Effects of shifts in visual, semantic, and acoustic-semantic stimulus attributes in STM tasks*

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Four groups of 20 Ss recalled triads of spelled-out numbers for three trials. The type of material presented on the fourth trial was the same for the control (C) group but differed either visually (V), semantically (S), or acoustically and semantically (AS) from prior material for three experimental groups. Recall for all groups decreased over the first three trials. Vocal and written recall on the fourth trial for Groups V and SA, but only vocal recall of Group S, was superior to that of Group C. In contrast to the recent emphasis upon acoustic storage, the present results indicate that short-term memory of verbal material entails both an auditory and visual process. The results were discussed in terms of extensions of the interference-encoding hypothesis.

In short-term memory (STM) tasks, Ss are presented stimuli either simultaneously or sequentially for approximately .5 to 4 sec per stimulus and are tested for retention usually within 60 sec from the onset of stimulus presentation. Since tests of retention immediately following rapid sequential presentation of a series of letters indicate that Ss confuse visually presented letters which have similar pronunciations (Adams, Thorsheim, & McIntyre, 1969a), it has been suggested that memory of verbal materials in STM tasks may be an auditory process irrespective of the form in which the items are presented (Neisser, 1967; Norman, 1969). The finding of acoustic confusion in STM tasks with sequential presentation, but not in long-term memory (LTM) tasks, has led to suggestions that different memory processes function at different recall intervals (Adams, 1967; Johnson & Chamberlin, 1970).

Reliable findings in STM tasks which have used simultaneous stimulus presentation, however, are that acoustic confusion is minimal (Adams, Thorsheim, & McIntyre, 1969b) and that recall decrements over trials (interference) can be reduced by a shift to a different conceptual class of material (Loess, 1967, 1968). These conclusions are further supported by findings (Wickens & Simpson, 1968; Wickens & Eckler, 1968) that conceptual-semantic shifts result in significant improvement in recall relative to nonshift control groups, even when both groups are shown acoustically identical words. Wickens and his associates concluded that acoustic interference was relatively unimportant in their type of STM experiment. They suggested that the

emphasis on acoustic confusion in STM may have resulted from a limited class of material investigated, but they also admitted that variations in procedure may account for the differences between their and other Es' findings. The latter explanation is supported by the Adams et al (1969b) and the Johnson & Chamberlin (1970) findings that acoustic interference has a "short life." The critical difference between sequential and simultaneous STM tasks appears to be that a fraction of a second usually separates the interfering items during sequential presentations, whereas the time between interfering items is typically 30 sec or longer with simultaneous presentations.

Wickens (1968, 1970) has interpreted the improved recall of dissimilar stimuli in STM tasks as evidence for an interference-encoding hypothesis. He suggested that there is a common way of encoding within a class which differs among different classes of items and that items encoded into different conceptual categories would not interfere with each other. Furthermore, he proposed that the encoding process is very complex, and the procedure of shifting classes and observing whether or not this produces enhanced recall may be a technique for identifying encoding attributes. If changes in the stimulus attributes are accompanied by augmented recall, then those stimulus attributes that were changed presumably led to encoding into different categories.

One interpretation of the interference-encoding hypothesis is that the improved recall is due to a specific retrieval cue or mediating response. Within-class material may elicit a common mediator which has its source in Ss' previously well-learned associations in LTM. Presentation of a novel stimulus may disrupt Ss' tendency to respond with the common mediator and may lead Ss to incorporate the distinctive characteristics of the isolated item into their mediating response for the novel item (Erickson, 1963). Consequently, Ss may reduce interference between the isolated item and previous items by dismissing tentative responses that are not associated with the unique mediator or retrieval cue.

Another interpretation of the interference-encoding hypothesis is that recall increments on shift trials are a fundamental aspect of stimulus change. Perhaps stimuli which are discordant with the properties of prior stimuli produce a loss or change in set through generalization decrement, which may also lead to both arousal and increased attention (Turvey, 1968; Gumenik & Rossman, 1970). As a result, the isolated item should be more discriminable and may be learned more rapidly and to a greater degree than control items that conform to Ss' previously acquired set. According to the decrement and attentional hypotheses, changes in either visual, semantic, or acoustic-semantic stimulus attributes should result in improved recall on the shift trial. The improved recall should be a joint function of both the magnitude of the stimulus change and the relative saliency of the stimulus attribute which is modified.

