msec into the current pause; 2) y msec into the current pause; 3) x msec into the current phrase; 4) y msec into the current phrase; where $y>x$. It should be made clear that Event 1 does not necessarily mark short pauses. At any event marker, it is impossible to know how long the present pause will last. If the end of the pause is waited for, the pause event is over, it is lost forever. The only operation possible is to define the event as pauses of at least length x (or y). In this way, Event 2 should demark pauses of longer average length than does Event 1 because all pauses of duration longer than x but shorter than y should be excluded from Event 2 but included in Event 1. Similar arguments hold for Events 3 and 4 with regard to phrase length.

In the earlier experiment, outlined previously, there was a confounding of the information rates, complexity of the perceptual stimulus arrays and the motor response required on the perceptual-motor task. The tasks requiring greater information processing(those tasks with a high information rate) also had a more complicated visual display and required a greater motor response. It is possible that the speech differences between the different task information rates may have been an artifact of the stimulus and response differences, rather than purely a function of the different cognitive resources required to make more complex decisions. In the present experiment, we are replicating the earlier finding controlling for these possible artifacts. Two different perceptual motor tasks are presented to the subject for each of the four stimulus presentation criteria outlined above. In both tasks, the stimuli and responses are exactly the same. Only the cognitive resources required for the decision process are different. One task is a simple RT task while the other is a choice RT task requiring more complex decisions.

Hypotheses

The use of two task complexities allows us to test further whether the interference of the perceptual-motor task with speech is a function of competition for limited central cognitive resources. If it is, the interference should be greater with the more difficult task.

> Hypothesis 1: the effect of the perceptual-motor task should be greater in the choice RT task than in the simple RT task.

Each subject's data is analyzed in terms of all eight combinations of task difficulty and stimulus presentation criterion.

In most studies of pausing in speech, it is assumed that major decision processes are taking place during hesitation pauses. This assumption is based upon correlational evidence whereby pauses lengthen and become more frequent when the speech task demands greater cognitive resources. In this study, this assumption is put to an experimental test. If the decision processes pertaining to speech generation are taking place during hesitation pauses, then (following Barik's (1968) analysis of juncture and hesitation pauses wherein long pauses have a higher mix of hesitation pauses vs juncture pauses), of the four stimulus presentation events outlined above, the central cognitive demands of speech generation should be greatest during Event 2 (long pauses). Therefore, the effect of the perceptual-motor task on speech should be greatest when the perceptual-motor task is presented during criterion 2.

> Hypothesis 2: of the four stimulus presentation criteria outlined above, the effect of the perceptual-motor task on speech should be greatest when the task is presented during long pauses(when criterion 2 is met).

It has been advanced by some experimenters (Boomer, 1965; Barik, 1968; Johnson, 1965; Osgood, 1963; Yngve, 1960; Martin and Roberts, 1967) that the bulk of decision making takes place at major constituent boundaries. That is, the decisions are made at or before the beginning of the phrase. If this is true, then the cognitive resources required should decrease as the speaker proceeds through the phrase. If such is the case, then the cognitive demands of the speech task should be greater at the beginning of a phrase than at the end of the phrase. Therefore, the effect of the perceptual-motor task on speech should be greater early in a phrase than late in a phrase.

Hypothesis 3: the interference of the perceptual motor task with speech should be greater when the perceptual-motor task is presented early in a phrase(criterion 3) than when it is presented late in a phrase(criterion 4).

CHAPTER II

METHOD

Subjects

Eight adult subjects were used in the experiment. They were all right handed. All subjects were screened so that only subjects without speech defects who were able to talk in a monologue for eight to ten minutes were used. All subjects were paid volunteers and had no previous knowledge of the experimental hypotheses.

Procedure

Upon entering the experimental room, the subject is seated and the microphone is positioned six inches in front of him about two inches below mouth level. He is shown both the response key box which is affixed to the end of the right arm of his chair and the oscilloscope on which the stimuli will be presented to him. The oscilloscope is positioned at eye level, three feet in front of the subject. There are two experimenters. One experimenter (E1) sits in the room with the subject, reads the topics to the subject and listens to the subject's responses. The other experimenter (E2) monitors the computer and reads the you will get a three minute break. Are you ready?" There are three different tasks that the subject will be given during the experiment. Following are the three sets of instructions:

Instruction 1 (Baseline task): "The experimenter in the room with you will read you a topic and I want you to prepare to talk about it for at least eight minutes. You will have no other task than to talk about the topic that I give to you. I will tell you when the time is up. You will get the topic and have one minute to think about it before I ask you to begin talking. You can get the topic now' (a topic card is read to the subject by E1). (One minute later) "O.K., now begin talking about the topic."

