SENTENCE PROCESSING WITH VISUAL PRESENTATION

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by

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SCOPE AND CONTENTS:

Two studies are reported investigating the role of articulation at input on the memory of visually presented sentences. The results of Experiment I indicated that irrelevant articulatory activity caused a decrement for the verbatim recall of both instructive sentences and word lists. However, there was no recall decrement for instructive sentences when the recall task consisted of carrying out the instructions given in the sentence. Experiment II indicated that irrelevant articulatory activity resulted in a decrement for sentence recognition with respect to both meaning and word changes.

The results of the two experiments are discussed in terms of a differential need for the articulatory apparatus in the processing of "light" versus "heavy" information loads.

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FIGURE CAPTIONS

Murray (1967) and Sperling (1967) have suggested that visual and auditory inputs are "translated" by covert or overt articulation into acoustic form before entering a short-term memory store, this store being acoustic in nature. Murray (1965) varied speech responding in Ss as items were presented visually or auditorily and found that recall increased as vocalization intensity increased from mouthing to whispering to loudly speaking words. In later work, Murray (1967) found that articulating visually-presented letters enhanced their recall when correct pronunciation was used. These results could be interpreted as support for a "translation hypothesis". Levy (1971) provided explicit support for the articulatory translation hypothesis. She adopted a technique used by Murray (1967) whereby Ss articulated an irrelevant word as stimuli were presented, and assumed that a S cannot be peripherally articulating one item and centrally processing a different item via the same mechanism. In a study on the role of overt articulatory activity in the processing of aurally and visually presented items, Levy found that if letters presented visually were either heard or articulated, they were recalled significantly better in a probe task than if they were neither heard nor articulated. With lists of words, which are much higher in meaningfulness, both probe recall and recognition tasks yielded the same results. Hence, Levy's data support the hypothesis that visually-presented items must be recoded via the articulatory apparatus in order to enter the memory store, while aurally-presented items do not. However, even when overt articulation of the stimuli is hindered, there is still the possibility that storage occurs by means of a more central process which does not require that the vocal apparatus be moved. The low level of recall when articulation was suppressed suggests that this central articulatory processing did not occur in Levy's experiments.

The present studies propose to test whether such explicit articulation is necessary for memory of either the essential meaning (gist) or the literal words of visually-presented sentences. It is possible that the greater meaningfulness of sentences allows the gist and maybe even the words to enter a memory store via a different mechanism than articulatory translation. The crucial role of meaning in memory is suggested by a body of evidence showing that the meaning of words and sentences can be retained better than the words themselves. (1) Data from recognition tasks show that synonyms of a previously-presented item are more often falsely recognized as that item than are control words (Fillenbaum, 1969; Grossman & Eagle, 1970). (2) In Recall of noun pairs which appear as the subject and object in each of two sentences, recall is better when the two sentence contexts bias the same meaning for the noun pair - "The dog's bark frightened the baseball pitcher" and "The animal's bark scared the big-league pitcher" - than when the two sentence contexts bias different meanings for the noun pair - "The dog's bark frightened the baseball pitcher" and "The medicinal bark filled the porcelain pitcher". Hence, semantics affect recall even though phonology remains identical (Bobrow, 1970). (3) False recognitions of sentences containing a high associate of a stimulus word occurred less when the associate did not fit into the context of the sentence than when it did (Hall & Crown, 1970). (4) The meaning of an ambiguous word is constrained by use in a sentence such that more false recognitions occur to associates of the meaning indicated by the sentence context than to associates of the other possible meanings (Perfetti & Goodman, 1970). (5) Subjects are sensitive to differences between sentneces containing an ordered "and" (those in which changing the order of the terms or clauses would change the meaning) and sentences containing an unordered "and " (those in which changing the order of the terms or clauses would not change the meaning), a difference that implied processing of semantic properties of the cojoined verbs (Fillenbaum, 1971). (6) The error patterns in verbatim recall of sentences imply that recall is a constructive process that uses the major semantic ideas of the sentence (Martin & Walter, 1969). Such work demonstrated that memory for semantic information is different from and often better than memory for the exact words. Therefore, although visually-presented sentences may need to be recoded via the articulatory apparatus in order for the exact words to be remembered, it is possible that gist could be processed without the aid of the articulatory translation mechanism. Hence, the first study to be reported used both a word recall task and a semantic recall task, i.e., one that measures the retention of the meaning as contrasted to the retention of the exact words. If irrelevant articulation interfered with word recall but not gist recall, we would have evidence that a mechanism other than articulatory translation exists for gist processing. If word recall is better than chance under irrelevant articulation, this would suggest that controlling overt articulation does not entirely eliminate word processing.

Experiment I also used two types of presentation: simultaneous, in which all the items of a word list or sentence appeared together, and successive, in which each item of a word list or sentence appeared alone in succession. Since normal sentence processing occurs with simultaneous presentation, this may be necessary to give a reasonable test of the gist variable. The successive presentation condition was included because it allows more control over the S's processing.

EXPERIMENT I

METHOD

Materials

Sixteen instructive sentences (commands and questions), each containing twelve words, were constructed by E. A pilot project had indicated that this sentence length would give an optimal verbatim recall level (approximately 40% errors). There were also sixteen word lists which consisted of the words in each sentence randomly arranged. The word lists and sentences were typed in block print without any punctuation. The material was presented visually on an IBM typewriter used as a memory drum. The objects necessary to carry out instructions given in the sentences were available on a table beside the S and the S used these objects in practice trials before the experiment began. Table 1 gives examples of the instructions given

TABLE 1

Examples of Instruction Sentences used in Experiment I

INSTRUCTION SENTENCE	MATERIALS AVAILABLE RELEVANT TO THE INSTRUCTION
FROM THE SET OF AVAILABLE COINS CHOOSE TWENTY CENTS IN THREE WAYS	5 QUARTERS; 7 DIMES; 8 NICKELS; 11 PENNIES.
DOES THE GIRL WITH BLONDE HAIR AND RED SUNGLASSES HAVE A SCARF	ONE PAPER DOLL WITH BROWN HAIR, NO SUNGLASSES, AND A SCARF; ONE PAPER DOLL WITH BLONDE HAIR, NO SUNGLASSES, AND A SCARF; ONE PAPER DOLL WITH BLONDE HAIR, RED SUNGLASSES, AND NO SCARF.
BUILD A TALL TOWER USING SEQUENCES OF RED YELLOW AND BLUE BLOCKS	4 BLUE BLOCKS; 4 GREEN BLOCKS; 4 RED BLOCKS; 4 YELLOW BLOCKS; 3 WHITE BLOCKS.

and the objects provided in order to carry out an instruction. Note that there were always incorrect alternatives available. The Ss were provided with an answer booklet for the written recall tasks.