The present experiment was designed to examine the decrement and attention hypotheses and to test Wickens and Simpson's conclusions about acoustic confusion in their STM task by requiring written responses in recall. Since Wickens and Simpson's Ss responded vocally (personal communication), the extent to which their Ss produced semantically correct responses cannot be determined because the two semantic classes of words were acoustically identical.

Table 1
Mean Recall Score for Each Group's Verbal and Written Responses Using Two Scoring Systems on Trial 4. Mean recall scores within each scoring system that do not have the same letter are significantly different.

Scoring System		Group			
		C	V	S	AS
0-1	Verbal	0.40 ^a	0.80 ^b	0.75 ^b	0.65 ^{ab}
0-1	Written	0.40 ^a	0.80 ^b	0.45 ^a	0.65 ^{ab}
0-8	Verbal	5.25 ^b	7.50 ^a	7.25 ^a	7.00 ^a
0-8	Written	5.25 ^a	7.50 ^c	5.70 ^{ab}	7.00 ^{bc}

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SUBJECTS

The Ss were 80 introductory psychology students who participated as part of a course requirement. Each S was assigned by rotation to one of four treatment conditions.

MATERIALS AND PROCEDURE

The specific sequence of events on each trial was as follows: (1) An asterisk appeared as a ready signal for 2 sec. (2) A diagonal block of three numbers or words appeared for 2 sec. The Ss were supposed to try to remember these items. (3) Ten color matrices of four colors each were presented successively for 2 sec each. A total of 12 colors were used, with each matrix containing four different colors. The Ss were instructed to name accurately as many colors as possible when the colors were shown. The color-naming activity was intended to prevent Ss from rehearsing the recall material during the retention interval. (4) A question mark appeared and remained in view for 10 sec as a signal for Ss to both say and write down on a note card the recall material that had been presented at the start of the trial. All stimuli were presented on an MTA 100 Scholar (teaching machine), controlled by an external timer. Considering that each full advancement of the teaching machine took approximately 1 sec, the total duration of each trial was 47 sec and the duration of the retention interval was 30 sec.

Four groups of Ss were shown identical blocks of three spelled-out numbers on the first three trials with each block containing completely different numbers. The stimuli presented on the 4th trial were the spelled-out numbers "eight, two, one" for the control (C) group; arabic numerals "8, 2, 1" for the visual (V) group; the acoustically identical but semantically different words "ate, too, won" for the semantic (S) group; and the words "toe, nose, arm" for the acoustic-semantic (AS) group. Each of the numbers presented to C and V groups on Trial 4 had been presented once before, each in a different prior item and in a different serial position. Their stimuli differed only on an aspect of formal similarity with V group's stimuli belonging to a different "visual" class. In contrast, both S and AS groups were shown stimuli from a semantic class that was different from that of the C or V groups' stimuli. Material shown the AS group, however, also differed acoustically from material shown to all other groups. Similarly, the S group was shown conceptually unrelated items, while all other groups were shown conceptually related items. Both the S and C groups were shown material identical to that used by Wickens and Simpson.

RESULTS

Scoring

Each S's vocal and written responses at the end of each trial were analyzed according to two scoring systems. In the 0-1 scoring system, each S's response was assigned a value of either 0 or 1, depending upon whether the response was incorrect or perfect. In this scoring system any failure to produce all words correctly and in the correct order was scored as 0. In the more sensitive scoring system, all responses were assigned an integer value from 0 to 8 according to whether S correctly recalled 0, 1, 2, or 3 items in the correct or incorrect positions. These scores varied inversely with the likelihood of correct recall due to random guessing of numbers 1 to 9. In both scoring systems, vocal responses were scored for acoustic correctness, while written responses were scored for semantic correctness.

Preshift Trials

The data were analyzed with respect to groups over the first three trials. Both measures indicated that recall decreased over trials, $F(2,152) \geq 3.44$, $p < .05$, while the effects of groups and the Groups by Trials interaction were nonsignificant ($p > .05$).

Critical Trial

On the critical fourth trial the data were analyzed using a simple analysis of variance. The groups differed significantly, $F(3,76) \geq 2.95$, $p < .05$, according to both measures. The means for each group for both vocal and written responses and both scoring systems are presented in Table 1. Independent two-tailed t tests were used to determine which groups differed significantly at the .05 level. The only significant difference for both measures was superior recall for Group V compared to Group C. In addition, Group V revealed greater recall than Group S for written responses using either scoring system. Group S showed better recall than Group C for vocal responses only, using either scoring system. And the AS group produced more correct responses than the C group for both vocal and written responses using the 0-8 scoring system only.