Instruction 2 (Simple RT task): the same as instruction 1 except insert the following in place of the second sentence of instruction 1. "While you are talking, you will notice a light come on in one of the four quadrants of the oscilloscope. When any, I repeat any, light comes on I want you to depress any of the buttons on the response box as fast as you can. It does not matter which button you press; your task is just to detect that a light has gone on. When you respond, you will notice that the light goes off. When the light goes off, take your finger off of the response key. I want you to do this detection task as you talk about your topic. Are there any questions?" (continues instructions to the subject. The subject is shown that there is an intercom set up between his room and the experimenter monitoring the computer; the experimenter in the room with the subject tells the subject that all further instructions will be given over the intercom and that he, the experimenter in the room with the subject will be there only to read the topics to the subject and listen to his responses. The following instructions are then read to the subject over the intercom by E2:

> "In this experiment, I will be asking you to talk for about eight minutes on each of a number of different topics. I will also ask you to do other things while you are talking. Before we begin, I need to adjust the volume on your microphone so that I can get a good recording. Could you talk for a minute or so about the weather while I adjust the microphone volume."

While the subject talks, E2 adjusts the sensitivity of the speech analyzer, and, if necessary, requests that the subject speak louder or that he enunciate more clearly. E2 then continues:

> "Thank you. In what follows, the experimenter in the room with you is going to be giving you a number of topics to talk on for about eight minutes each. Between topics,

with sentence 3 on instruction 1)

Instruction 3 (Choice RT task): the same as instruction 1 except insert the following in place of the second sentence of instruction 1. "While you are talking, you will notice a light come on in one of the four numbered quadrants of the oscilloscope. When a light comes on, I want you to depress the response key corresponding to the number of the quadrant in which the light comes on as fast as you can. For example, if quadrant three has the light, I want you to depress button three. Your task is to detect both the presence and the location of the stimulus light. When you respond, you will notice that the light goes off. When the light goes off, I want you to take your finger off the response key. I want you to do this detection task as you talk about your topic. Are there any questions?" (continues with sentence 3 of instruction 1)

Computer Control of the Experiment

The presentation of stimuli, recording of responses and stimulus presentations, and the analysis and recording of temporal speech events is accomplished under the control of the PDP-12 computer.

1. Presentation of stimuli: Stimuli are presented on the screen of a Techronix model 564B oscilloscope. The face

of the oscilloscope is 3 1/2 inches high by 4 1/2 inches wide and has tape dividing it into four quadrants. The quadrants are numbered clearly from one to four (clockwise from the upper right: 2,4,3,1). The stimuli consist of a single point light source in the middle of a quadrant. This is accomplished by programming the computer to display the stimuli on the cathode display of the PDP-12 and then slaving the oscilloscope to the PDP-12 cathode display controller.

2. Detection of responses: There is a battery powered response box with four buttons affixed to the end of the right arm of the subject's chair. The output of the box is connected via a phone jack to one of the analog/digital (A/D) converter channels on the PDP-12. There is a battery circuit in the box so that each of the buttons sends a different voltage into the A/D converter. At the beginning of each experimental session, the program checks the four voltages coming from the response box against the four criterion voltages in the program. If the voltages do not match, either a new battery is installed in the box, or the program voltage values are changed.

3. Analysis of speech events. The speech is analyzed by a portion of the programming system that was designed by Dr. Samuel Anderson. It is described fully in a technical report by Anderson and Jaffe (1972). The system has been

used previously in the analysis of speech rate (Jaffe, Anderson, and Rieber, 1973). In essence, the speech analysis subroutines code speech into a system of vocalic segments, transyllabics and silences. The computer codes as a vocalic segment any time between 0.040 and 1.630 seconds during which the speech signal (full-wave rectified and low pass filtered at 2 kHz) rises to and remains no lower than 6 dB from background noise, continuing until it drops as much as or more than 6 dB from a momentary value without rising again for at least 0.020 seconds. The evidence showing that this program does detect vocalic features is presented in the Jaffe, et. al. (1973) article.

In addition to the vocalic feature coding, there is also a pause coding. An event qualifies as a pause when there has been silence for 200 msec. Thus, a pause is seen as a break of greater than 200 msec between clusters (phrases) of vocalic segments seperated by transyllabics and silences of less than 200 msec. duration.