Design

The within-subject variables formed a 2^4 factorial classification. There were two types of material (sentences and word lists), two types of presentation (simultaneous presentation of all the items in a sentence or word list or successive presentation of each item in the sentence or word list), two types of articulation (silent in which the S read the words silently as they appeared and irrelevant in which the S said "Hiya" aloud rapidly and continuously during the presentation), and two types of recall (verbatim in which the S wrote each word that he saw in the correctly numbered blank, starting with whichever blank he chose, or semantic in which the S carried out the instruction given in the sentence with the materials available). Two list replications of each type were used, making a total of 32 lists per S. The four within-subject variables were counterbalanced across Ss for order of presentation yielding a 2^4 between-subjects design, requiring 16 Ss for one observation per cell. Two replications of the between-subjects design were conducted requiring a total of 32 Ss.

PROCEDURE

The Ss were tested individually. Six practice sentences were given to familiarize the S with the presentation displays, articulation modes, and types of recall. The E corrected any faulty "Hiya" articulation making sure the irrelevant articulation was continuous. Ss were told before each trial whether to read silently or say "Hiya", whether presentation would be simultaneous or successive, and whether verbatim recall or semantic recall would be tested. The entire sentence or word list was presented for six sec. in simultaneous presentation and each item of a sentence or word list was presented for 0.5 sec. in successive presentation. At the end of presentation, a blank appeared in the typewriter window, signalling the S to begin recall. The S was given as much time as he wanted for recall. The E recorded the S's performance on the semantic test.

Subjects

The Ss were 32 undergraduate students at McMaster University who were paid for their participation in the experiment.

RESULTS

Analyses of variance, with arcsin transformations, were performed following Murdock & Ogilvie (1968). Separate analyses were performed for (1) words, (2) sentences tested by verbatim recall, and (3) sentences tested by semantic recall. Spearate analyses were necessary because sentences had a semantic recall task and a verbatim recall task, while the word lists had only a verbatim recall task. Also, verbatim recall was scored in terms of memory for the item in each serial position, while in the semantic recall task this was not possible. The ANOVA tables for these analyses are contained in Appendix 1.

Words

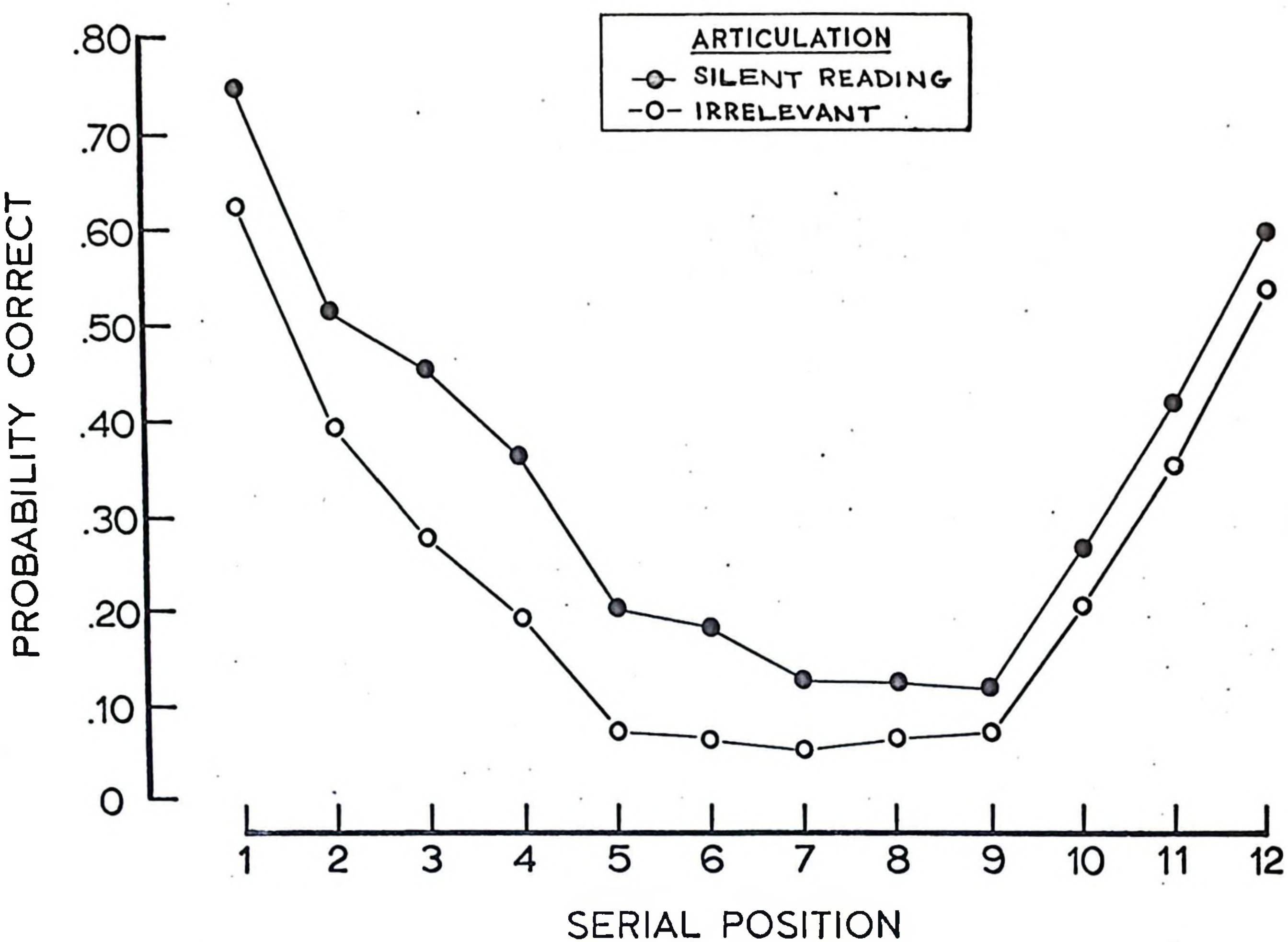
The ANOVA yielded a main effect of Type of Articulation ($F(1,\infty)=113.5$, $p < .01$) with recall being better under silent reading than under irrelevant articulation (Fig. 1), a main effect of Serial Position ($F(11,\infty)=144.7$, $p < .01$) and a main effect of Type of Presentation ($F(1,\infty)=43.39$, $p < .01$) with simultaneous presentation being better than successive presentation.