The finding of superior recall in the S group compared to the C group with acoustic scoring only is attributable to seven Ss in the S group who wrote numbers acoustically identical to the words that had been shown. One S in the S group wrote a number that was acoustically different from the words that had been presented. In contrast, no Ss in the AS group wrote any numbers on the fourth trial. The S and AS groups were the only groups shown words rather than numbers. The difference between these two groups in the

proportion of Ss writing numbers was statistically significant ($z = 5.16$).

DISCUSSION

Most of the results of the present experiment are consistent with those obtained from other STM experiments. The present results confirm Loess's findings of recall decrements across trials when semantic and formal similarity remain constant and show that changes in semantic-acoustic similarity result in improved recall. Furthermore, the results confirm Wickens and Simpson's finding that two groups will perform differently on acoustically identical but semantically different items when responses are scored for acoustic correctness. At the same time the results confirm the finding that acoustic similarity can be a strong factor in STM experiments. This result, however, does not mean that STM is purely an auditory process. If STM were purely an auditory process, then Ss' vocal recall should not have increased when Ss were shown acoustically identical but semantically different material. The finding that Ss mixed semantic classes may be attributable to Ss' set to recall numbers, to low interitem association between the words "ate, too, won," or to Ss' auditory rehearsal of words. The assumption that Ss mixed classes due to their set to recall numbers is supported by Wickens and Eckler's finding that Ss did not mix semantic classes after they had become accustomed to shifting from one class of material to another.

Additional evidence against a purely acoustic encoding hypothesis is the finding that V and C groups differed significantly, even though they contained acoustically and semantically identical items. Furthermore, the visual change produced equal or greater recall increments than the acoustic-semantic change. This latter finding seems to exclude the possibility that differential recall recovery on the shift trial reflects the degree to which items are encoded similarly or differently in mediating responses. Since spelled-out numbers (SON) and arabic numerals (AN) differ only on an aspect of formal similarity, whereas the items from the different semantic classes have different pronunciations and meanings and are only related in that they appear in word form, one would assume that SON and AN are more similar than two different semantic classes, e.g., SON and names of parts of the body. Thus, if items are encoded in several categories, as Wickens suggested, then there should be more common categories and thus greater interference between SON and AN. Similarly, there should be more competing responses due to similar or shared mediating responses between SON

and AN than between SON and words corresponding to parts of the body. Nevertheless, a detectable stimulus change may be expected to lead to a generalization decrement irrespective of Ss' reported awareness of the change. This generalization decrement, which would lead to a loss or change in set, may also lead to attention arousal. If such distinctive items increase a person's attention, then an isolated item may be learned more rapidly and to a greater degree than nonisolated items.

If the above conclusions were based only on the present results, they might be unwarranted because the authors used a reversed proactive transfer paradigm in which a shift in material was confounded with potential differences in difficulty of different types of material. The above conclusions appear valid, however, because large recall increments following symbolic shifts from both SON to AN and AN to SON have been reported (Brodie & Lippman, 1970), and Reutener (1969) has independently confirmed these findings. Furthermore, Wickens (1970) indicated that symbolic shifts produce equal recall increments compared to shifts between taxonomic or semantic classes.