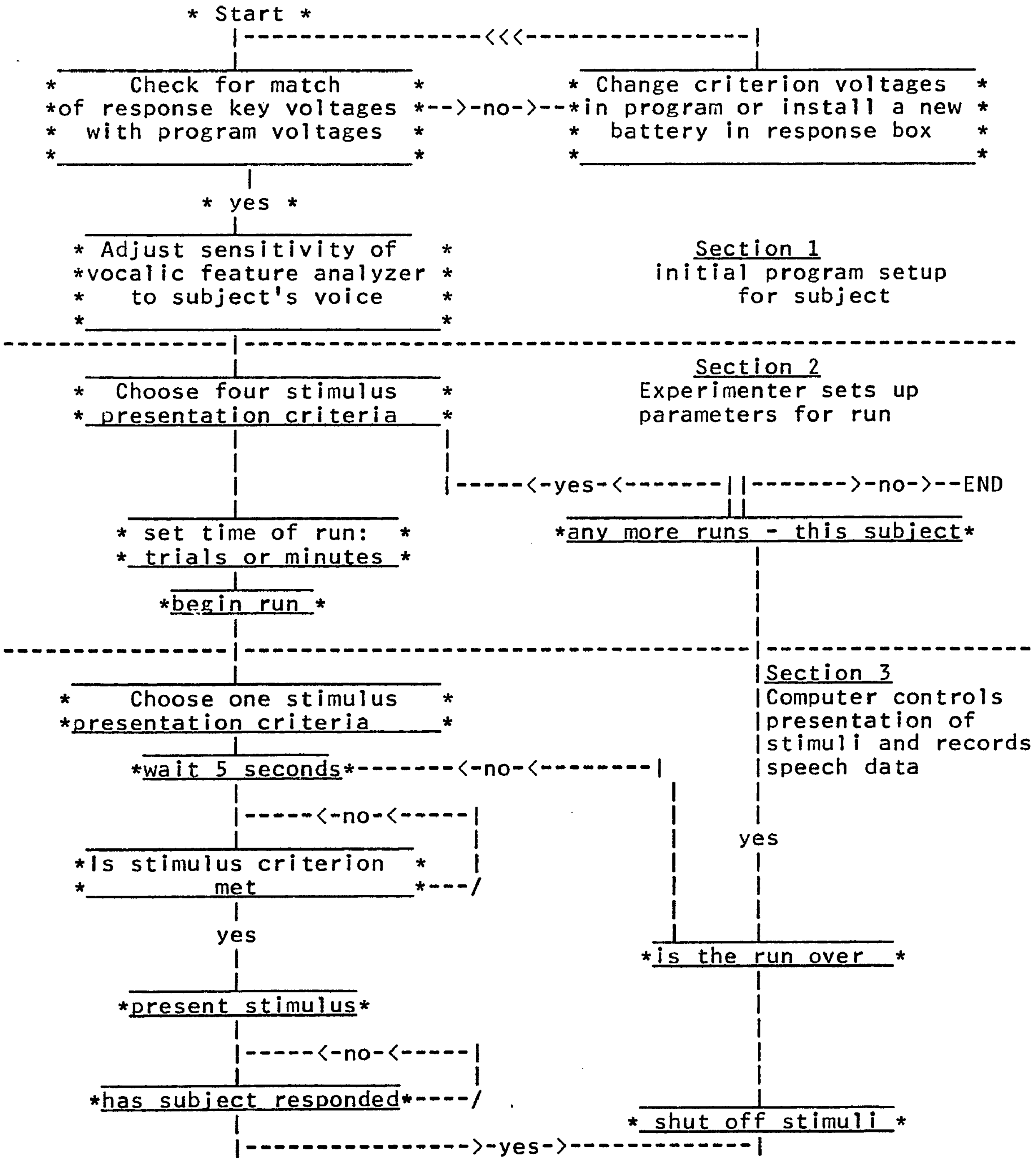
Finally, the computer keeps track of the number of vocalic segments (syllables) in the current phrase. All three speech codes(vocalic feature, pause code and syllable count), together with information on presence or absence of stimuli and response are recorded on magnetic tape by the program once every 400 micro-seconds.