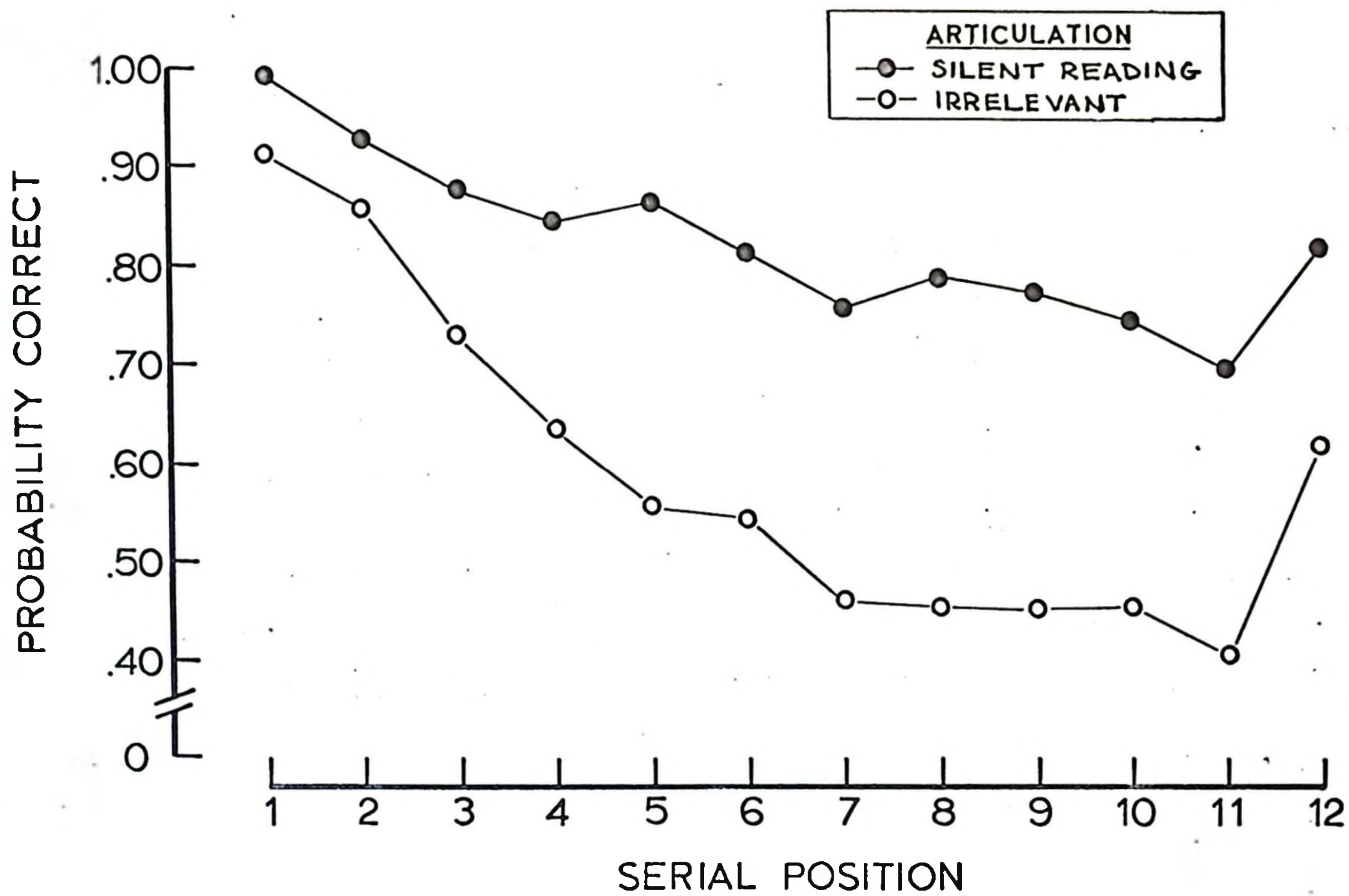
Sentences-Verbatim Recall

The ANOVA yielded a main effect of Type of Articulation ($F(1,\infty)=224.13$, $p < .01$), Type of Presentation ($F(1,\infty)=14.23$, $p < .01$), and Serial Position ($F(11,\infty)=25.48$, $p < .01$). Performance with silent reading was better than performance with irrelevant articulation under all conditions (Fig. 2) and simultaneous presentation was better than successive presentation (Fig. 3).

Sentences-Semantic Recall

The ANOVA yielded no significant effects or interactions for any of the experimental variables. There was no difference between performance under silent reading (probability correct = .80) and under irrelevant articulation (probability correct = .79). Also, performance under simultaneous presentation (probability correct = .81) was essentially the same as performance with successive presentation (probability correct = .78). Tables 2A and 2B show the performance of individual Ss under the articulation and presentation conditions.


ARTICULATION
SILENT READING
IRRELEVANT
PROBABILITY CORRECT
.80
.70
.60
.50
.40
.30
.20
.10
0
1
2
3
4
5
6
7
8
9
10
11
12
SERIAL POSITION



ARTICULATION
SILENT READING
IRRELEVANT
PROBABILITY CORRECT
1.00
.90
.80
.70
.60
.50
.40
0
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10
11
12
SERIAL POSITION

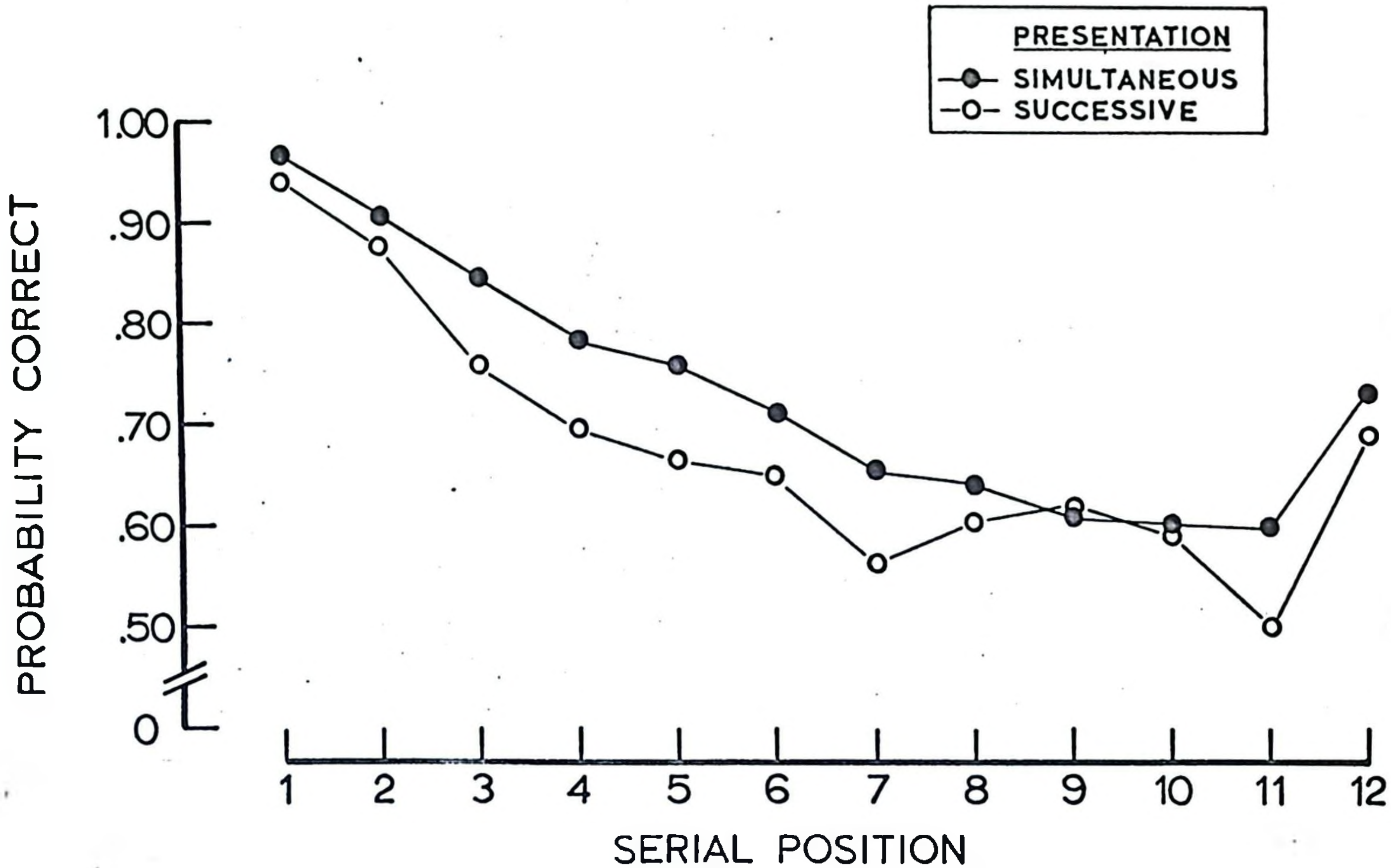
PRESENTATION
SIMULTANEOUS
SUCCESSIVE
1.00
.90
.80
.70
.60
.50
0
PROBABILITY CORRECT
1
2
3
4
5
6
7
8
9
10
11
12
SERIAL POSITION