REFERENCES

- ADAMS, J. A. *Human memory*. New York: McGraw-Hill, 1967.
- ADAMS, J. A., THORSHEIM, H. I., & McINTYRE, J. S. Item length, acoustic similarity, and natural language mediation as variables in short-term memory. *Journal of Experimental Psychology*, 1969a, 70, 39-46.
- ADAMS, J. A., THORSHEIM, H. I., & McINTYRE, J. S. Short-term memory tasks. *Psychonomic Science*, 1969b, 15, 77-78.
- BRODIE, D. A., & LIPPMAN, L. G. Symbolic and size shifts in short-term memory tasks. *Psychonomic Science*, 1970, 20, 361-362.
- ERICKSON, R. L. Relational isolation as a means of producing the von Restorff effect in paired-associate learning. *Journal of Experimental Psychology*, 1963, 66, 111-119.
- GUMENIK, W. E., & ROSSMAN, F. A perceptual isolation effect in short-term memory. *Psychonomic Science*, 1970, 19, 98-99.
- JOHNSON, W. L., & CHAMBERLIN, C. M. Semantic and acoustic similarity and their effects on short-term retention. *Psychonomic Science*, 1970, 19, 217-218.
- LOESS, H. Short-term memory, word class and sequence of items. *Journal of Experimental Psychology*, 1967, 74, 556-561.
- LOESS, H. Short-term memory and item similarity. *Journal of Verbal Learning & Verbal Behavior*, 1968, 7, 87-92.
- NEISSER, U. *Cognitive psychology*. New York: Appleton-Century-Crofts, 1967.
- NORMAN, D. A. *Memory and attention*. New York: Wiley, 1969.
- REUTENER, D. Background, symbolic and class shift in short-term memory. Unpublished doctoral dissertation, Ohio State University, 1969.
- TURVEY, M. T. Analysis of augmented recall in short-term memory following a shift in connotation. *British Journal of Psychology*, 1968, 59, 131-137.
- WICKENS, D. D. Encoding categories in short-term memory. Paper presented at American Psychological Association meeting, 1968.
- WICKENS, D. D. Encoding categories of words: An empirical approach to meaning. *Psychological Review*, 1970, 77, 1-15.
- WICKENS, D. D., & ECKLER, G. R. Semantic as opposed to acoustic encoding in STM. *Psychonomic Science*, 1968, 12, 63.
- WICKENS, D. D., & SIMPSON, H. K. Semantic versus phonetic encoding in short-term memory. Paper presented at Midwestern Psychological Association meeting, 1968.

The repeated use of mnemonic imagery

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Can the same mnemonic system be used repeatedly without deterioration in performance through interference? Ss used a "peg-word" system to memorize a single list of 10 nouns in different orders. No decline in performance was found. A control group improved on successive trials but at all times recalled less than the mnemonic group.

The "peg-word" system, part of the stock-in-trade of mnemonic experts, is intended to facilitate memorizing lists of items. As a preliminary to one method, a jingle associating objects with ordinal positions is mastered (one is a bun, two is a shoe, . . . ten is a hen). To memorize a list of items, the first is visualized in association with a bun, the second with a shoe, and so on. Instructions usually require the learner to conjure up bizarre mental pictures including movement, e.g.,

given "car" as the first item, a fanciful image of a tiny car in motion with huge buns as wheels.

Although techniques of this kind figure in William James' *The Principles of Psychology* (1890), they appear to have escaped empirical investigation until recently. Reports by Miller, Galanter, & Pribram (1960), Hunter (1964), and Bugelski, Kidd, & Segmen (1968), among others, have now shown the claims of the mnemonic experts to be well founded.

One might suspect that an unusual but easily grasped method could give good results on a first trial with naive Ss, but that performance would deteriorate rapidly, the buns and shoes becoming encrusted with interfering associations. Psychologists have learned to fear proactive inhibition (Underwood, 1957; Postman, 1961). The writers of memory-improvement books are optimistic on the whole, but there are some differences of opinion among them. Lorayne (1958) assumes that the same peg-word can be used without restraint, while Weinland (1957) is apprehensive about interference, and Hamilton (1948) advises his readers to limit the frequency of use to no more than once per day.

Some evidence is available from an experiment by Bugelski (1968). Six lists of common nouns were memorized and tested one after the other in a single session. E group Ss were told how to use the peg-word jingle. C group Ss were simply told to learn. The mnemonic group was significantly superior, maintaining an almost perfect performance throughout the six lists. The control group zig-zagged from high to low performance on successive lists, improving overall from first to last.

In Bugelski's experiment each S was free to go at his own pace and so would have been able to compensate for increasing interference by lengthening the time taken per item. No data are reported on this point. In the following experiment each item was exposed for a fixed duration and a more stringent test of interference was attempted. Where response learning is minimal, an A-B, A-Br arrangement, in which the response items of the first list are reallocated to different stimuli in the second list, can be expected to produce greater interference than when the responses of the second lists are new items (McGovern, 1964; Kausler, 1966). Bugelski used a different set of nouns as responses for each list. Following the A-B, A-Br paradigm, we used the same 10 nouns re-paired with new numbers. Thus, while Bugelski's Ss had to associate six nouns with each position in the list, ours had to associate the same noun with a different position for each of six tests of recall.

METHOD

The Ss were 54 first-year university students. Six lists were made up in which the numbers 1-10 in sequence were paired with a set of 10 concrete nouns: *window, tomato, carpet, bus, photograph, ship, pencil, lake, mountain, donkey*. In each list the nouns appeared in a different random order, constrained so that no noun was paired more than once with the same number. Six lists of the numbers 1-10 in different random orders without the nouns