4. Real-time presentation of stimuli contingent upon speech events. The program control of the experiment is shown pictorally in the flowchart of program control (figure 1). There are two criteria that can be used for stimulus presentation: pause or vocalization. A vocalization (the inverse of a pause) indicates that you are within a phrase. In the setting of the criteria for a specific run, the event, the duration of the event, and, for vocalizations, the number of current syllables (vocalic segments) in the current phrase (vocalization) must be specified. This last element of the criteria specification allows the experimenter to eliminate most filled pauses when he wants stimuli presented during vocalizations (filled pauses are usually phrases with only one vowel or vocalic segment).

For each run, four stimulus presentation criteria were selected: 1)pauses of at least 250 msec duration; 2)pauses of at least 700 msec duration; 3)phrases of at least 250 msec duration; and 4)phrases of at least 700 msec duration. Both phrase criteria (3 and 4) have a requirement that there be at least 2 vocalic segments in the phrase. The four criteria varied randomly over stimulus presentation trials within each run. As the run began, the program waited until the subject began to talk. Then the program had a five second dead period during which no stimuli were presented. During the dead period, a stimulus presentation criteria was chosen randomly from among the four alternatives. When the

Figure 1

Flowchart of Program Control



dead period was over, at the first moment when the criteria was met, a stimulus was presented by the program. The stimulus remained on until any response was detected, at which time the stimulus was turned off. After the response, another stimulus trial was initiated by randomly changing the stimulus presentation criteria and initiating another dead period of 5 seconds. The run lasted until the specified total time of eight minutes from speaker onset had elapsed.

Design

The experiment was a repeated measures design where each subject went through eight runs. The first and last run used Instruction 1 where no perceptual-motor task was presented. This was done to get baseline measures for the speech characteristics and to look at the changing baseline over the experimental session. The six remaining runs consisted of three runs with the simple RT task and three runs with the choice RT task. The six task runs were counterballanced to allow separate measurement of task and order effects. For each subject, the eight topics were randomly assigned to the eight experimental conditions.

Analysis of the Data

For each run, the output of the PDP-12 computer consisted of a magnetic tape record of the following five pieces of information every 400 micro-seconds: 1)vocalic feature code ; 2) pause code; 3) syllable count in present phrase (zero during pauses); 4) stimulus information (which stimulus, if any, is present); and 5)response information (which response, if any, is present). This tape was then analyzed on an IBM 370/168 computer as follows:

1)For those runs during which there was no stimulus presented (Baseline condition), the computer ran a simulation routine by randomly choosing one of the four stimulus presentation criteria and marking on the tape as a simulated stimulus presentation the first time the criterion was met. The simulation routine then had a five second dead period, followed by a new stimulus presentation criteria and a new simulated stimulus marker. In this way the baseline run had markers indicating where stimuli would have been presented, had it been a stimulus run.

2)For each stimulus or simulated stimulus, reaction time and pause time in each of the first five seconds after stimulus onset were computed. Of course, there were no reaction time measures made for the simulated stimuli because there were no actual stimuli presented.

3)Each stimulus or simulated stimulus was classified on three independent variables specifying the stimulus presentation criteria: (See figure 2).

I1)simple task, complex task or simulation

I2)stimulus presented during pause or vocalization

I3)stimulus presented early or late in speech event (pause or vocalization)

Independent variable 1 (I1) having three levels was broken down into two independent variables (planned comparisons):

I1A)task vs simulation

I2B)simple task vs complex task

Interactions of the independent variables were also coded and each stimulus presentation was also classified on each interaction variable.

4)Within each subject a multiple regression analysis was performed on each of the six dependent variables (reaction time and the five pause time measures) using as independent variables I1A, I1B, I2, I3, and their interactions.

5)Tests on the eight subjects were then combined (Winer,1962; p 49) to give an overall p value for all 8 subjects.

Figure 2

Design of the Experiment

	Stimulus Presentation Criteria			
	Pause		Vocalization	
Response Task	250 msec	700 msec	250 msec	700 msec
Simple RT				
Choice RT				
No Response Task (Simulation)				

CHAPTER III

RESULTS

It was hypothesized that pause-time would be increased as a result of the stimulus presentations. The present experiment was designed to examine the ways in which this increase varied as a function of the specific speech event in progress when the stimulus was presented. Table 2 presents the means over the eight subjects for reaction time and pause time in each of the first five post-stimulus seconds for each of the twelve combinations of task by stimulus presentation criterion.

Initial Results

Reaction time. Reaction times were significantly $(p<.05)$ longer in the complex task as compared to the simple task in seven of the eight subjects. In the eighth subject, there was a longer reaction time to the simple task as compared to the complex task. It is interesting to note that in a spontaneous discussion with this subject after the experiment was over, the subject talked about her difficulty in dealing with simple tasks.