TABLE 2A

INDIVIDUAL SUBJECT SCORES OUT OF A MAXIMUM OF 4 FOR THE TWO ARTICULATION CONDITIONS ON THE SEMANTIC RECALL TASK OF EXPERIMENT I

	IRRELEVANT ARTICULATION	SILENT READING
S(1)	2	3
S(2)	2	3
S(3)	2	4
S(4)	3	3
S(5)	3	3
S(6)	4	4
S(7)	3	4
S(8)	3	2
S(9)	4	3
S(10)	3	4
S(11)	3	4
S(12)	1	2
S(13)	4	3
S(14)	4	4
S(15)	4	4
S(16)	4	3
S(17)	3	4
S(18)	4	3
S(19)	3	3
S(20)	3	3
S(21)	4	2
S(22)	4	3
S(23)	4	3
S(24)	3	3
S(25)	3	3
S(26)	3	4
S(27)	1	1
S(28)	3	4
S(29)	4	2
S(30)	4	4
S(31)	3	3
S(32)	4	3

TABLE 2B

INDIVIDUAL SUBJECT SCORES OUT OF A MAXIMUM OF 4 FOR THE TWO PRESENTATION CONDITIONS ON THE SEMANTIC RECALL TASK OF EXPERIMENT I

	SIMULTANEOUS PRESENTATION	SUCCESSIVE PRESENTATION
S(1)	3	2
S(2)	4	1
S(3)	3	3
S(4)	4	2
S(5)	3	3
S(6)	4	4
S(7)	4	3
S(8)	4	1
S(9)	3	4
S(10)	4	3
S(11)	3	4
S(12)	1	2
S(13)	4	3
S(14)	4	4
S(15)	4	4
S(16)	4	3
S(17)	3	4
S(18)	4	3
S(19)	2	4
S(20)	4	2
S(21)	3	3
S(22)	3	4
S(23)	4	3
S(24)	4	2
S(25)	3	3
S(26)	3	4
S(27)	1	1
S(28)	4	3
S(29)	3	3
S(30)	4	4
S(31)	2	4
S(32)	3	4

DISCUSSION

The results for recall of the word lists in the present experiment replicated those of Levy (1971). Despite the differences in material used, there was a significant decrement in recall when Ss were required to say "Hiya" during stimulus presentation. Fig. 1 shows however, that irrelevant articulation did not completely prevent items from being stored. In Levy's study, the probability of recall for word lists under irrelevant articulation did not vary significantly from chance for either probe or recognition tasks. This discrepancy between the two studies will be dealt with in the final discussion section.

The analysis for sentences tested by verbatim recall showed that irrelevant articulation caused a significant impairment in recall of highly-organized material. Again recall under irrelevant articulation as illustrated in Figure 2, shows that irrelevant articulation did not completely prevent items from being stored. The fact that irrelevant articulation does not eliminate recall completely may be interpreted in at least two ways. Either the technique of repeating an irrelevant word does not take up all the articulatory capacity or the encoding of visually-presented information can occur via other mechanisms than articulatory translation.

Although the nature of the irrelevant articulation task has been considered responsible for the decrement in recall under the irrelevant articulation condition (i.e., articulatory translation is prevented or hindered), one might suggest that verbatim recall is lower under irrelevant articulation than under silent reading because in the former condition the Ss had an extra task to perform - say "Hiya" while reading the material (the nature of the extra task being immaterial). However, Levy (1971) had found that with an auditory presentation, recall was the same for Ss who mouthed "Hiya" as for Ss who mouthed the items being presented for recall. In view of this data, the extra task is not considered to be responsible for the recall differences under the two articulation conditions.

There was a higher probability of recall for simultaneously-presented items than for successively-presented items in the verbatim recall of sentences and in two replications of the word lists. This is not surprising because with simultaneous presentation, the S has the option of encoding the sequence in chunks, of distributing presentation time differentially over certain chunks, or of returning to an item that was not grasped or comprehended on a first scan and consolidating it with reference to a context.

The interpretation of the results for sentences tested by a semantic recall task poses problems. The overall higher level of recall here is interpreted in terms of a lighter memory load leading to correct performance. In msot cases the S did not have to know every item or the exact order of items in the sentence in order to carry out the instruction correctly. In verbatim recall, each item had to be recalled and placed in the correctly numbered blank, and performance was scored for each of the twelve items in a sentence. In the verbatim recall task, there was also a fairly high level of output interference whereas in semantic recall, output interference was minimal. The fact that recall level did not differ for irrelevant articulation and silent reading on the semantic test cound be interpreted as suggesting that the articulatory translation hypothesis does not hold for the encoding of sentence gist. However, because irrelevant articulation did not eliminate all the items in verbatim recall, it is also possible that the sentence information is simply redundant enough so that even when a lot of information is lost in irrelevant articulation enough is retained to provide the gist, i.e., allow the S to carry out the instruction correctly. In order to compare the effects of irrelevant articulation on words and semantics, it is necessary to have a word test and a semantic test for which the number or relevant words is equal. Hence, Experiment II was designed using a technique whereby the meaning of a sentence was changed by interchanging its subject and object (Sachs, 1967). In such a semantic change, the words remain the same (only their order differs) and the meaning of the sentence changes. The substitution of a synonym for one word in a sentence, referred to as a lexical change, causes the words to change, while the meaning of the sentence remains the same. When the recall task is to indicate the type of change made in a test sentence as compared to its original, then the amount of relevant information for gist recall and word recall is more equal than it was in Experiment I. Also, the output interference that existed in the verbatim recall of Experiment I is eliminated.