Pause time in the first five post-stimulus seconds. There were no significant increases in pause time in any of

Table 2

Mean Reaction Time and Pause Time in the First Five Post - Stimulus Seconds

Detection Task	Stimulus Criterion	RT	---Pause Time in Sec 1 to 5----				
			Sec 1	Sec 2	Sec 3	Sec 4	Sec 5
Simple	EP	0.89	.505	.319	.322	.288	.277
Simple	LP	1.00	.452	.320	.271	.275	.277
Simple	EV	0.95	.228	.265	.285	.285	.275
Simple	LV	0.92	.214	.318	.260	.284	.270
Complex	EP	1.12	.556	.336	.319	.317	.297
Complex	LP	1.13	.485	.333	.297	.254	.310
Complex	EV	1.15	.199	.255	.268	.283	.290
Complex	LV	1.17	.204	.306	.304	.272	.285
Simulation	EP	a	.576	.362	.345	.322	.291
Simulation	LP	a	.564	.461	.332	.312	.412
Simulation	EV	a	.216	.310	.311	.330	.306
Simulation	LV	a	.156	.272	.258	.291	.287

EP:Early Pause LP:Late Pause EV:Early Vocalization
LV:Late Vocalization
a) There are no RTs for the simulation condition because there were no stimuli

the five seconds after stimulus presentation in any subject for any of the independent variables or their interactions. Opposite to the hypotheses, there was an actual decrease in pause time in each of the first two seconds post stimulus whenever the stimulus was presented late in a pause($p < .05$ in each of the eight subjects; combined $p < .001$; average rsquare=.08). By the third second, this decrease in pause time was significant in only five of the eight subjects. The F-test for the family of eight subjects became nonsignificant at this third second and remained nonsignificant for the fourth and fifth post stimulus seconds.

Additional Variables

In order to examine whether this decrease in pause time was manifested by the stimulus criterion pause becoming shortened or by subsequent pauses becoming shortened, the following variables were measured and subjected to this same kind of analysis:

1)pause length of the stimulus criterion pause. This variable enabled a determination to be made of whether the stimulus lengthened or shortened the specific pause in progress when it (the stimulus) was presented. This variable only exists for stimuli (or simulated stimuli) presented during a pause.

2)vocalization length of the stimulus criterion vocalization.

3)number of vowels in the stimulus criterion vocalization

Variables 2 and 3 are only measured for stimuli presented during a voaclization.

4)vocalization time in the two seconds after stimulus onset.

5)vocalization time in the five seconds after stimulus onset.

6)number of vowels in the two seconds after stimulus onset.

7)number of vowels in the five seconds after stimulus onset.

8-10)length of the (first - third) pause to begin after stimulus onset.

11-13)length of the (first - third) vocalization to begin after stimulus onset.

14-16)number of vowels in the (first - third) vocalization to begin after stimulus onset.

In addition, for each of the vowel counts (number of vowels per vocalization), there was also computed a vowel time rate (vowels/sec) (e.g., variable 3 / variable 2 = number of vowels/sec in the stimulus criterion vocalization).

Pause lengths. The mean values for stimulus criterion pause length and the first two post stimulus pause lengths are presented in Table 3. The stimulus criterion pause length was significantly decreased in seven of the eight subjects when the stimulus came late in a pause. In the eighth subject, there was no difference. The average size of effect was rsquare = .065 and the significance level of the family (eight subjects) of tests was $p < .01$.

Vocalization lengths, vowel counts, and vowel rates. Table 4 shows the vocalization time, vowel count and vowel rate for criterion vocalizations and the first two post-stimulus vocalizations. Stimulus criterion vocalizations became longer (seven of eight subjects; mean rsquare = .093; family $p < .001$), and the vowel rate became higher (eight of eight subjects; mean rsquare = .047; $p < .01$) when the stimuli were presented as compared to the simulation condition. In only two of the eight subjects was there a significant difference between the simple and complex task on the stimulus criterion pause and vocalization measures with the largest rsquare in any case being <.015. There were also no significant differences in stimulus criterion pause and vocalization measures when the stimulus came early in a pause or late in a vocalization.