EXPERIMENT II

METHOD

Material

Three hundred concrete sentences of the form: the, adjective, noun, verb (past tense), the, adjective, noun- were constructed by the E. Table 3 gives examples of the sentences used. These sentences were typed in 60 sets of five, each set followed by the words "Test Sentence". All sentences were typed in block print without any punctuation and presented visually on an IBM typewriter used as a memory drum. No sentence was repeated. Any word repeated in the entire set of 60 sentences was separated by a minimum of twenty-five sentences from its first incidence. Four sets of test sentences were constructed in accordance with the between-subjects design. Each test sentence was typed in block print without any punctuation on an index card. Answer booklets with a separate page for each test sentence were provided.

Design

The within-subject variables formed a 2x3x2x5 factorial classification. There were two types of articulation (irrelevant in which the S said "Hiya" as the sentences appeared and silent in which the S read the sentences to himself as they appeared); three types of changes made in the test sentence (semantic, in which the subject and object were interchanged, lexical, in which one noun was changed to a synonym, and filler, in which a lexical change, synonym substitution, was made with respect to the verb or an adjective); two types of test sentence (identical to its preceding counterpart or different in one of the above ways from its preceding counterpart); and five set positions to be tested (the test sentence could be the first, second,

TABLE 3

EXAMPLES OF SETS OF SENTENCES USED IN EXPERIMENT II

THE TRAINED ENEMY ENCIRCLED THE NAIVE DEFENDERS

THE BOLD PROPRIETOR CHEATED THE INNOCENT GYPSIES

THE SLIM DANCER IMPRESSED THE PRETTY LADY

THE ANGRY COLLIE INTIMIDATED THE CONFUSED BULL

THE UPRIGHT POLICEMAN ANNOYED THE SCHEMING DRIVER

THE TORTURED PRISONERS ESCAPED THE HEARTLESS GUARDS

THE GRACIOUS DUCHESS THANKED THE GENEROUS PRIEST

THE SWIFT SPARROW OVERTOOK THE FLEEING ATTACKER

THE BELEAGURED BATTALION WELCOMED THE AWAITED RECRUITS

THE SMILING STEWARDESS REASSURED THE ANXIOUS PILOT

THE IMPATIENT CHILD SLAPPED THE INTERFERING PARENTS

THE GREAT WAVES OVERSHADOWED THE TINY SHIP

THE CONSIDERATE BOY HELPED THE CRIPPLED LADY

THE ELOQUENT LAWYER PERSUADED THE RELUCTANT CLIENTS

THE RECKLESS HOODLUM DISARMED THE DROWSY GUARD third, fourth or fifth member of the set). This required a total of 60 sets of sentences for the within-subject design. The three types of changed test sentences and the identical test sentences occurred randomly in the 60 sets, with the restrictions that half the test sentences be changed and half the test sentences be identical, and that, for the changed test sentences, there be equal numbers of semantic, lexical, and filler changes. There were two sets of test sentences such that "changed" test sentences in one set were tested as "identical" sentences in the second set and vice versa. For each test type (semantic, filler, lexical, and identical) each of the five sentence positions in the set was tested an equal number of times. Two orders of testing sentence position within a set were used: 4, 1, 3, 2, 5 and 2, 4, 5, 1, 3. A factorial classification of the two sets of test material, two orders of testing sentence position and two orders of presenting the articulation conditions formed the between-subjects design. This design required 8 _S_s for one replication per cell. There were six replications per cell, making a total of 48 _S_s.

PROCEDURE

The _S_s were tested individually. There were three practice sets to familiarize the _S_ with the procedure. During the practice sets, _E_ corrected any faulty "Hiya" articulating, making sure that the _S_ articulated rapidly and continuously. Each sentence was shown for 3.5 sec., a two word per sec. rate. Immediately after the set of five sentences, the test sentence was presented on an index card. The _S_ had 12 sec. to make a judgement of "Identical" or "Different". If the _S_ indicated "Different", he had to indicate either "Semantic" or "Lexical" according to whether the change was one of meaning or one of wording only with meaning relatively unchanged. When he did not inow whether the test sentence was identical or different or how it differed, the S was instructed to guess. The Ss were all told that half of the test sentences were identical and half were different. The sentence presentation was controlled automatically by a pair of Hunter decade interval timers connected by means of a solenoid to the index key of the typewriter.

Subjects

Forty-eight grade twelve students served as Ss and were paid for their participation in the experiment.

RESULTS

The filler sets were included in the design to ensure that the S attended to all the words in each sentence. They were not included in the analysis. The mean proportions correct were calculated for the identical, semantically-different, and lexically-different test sentences under silent reading and under irrelevant articulation. These proportions are presented in Table 4. As they represent raw data and make no correction for a priori probability of stimulus presentation or response bias, no analyses were performed on these mean proportions. Instead, ability to detect test sentences with word changes (lexical changes) from all other test sentences and ability to detect test sentences with gist changes (semantic changes) from all other test sentences was determined by computing the tables in Appendix 2. These tables represent the hits and false alarms in detecting lexical changes from identical sentences or semantic changes

TABLE 4

MEAN PROPORTIONS CORRECT IN EXPERIMENT II AS A FUNCTION OF ARTICULATION MODE X TYPE OF TEST SENTENCE

	IDENTICAL	LEXICAL DIFFERENT	SEMANTIC DIFFERENT
IRRELEVANT ARTICULATION	.46	.37	.48
SILENT READING	.65	.48	.59

and in detecting semantic changes from identical sentences or lexical changes for each group of six Ss. After combining the data in this way to give independent measures of ability to detect wording changes and ability to detect meaning changes, alpha values (formula given in Appendix 2) were computed according to Luce (1959). According to a one-tail sign test (Siegel, 1956), semantic changes were easier to discriminate than lexical ones ($Z = 2.25$, $p < .05$), and performance under silent reading was better than performance under irrelevant articulation ($Z = 3.25$, $p < .01$). However, analyzing the articulation conditions separately shows that semantic changes are not significantly better discriminated than lexical ones in irrelevant articulation ($Z = 1.06$, $p > .05$), although the trend is in the right direction. In silent reading, semantic changes are better detected than lexical ones ($Z = 1.77$, $p < .05$).

Serial position curves for position of the test sentence within a set of five sentences were constructed using d' values (Elliot, 1964). The d' values were used because they, like alpha scores, correct for a priori probability of stimulus presentation and response bias. The curves show that irrelevant articulation leads to a severe decrement in ability to detect both semantic and lexical changes (Fig. 4). Furtheremore, the strong recency effect that exists under silent reading is not present under irrelevant articulation. Chi-square tests for independence (Ferguson, 1959) were computed for performance on each sentence position within a set under irrelevant articulation (Table 5). Responses to test sentences for sentence positions 1 and 2 and for lexical changes in sentence position 4 were not significantly above chance level.

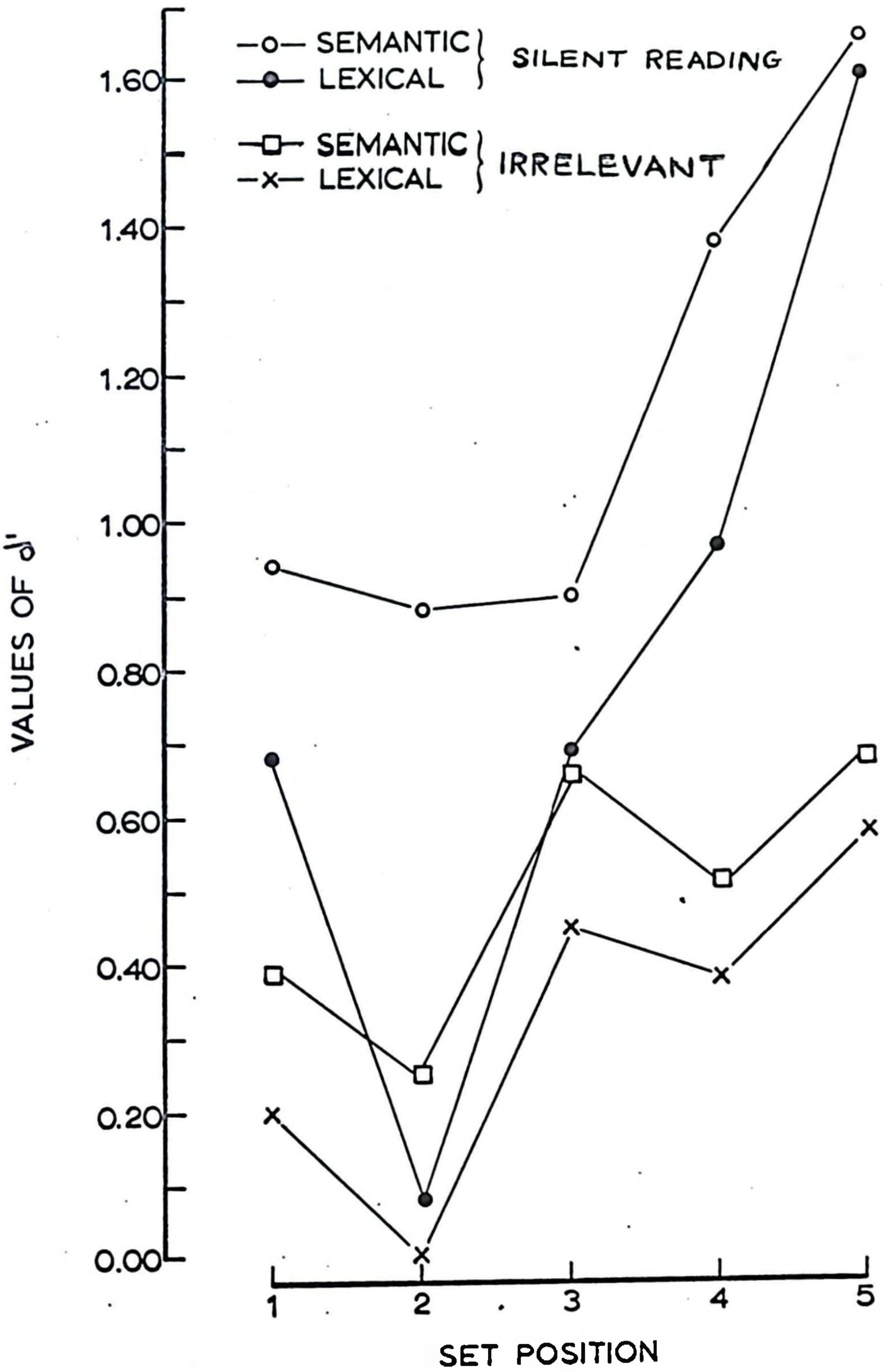
SEMANTIC
LEXICAL
SILENT READING
SEMANTIC
LEXICAL
IRRELEVANT
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
VALUES OF d'
1
2
3
4
5
SET POSITION

TABLE 5

CHI-SQUARE SCORES FOR EFFECT OF SENTENCE POSITION WITHIN SET UNDER IRRELEVANT ARTICULATION IN EXPERIMENT II

SET POSITION	LEXICAL CHANGES	SEMANTIC CHANGES
1	X^2=.90, $p > .05$	X^2=3.29, $p > .05$
2	X^2= 0, $p > .05$	X^2=1.33, $p > .05$
3	X^2=4.16, $p < .05$	X^2=9.84, $p < .01$
4	X^2=3.13, $p > .05$	X^2=6.13, $p < .05$
5	X^2=7.26, $p < .01$	X^2=10.23, $p < .01$

DISCUSSION

That Ss are better able to detect semantic changes than lexical ones, even in circumstances where they have been set to attend to both, is very consistent with the literature; it adds to the wealth of evidence demonstrating that normal sentence processing attends largely to semantic features (Sachs, 1967; Bobrow, 1970; Hall & Crown, 1970; Perfetti & Goodman, 1970; Fillenbaum, 1971). A possible objection to this statement is that Ss were not attending to semantic features and that "semantic detection" was due to noticing the position changes of the two nouns in the test sentences. "Semantic detection" was thus better than lexical detection because the position of two words were changed, while in a lexical change, only one word was changed. However, this technique was used to give semantic changes by Sachs (1967) and by Begg & Paivio (1969), and their results indicate that the technique manipulated semantic coding. There is no reason to assume that it does not in this study.

The differences in recall for the various positions within a set reflect, in silent reading, the usual serial position curve with primary and secondary memory components (Waugh & Norman, 1965). With irrelevant articulation, the recency effect seems to be eliminated (Fig. 4).

The effects of irrelevant articulation on performance level are very consistent. For both identical and different test sentences and semantic and lexical changes, irrelevant articulation gives considerably lower recall than silent reading. These results lend support to the articulatory translation hypothesis. But again, irrelevant articulation does not entirely prevent item storage. Table 4 shows that performance on set position 3, 4 and 5 is significantly above chance (although this is true only for semantic changes in set position 4) according to a Chi-square test for independence (Ferguson, 1959). In Experiment I some storage had also occurred under irrelevant articulation.

GENERAL DISCUSSION

Some storage may occur in irrelevant articulation because there is a mechanism other than articulatory translation by which information gets stored. Paivio (1970) speaks about language coding in this way. "The major theoretical assumption is that language is closely linked to two basic coding systems, or cognitive modes. One mode is related directly to speech itself; that is, we can think in terms of words and their inter-relations and these implicit verbal processes can mediate our language behavior. The other code is nonverbal and is presumably tied closely to the private experience that we call imagery. Thus, if I say to you, 'The red-haired boy is peeling a green orange', your comprehension of the phrase is likely to include some kind of mental picture of the boy and the orange, together with implicit activities related to peeling oranges, not merely silent rehearsal of the words themselves. The language code has flipped over into a nonverbal one and, if I now ask you to remember the sentence, you might do so by remembering the objects and actions involved in the image and then reconstructing the sentence from it" (p. 1). Paivio assumes the two systems to be closely interconnected.