There was an increase in vocalization time in the two seconds post stimulus when the stimulus was presented late in a pause. This is just a repeat of the first analysis presented at the beginning of the results. There was no

Table 3

Duration of Stimulus Criterion Pause and First Two Post Stimulus Pauses

		--------Pause Lengths---------		
Detection Task	Stimulus Criterion	Stimulus Criterion	1st Post Stimulus	2nd Post Stimulus
Simple	EP	1.052	.851	.804
Simple	LP	1.409	.966	.897
Simple	EV	a	.793	.782
Simple	LV	a	.771	.801
Complex	EP	1.319	.839	.799
Complex	LP	1.208	.887	.812
Complex	EV	a	.741	.781
Complex	LV	a	.839	.910
Simulation	EP	1.178	.692	.744
Simulation	LP	1.597	.930	.840
Simulation	EV	a	.860	.904
Simulation	LV	a	.752	.796

EP:Early Pause
LP:Late Pause
EV:Early Vocalization
LV:Late Vocalization
a) There are no stimulus criterion pauses when stimuli were presented in a vocalization

Table 4

Duration and Vowel Rates of Criterion Vocalization and First Two Post Stimulus Vocalizations

		Criterion Vocalization		Post Stimulus Vocalizations First		Post Stimulus Vocalizations Second	
Detection Task	Stimulus Criterion	Duration	Vowel Rate	Duration	Vowel Rate	Duration	Vowel Rate
Simple	EP			1.681	3.281	1.480	3.184
Simple	LP			1.634	3.228	1.521	3.197
Simple	EV	2.750	3.231	1.265	3.364	1.345	3.091
Simple	LV	3.062	3.046	1.346	3.310	1.391	3.061
Complex	EP			1.547	3.100	1.487	3.010
Complex	LP			1.494	3.154	1.410	3.104
Complex	EV	2.407	3.276	1.149	3.312	1.234	2.987
Complex	LV	2.711	3.026	1.215	3.325	1.204	3.081
Simulation	EP			1.588	3.240	1.610	3.181
Simulation	LP			1.545	3.206	1.444	3.195
Simulation	EV	1.799	2.959	1.386	3.014	1.510	3.046
Simulation	LV	2.529	3.160	1.288	3.227	1.394	3.213

EP:Early Pause LP:Late Pause EV:Early Vocalization LV:Late Vocalization
Durations in seconds; Vowel rates in Vowels/second

difference in vocalization time in the two seconds post stimulus when the stimulus was presented early in a vocalization. This is surprising when it is noted that the length of stimulus criterion vocalizations increased. What accounts for this balancing out is that the length of the first vocalization after the stimulus criterion vocalization is decreased in the task condition relative to the simulation condition($p<.05$ in seven of eight subjects; mean rsquare = .026; family $p <.01$). Although this first post stimulus vocalization length is less in the task condition than in the simulation, the vowel rate is higher in all eight subjects ($p <.05$ in all subjects; mean rsquare=.031; family $p <.001$). The vowel rates for both the task and simulation for the first post stimulus vocalization are almost the same as those for the stimulus criterion vocalizations.

There were no consistent differences in the length of the first post stimulus vocalization when the stimulus came in a pause. There were also no significant differences in the second or third pause length, vocalization length, or vowel rate for any of the stimulus criterion.

CHAPTER IV

DISCUSSION

In the present experiment, the visual information processing task increases verbal output when it is presented at certain times during pauses in the speech task. This is opposite to the effect of the visual task in the preliminary experiment wherein the visual task increased pausing and decreased verbal output. This difference can be understood by examining the information processing demands of the two experiments.

In the preliminary experiment, the visual task was presented regularly every second and the subject knew that he had to respond within one second before the next stimulus was presented. This was a high demand discrimination task (Pribram and McGuinness, 1975) with a constant and short inter-stimulus interval. Because of this high demand, it was assumed that the visual task had a higher priority for the use of the cognitive operators than did the speech task. The visual task, therefore, decreased the availability of information processing operators to the speech task. The consequent speech generated was interpreted as being a function of the diminished information processing capacity available to the speech task.

In the present experiment, the information processing demands of the visual task were different than they were in the preliminary experiment. The visual task was presented with an inter-stimulus interval barying between five and twenty seconds. Because of the relatively infrequent presentation of the visual task, and the instructions that the subject was to talk continuously for the eight minute run, the demands were such that the speech task take priority over the visual task for the use of the cognitive operator. This experiment is a vigilance experiment (Pribram and McGuinness, 1975; Antrobus and Singer, 1964) with a concurrent speech task. In the experiment, the visual stimuli increase activation (Berlyne, 1969; Pribram and McGuinness, 1975) as measured by an increase in verbal output.

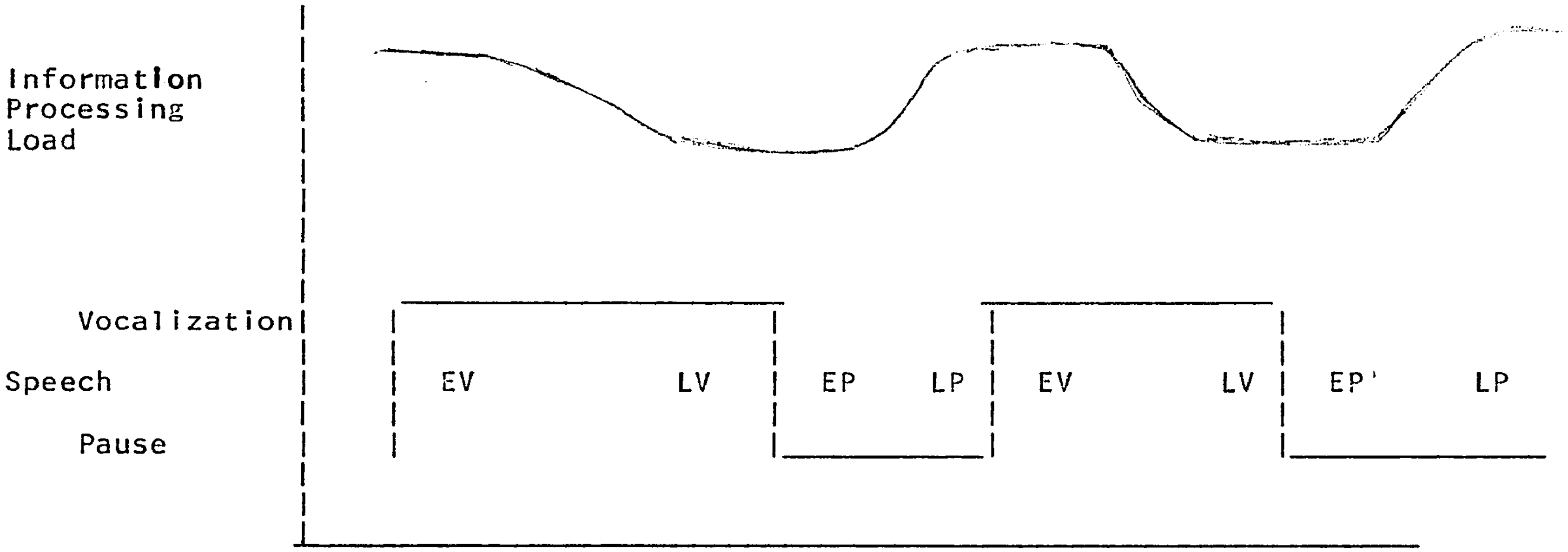
This increased verbal output can be seen as a kind of orienting response. It is important to point out that this model of orienting responses is not the model presented in the literature (Pribram and McGuinness, 1975; Sokolov, 1963; Broadbent, 1958; Berlyne, 1969), but is a variation on it. In most uses of the orienting model, there is only one task to which the subject is attending. Changes in the information content in this one task elicit orienting responses to the task. In the present experiment, there are two tasks to which the subject is attending. The model I am using suggests that orienting responses to stimuli from task B(the visual task) are evidenced by an increased output on task A (the speech task). Even though there is no empirical evidence (other than from the present experiment) relevant to this new extension to the orienting model, it does not seem like an unreasonable extension of the classic orienting model.

In the present experiment, the visual information processing task only elicited this activation or orienting response when the stimuli was presented late in a pause or early in a vocalization. An organism will orient when there is a change in information (Sokolov, 1963; Berlyne, 1969). If we assume that there is a certain magnitude of change in information level necessary to elicit an orienting response, then the results of the present experiment suggest a larger increment in total information processing when stimuli were presented late in a pause or early in a vocalization as compared to late in a vocalization or early in a pause. Since the information content of the visual task is constant, this would imply that there is less information processing taking place late in a pause and early in a vocalization as compared to late in a vocalization and early in a pause (see Figure 3).