It is feasible to postulate that articulatory activity is particularly relevant to the verbal processing and its connections with imagery, but that imaging alone allows some information to be stored when verbal processing is disrupted. Hence, the finding that some storage occurs with irrelevant articulation. In Experiment I the S was told immediately before each sentence whether he was to write out the exact words or perform the command. In the semantic recall task, it was therefore possible for the S to rely on imaginal processing (the sentences were all concrete) rather than verbal processing and hence articulatory activity might have little effect. This is a possible explanation for the fact that irrelevant articulation had absolutely no detrimental effect on the semantic recall task of Experiment I. Also, as pointed out before, even if irrelevant articulation lowered incoming information, the redundancy of sentence information might easily have permitted the S to grasp enough of the gist to perform correctly, imagery offering a way to code this gist. In Experiment II, the S never knew before a set whether the test sentence would be changed and, if so, whether the change would be one of meaning or wording. Hence, it was necessary to rely heavily on verbal processing, which is more likely to be disrupted by irrelevant articulation. Irrelevant articulation did have a detrimental effect on both semantic and lexical changes in Experiment II.

The other possible explanation for irrelevant articulation not preventing storage completely lies in a criticism of the technique. Although it is clearly impossible to continuously articulate "Hiya" and also articulate the stimulus material at the laryngeal level there is no guarantee that the S cannot be centrally processing the item in an articulatory way, i.e., hearing the stimulus word in his head as he says "Hiya". In other words, the "Hiya" technique may not prevent articulatory translation at a central level. Furthermore, there is always the possibility of some peripheral coding other than that of saying the words. Levy (1971) had assumed that the S could not peripherally process one item and centrally process another in the same way, and her data supported this assumption. The data of the present studies do not. Therefore, one can only safely conclude that preventing the translation of visual material at the articulatory muscle feedback level leads to decrements in recall for both word and semantic recall. This interpretation of the results provides more limited support for the articulatory translation hypothesis than the previous interpretation but both interpretations say that interfering with articulation lowers recall.

It is necessary to explain why Levy (1971) found negligible recall under irrelevant articulation even when using words, when the results for the two studies being reported show that under irrelevant articulation some information still got stored. Hardyck & Petrinovich's (1970) work suggests an explanation for the discrepancy. They eliminated laryngeal activity in one group of Ss and found that recall of difficult material was significantly lower for these Ss than for Ss who could subvocalize; on easy material, there was no difference between the two groups. Levy's task was a very difficult one as evidenced by the low probability of correct recall and articulatory processing at the peripherial level was obviously crucial for storage. The verbatim recall levels in the first experiment being reported indicate that the task was not as difficult as that of Levy, while the semantic recall task was quite easy (the probability of correct recall was approximately .80). In the second experiment, the task was more difficult and in set positions 1 and 2 (Table 5) performance under irrelevant articulation was not significantly above chance. Hence, there does seem to be a differential need for articulatory translation according to difficulty of the Ss task. Furthermore, in Levy's letter and word lists, there would be little possibility of Ss coding information in terms of imagery. The discrepancy between the present results and those of Levy (1971) are considered due to the differences in the difficulty of the tasks and/or in availability if imaginal coding.

In summary, the articulatory translation hypothesis does receive limited support. The use of the articulatory apparatus is one way of encoding visually-presented material, and its importance appears to be a function of the difficulty or type of stimulus material. Irrelevant articulation seems to eliminate the primary memory component of the serial position curve. As suggested by the literature, processing for meaning is better than processing for wording. Irrelevant articulation can lead to decrements in recall performance for both wording and gist of sentences.

REFERENCES

Begg, I. & Paivio, A. Concreteness and imagery in sentence meaning. Journal of Verbal Learning and Verbal Behavior, 1969, 8, 821-827.

Bobrow, S. A. Memory for words in sentences. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 363-372.

Elliott, P. B. Tables of d'. In J. A. Swets (Ed.) Signal detection and recognition by human observers. New York: Wiley, 1964, Pp. 651-684.

Ferguson, G. A. Statistical analysis in psychology and education. New York: McGraw-Hill, 1959.

Fillenbaum, S. Words as feature complexes: False recognitions of antonyms and synonyms. Journal of Experimental Psychology, 1969, 82, 400-402.

Fillenbaum, S. On coping with ordered and unordered conjunctive sentences. Journal of Experimental Psychology, 1971, 87, 93-98.

Grossman, L. & Eagle, M. Synonymity, antonymity, and association in false recognition responses. Journal of Experimental Psychology, 1970, 83, 244-248.

Hall, J. W. & Crown, I. Associative encoding of words in sentences. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 303-307.

Hardyck, C. D. & Petrinovich, L. F. Subvocal speech and comprehension level as a function of the difficulty level of reading material. Journal of Verbal Learning and Verbal Behavior, 1970, 9, 647-652.

Levy, B. A. Role of articulation in auditory and visual short-term memory. Journal of Verbal Learning and Verbal Behavior, 1971, 10, 123-132.

Luce, R. D. Individual choice behavior: A theoretical analysis. New York: Wiley, 1959.

Martin, E. & Walter, D. A. Subject uncertainty and word-class effects in short-term memory for sentences. Journal of Experimental Psychology, 1969, 80, 47-51.

Murdoch, B. B., Jr., & Ogilvie, J. C. Binomial variability in short-term memory. Psychological Bulletin, 1968, 70, 256-260.

Murray, D. J. The effect of white noise upon the recall of vocalized lists. Canadian Journal of Psychology, 1965, 19, 333-345.

Paivio, A. Imagery and language. Research Bulletin No. 167, Department of Psychology, University of Western Ontario, 1970.

Perfetti, C. A. & Goodman, D. Semantic constraint on the decoding of ambiguous words. Journal of Experimental Psychology, 1970, 8, 420-427.

Sachs, J. S. Recognition memory for syntactic and semantic aspects of connected discourse. Perception and Psychophysics, 1967, 2, 437-442.

Siegel, S. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill, 1956.

Sperling, G. Successive approximations to a model for short-term memory. Acta Psychologica, 1967, 27, 285-292.

Waugh, N. C. & Norman, D. A. Primary memory. Psychological Review, 1965, 72, 89-104.

EXPERIMENT I <u>WORDS</u> (4 REPLICATIONS COMBINED)

Source	df	Mean Square	F Ratio
Replication	3	.16	4.99**
Presentation	1	1.36	43.39**
Replication X Presentation	3	.01	<1.00
Articulation	1	3.55	113.53**
Replication X Articulation	3	.04	1.35
Presentation X Articulation	1	.00	<1.00
Replication X Presentation X Articulation	3	.14	4.35**
Serial Position	11	3.58	144.70**
Replication X Serial Position	33	.04	1.25
Presentation X Serial Position	11	.27	8.79**
Replication X Presentation X Serial Position	33	.04	1.15
Articulation X Serial Position	11	.04	1.31
Replication X Articulation X Serial Position	33	.03	<1.00
Presentation X Articulation X Serial Position	11	.04	1.34*
Replication X Presentation X Articulation X Serial Position	33	.02	

E(MS)=.031

* =.05

** =.01

EXPERIMENT I SENTENCES - VERBATIM RECALL

Source	df	Mean Square	F ratio
Presentation	1	.22	14.23**
Articulation	1	3.50	224.13**
Presentation X Articulation	1	.00	<1.00
Serial Position	11	.40	25.47**
Presentation X Serial Position	11	.01	<1.00
Articulation X Serial Position	11	.02	1.52
Presentation X Articulation X Serial Position	11	.01	

EXPERIMENT I SENTENCES - SEMANTIC RECALL

Source	df	Mean Square	F ratio
Presentation	1	.03	1.00
Articulation	1	.00	<1.00
Presentation X Articulation	1	.03	

E(MS) = .016

* = .05

** = .01

APPENDIX 2

EXPERIMENT II

Alpha Values for Lexical Changes and Semantic Changes Detected Under Silent Reading and under Irrelevant Articulation in each of the Eight Subject-Replication Conditions

Alpha values were computed according to Luce's choice model (1959). If there is no detectability, the product of cells 1 and 3 divided by the product of cells 2 and 4 is an alpha score of 1. Alpha scores were computed for each cell by means of this calculation.