The model presented in Figure 3 suggests that the information processing demands of speech generation are

Figure 3

Model of the Information Processing Load During Speech



EP:Early Pause LP:Late Pause EV:Early Vocalization
LV:Late Vocalization

lowest late in a pause and early in the subsequent vocalization. Is this model (Figure 3) in opposition to the previously stated model that thinking or planning of subsequent speech takes place in hesitancy pauses? More specifically, are the results of the present experiment in opposition to the results of the preliminary experiment where as less cognitive processes became available to the speech task, pausing increased in the speech? The present results are not in opposition to either the earlier model nor the results of the preliminary experiment. In fact the present results are orthogonal to the results of the preliminary experiment. The present experimental results only say that there is lower information processing load late in pauses and early in vocalizations as compared to early in pauses and late in vocalizations. It is certainly possible that planning is taking place late in pauses. The present results suggest that whatever processes are taking place late in a pause (700 msec into a pause) these processes do not make as great a demand on the cognitive operators as do the processes that take place early in a pause (250 msec into a pause). The present experiment says nothing about what specific information processing is taking place during the different speech events, it only measures the relative information processing loads of the tasks that are taking place.

There is an alternative explanation of the decrease in pause time after stimuli that come late in a pause as compared to stimuli that come early in a pause. It is possible that the early and late pause conditions are not really early and late portions of the same kind of pause. Events in the early pause condition can come from pauses which might have been short or long had they been allowed to continue. Hence, early pauses could come from rapid or slow speech. Late pauses can come only from longer pauses. Hence, they can only come from slower speech. The decrease in pause time after stimuli presented late in a pause may be because the stimuli came during slow speech as compared to faster speech for the early pause condition.

The orienting response or increase in verbal output was manifested differently when the stimuli came late in a pause as compared to early in a vocalization. When the stimulus comes late in a pause, the subject ends the pause earlier than he would have had there not been a stimulus. There was no effect on any of the measures of pause length, vocalization length or vowel rate (number of vowels per phrase and number of vowels per second) for the speech after the shortened pause. The stimulus seemed to have the effect of bringing the subject back to the speech task, without affecting the temporal characteristics of the subsequent speech. This could also be seen as the subject being almost ready to begin speaking when he was late in a pause and the stimuli recruiting the speaking response and thereby shortening the pause length. This would fit in with the model presented above wherein long pauses came from slower speech.

When the stimuli came early in a vocalization, the current vocalization was lengthened, and this vocalization had an increased vowel rate. Thus, more speech (more syllables or vowels) was uttered in the phrase during which the stimulus was presented.

One possibility is that the same kind of effect took place as it did in Yngve's experiment (1973) where subjects backtracked and repeated themselves when they had to detect stimuli and respond verbally. I listened to the tape recordings of the speech informally and noticed only two instances in all the speech of the eight subjects where this backtracking phenomenon took place. Therefore, the backtracking phenomenon cannot account for the present experimental results. In light of the present results, it seems as though Yngve's backtracking results (Yngve, 1973) were more a result of his verbal response requirements than of his visual detection task itself.

Is this increased verbal output in the present experiment relevant to the speech being produced? Does it add to the information content that was being produced, or is it extraneous? These questions cannot be answered without examining the actual semantic content of the phrases in question in further experimentation. These experiments could be done by expanding the technology in the current experiment to enable stimulus presentation and stimulus criterion to be encoded onto the recording of the actual speech. The speech could then be transcribed and the appropriate phrases judged on measures of information content.

These possible further experiments on the information content of phrases lengthened by visual orienting stimuli would be worthwhile because of their relevance to a model of speech disorder in schizophrenia. In schizophrenia, the normal inhibitions imposed on speech behavior, which prevent every intrusive percept from being uttered or having an effect on speech, are weakened (Locke, 1975). In schizophrenic patients, this inhibitory release is especially evident with respect to the visual modality (Locke, Caplan, and Kellar, 1973).

> The efficacy of vision as an initial releaser can be demonstrated in the same group of patients (both demented and schizophrenic patients) by the recording of spontaneous verbal output in an illuminated environment and in total darkness. The ratio of percentage of spontaneous speech (speech time/total time) in darkness to percentage of spontaneous speech in light demonstrates strikingly the relation between speech behaviour and visual input in schizophrenia, and the comparative independence of the two in the dementing diseases in which the auditory percept serves as a more potent releaser (Locke, 1975).

Getting back to the experiments on normal subjects, in those cases where the subject is attentive to a visual task and there is a relatively low information load in the speech task (early in a vocalization), the visual stimulus acts to increase verbal output. This might be a possible model for the processes taking place in the disordered speech of schizophrenics.

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