RESPONSES

STIMULI	1	2
	4	3

ID = IDENTICAL

SD = SEMANTIC DIFFERENT

LD = LEXICAL DIFFERENT

α = ALPHA VALUE

SUBJECTS		LEXICAL				SEMANTIC			
		SILENT		IRRELEVANT		SILENT		IRRELEVANT	
		ID+SD	LD	ID+SD	LD	ID+LD	SD	ID+LD	SD
1-6	ID + SD / ID + LD	71	19	66	24	73	17	53	37
	LD / SD	15	15	19	11	10	20	13	17
		α = 3.777		α = 1.592		α = 8.588		α = 1.873	
7-12	ID + SD / ID + LD	65	25	63	27	72	18	67	23
	LD / SD	16	14	21	9	12	18	17	13
		α = 2.275		α = 1.000		α = 6.000		α = 2.228	
13-18	ID + SD / ID + LD	73	19	72	18	80	10	65	25
	LD / SD	14	16	19	11	12	18	15	15
		α = 4.391		α = 2.315		α = 12.00		α = 2.60	
19-24	ID + SD / ID + LD	81	9	71	19	66	24	58	32
	LD / SD	18	12	21	9	9	21	19	11
		α = 6.000		α = 1.602		α = 6.417		α = 1.049	

SUBJECTS	LEXICAL						SEMANTIC					
	SILENT			IRRELEVANT			SILENT			IRRELEVANT		
		ID+SD	LD		ID+SD	LD		ID+LD	SD		ID+LD	SD
25-30	ID + SD	75	15	ID + SD	67	23	ID + LD	71	19	ID + LD	70	20
	LD	17	13	LD	20	10	SD	17	13	SD	12	18
	$\alpha = 3.824$			$\alpha = 1.457$			$\alpha = 2.858$			$\alpha = 5.250$		
		ID+SD	LD		ID+SD	LD		ID+LD	SD		ID+LD	SD
31-36	ID + SD	74	16	ID + SD	71	19	ID + LD	77	13	ID + LD	64	26
	LD	13	17	LD	14	16	SD	10	20	SD	15	15
	$\alpha = 6.048$			$\alpha = 4.271$			$\alpha = 11.846$			$\alpha = 2.462$		
		ID+SD	LD		ID+SD	LD		ID+LD	SD		ID+LD	SD
37-42	ID + SD	63	27	ID + SD	64	26	ID + LD	70	20	ID + LD	67	23
	LD	20	10	LD	22	8	SD	18	12	SD	19	11
	$\alpha = 1.166$			$\alpha = 0.895$			$\alpha = 2.333$			$\alpha = 1.687$		
		ID+SD	LD		ID+SD	LD		ID+LD	SD		ID+LD	SD
43-48	ID + SD	73	17	ID + SD	59	31	ID + LD	76	14	ID + LD	67	23
	LD	12	18	LD	15	15	SD	11	19	SD	16	14
	$\alpha = 6.441$			$\alpha = 1.903$			$\alpha = 9.377$			$\alpha = 2.549$		

APPENDIX 3

EXPERIMENT II

The d' Values for Sentence Position Within the Set

The detection rate and the false alarm rate serve as estimates of the desired detection probability, $P_{SN}(A)$, and false-alarm probability, $P_N(A)$.

RESPONSES

STIMULI	ID + SD	LD
ID+SD	CORRECT REJECTION Z	FALSE ALARM Y
LD	X	HIT W

$$P_N(A) = \frac{Y}{Y + Z}$$

$$P_{SN}(A) = \frac{W}{W + X}$$

By means of the computed values of $P_{SN}(A)$ and $P_N(A)$, the appropriate values of d' may be read from the table (Elliott, 1964).

ID = IDENTICAL

SD = SEMANTIC DIFFERENT.

LD = LEXICAL DIFFERENT

α = ALPHA VALUE AS DESCRIBED IN APPENDIX 2

d' = d' VALUE AS CALCULATED ABOVE

POSITION	Task	Condition	Row	ID+SD / ID+LD	LD / SD	α	d'
1	LEXICAL	SILENT	ID + SD	116	28	2.959	.68
			LD	28	20		
	LEXICAL	IRRELEVANT	ID + SD	109	35	1.416	.20
			LD	33	15		
	SEMANTIC	SILENT	ID + LD	111	33	4.709	.94
			SD	20	28		
	SEMANTIC	IRRELEVANT	ID + LD	96	48	1.840	.39
			SD	25	23		
2	LEXICAL	SILENT	ID + SD	101	43	1.174	.08
			LD	32	16		
	LEXICAL	IRRELEVANT	ID + SD	99	45	1.000	0
			LD	33	15		
	SEMANTIC	SILENT	ID + LD	108	36	4.20	.88
			SD	20	28		
	SEMANTIC	IRRELEVANT	ID + LD	100	44	1.489	.25
			SD	29	19		
3	LEXICAL	SILENT	ID + SD	115	29	3.084	.69
			LD	27	21		
	LEXICAL	IRRELEVANT	ID + SD	109	35	2.040	.45
			LD	29	19		
	SEMANTIC	SILENT	ID + LD	107	37	4.414	.90
			SD	19	29		
	SEMANTIC	IRRELEVANT	ID + LD	102	42	2.870	.66
			SD	22	26		
4	LEXICAL	SILENT	ID + SD	112	32	4.900	.97
			LD	20	28		
	LEXICAL	IRRELEVANT	ID + SD	101	43	1.827	.38
			LD	27	21		
	SEMANTIC	SILENT	ID + LD	127	17	10.459	1.38
			SD	20	28		
	SEMANTIC	IRRELEVANT	ID + LD	95	49	2.291	.51
			SD	22	26		
5	LEXICAL	SILENT	ID + SD	130	14	15.476	1.61
			LD	18	30		
	LEXICAL	IRRELEVANT	ID + SD	115	29	2.598	.58
			LD	29	19		
	SEMANTIC	SILENT	ID + LD	133	11	18.455	1.66
			SD	19	29		
	SEMANTIC	IRRELEVANT	ID + LD	117	27	3.095	.68
			SD	28	20		