Release from proactive interference in short-term memory as a function of change in visual and phonemic structure and retention interval¹

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Experiment 1 demonstrated that in a short-term memory (STM) test series, a shift from a horizontal arrangement of the consonants comprising visually presented trigrams to a vertical arrangement, with phoneme class held constant, produced a highly significant release from proactive interference (PI). Release from PI was also observed with a shift from one phoneme class to another with spatial arrangement held constant. The effects of visual change and phoneme change were independent of each other. Experiment 2 verified the PI release effect of phoneme class change but failed to confirm an observation in Experiment 1 that the effect of phoneme change was a function of the retention interval. The results were discussed in relation to interpretations of PI in STM and the interpretation of STM as a linguistic system.

Proactive interference (PI) develops rapidly in a short-term memory (STM) test series (e.g., Loess, 1964). However, several studies have shown that an increase in retention obtains following a shift to a new class of material subsequent to PI buildup. This "release from PI" has been demonstrated with a shift from consonants to digits and vice versa, with change in taxonomic categories, and with change in connotation (Wickens, in press). The present investigation was conducted to examine whether or not the phenomenon of PI release could be obtained by changing more fundamental properties of such visually presented verbal items as spatial arrangement and phonemic content. The contention that STM is a linguistic system (Adams, 1967; Neisser, 1967) suggests that a release from PI should be obtained with a shift in phoneme class but should not be obtained with a spatial change that leaves phoneme class invariant.

EXPERIMENT 1

Method

Subjects. The Ss were 224 students from introductory psychology courses at the University of Connecticut. The students participated in the experiment as part of their course requirement.

Procedure and materials. Each S received

five successive STM tests of the Peterson and Peterson (1959) variety. A test was composed of the following events presented as a sequence of slides delivered by a Kodak Carousel projector and controlled by a tape-timer: First, a ready signal of 2-sec duration; second, a consonant trigram exposed for 2 sec that S read aloud once; third, a three-digit number, present throughout the retention interval of either 5 sec or 15 sec, from which S counted backward aloud by threes to the beat of a metronome set at 60 beats/min; fourth, a recall cue of 10-sec duration that cued S to recall the trigram. With the termination of the recall cue, the ready signal for the next test appeared. S's recall was recorded by E.

The first four tests were the PI buildup tests. The consonants in these trigrams were arranged horizontally on the slides and shared the common vowel sound "ē." These trigrams were counterbalanced on Tests 1-4, with each trigram appearing an equal number of times at each test position. Four slides were constructed for presentation on Test 5. On two slides was printed the consonant trigram, TGP. The consonants of this trigram shared the vowel sound "ē" with consonants of the trigrams on Tests 1-4. On one slide, these consonants were arranged horizontally and on the other they were arranged vertically in the same order. The horizontal arrangement of TGP afforded the control slide since its visual and phoneme characteristics were the same as the trigrams on Tests 1-4. The vertical arrangement of TGP afforded a trigram that differed visually, but not phonemically, from the preceding trigrams. On two slides, the trigram, FMX, was printed. The consonants of this trigram contained the vowel sound "ē" and therefore differed phonemically from the preceding consonants on Tests 1-5. On one of the two slides, the consonants were arranged horizontally and on the other, they were arranged vertically, in the same order. The horizontal arrangement of FMX afforded a trigram that differed phonemically from the preceding four trigrams but that did not differ visually. The vertical arrangement of FMX afforded

a trigram that differed both visually and phonemically from the trigrams in the PI buildup tests.

Two retention intervals of 5 sec and 15 sec were used. There were, therefore, eight conditions, differing only in the type of item on Test 5 and the retention interval. These were: visual change with 5-sec interval (V5) and 15-sec interval (V15), phoneme change with 5-sec interval (P5) and 15-sec interval (P15), combined visual and phoneme change with 5-sec interval (VP5) and 15-sec interval (VP15), and two control conditions with no change in visual or phoneme structure (C5, C15). Ss were assigned, in order of appearance at the laboratory, to one of the eight conditions, with 28 Ss per condition.

Results

The recall data for each S on each test were scored in the manner suggested by Wright (1967). A value of 2 was assigned to a consonant reported in its correct trigram-letter position, a value of 1 was assigned to a correct trigram consonant reported in an incorrect location, and a value of 0 was assigned to incorrect consonants and omissions. This measure afforded a maximum score of 6 and a minimum score of 0. In all conditions, Ss had been instructed to report the consonants in the order in which they read them, which was, of course, left to right for horizontal presentation and top to bottom for vertical presentation. Figure 1 represents the mean STM index scores across tests for the 5-sec conditions, and Fig. 2 represents the mean STM index scores across tests for the 15-sec conditions. Inspection of Figs. 1 and 2 clearly shows that PI buildup occurred across Tests 1-4.

The difference between performance on Test 4 and performance on Test 5 was computed for each S in each condition. These difference scores were cast into a 2(phoneme change) by 2(visual change) by 2(retention interval) analysis of variance. This analysis yielded three significant F ratios. The main effect of visual change was highly significant [$F(1,216) = 13.15$, $p < .001$] as was the main effect of phoneme change [$F(1,216) = 7.03$,

Fig. 1. Mean STM index across tests for the 5-sec retention-interval conditions in Experiment 1.

Fig. 2. Mean STM index across tests for the 15-sec retention-interval conditions in Experiment 1.

$p < .01$]. The only significant interaction was the Phoneme Change by Retention Interval interaction [$F(1,216) = 4.64$, $p < .05$]. All other interactions, and the main effect of retention interval, were insignificant. The F ratio in all these insignificant cases was less than 1.

A Duncan test for post hoc comparisons at the .05 level showed that on Test 5, VP5 was significantly greater than P5 but was not greater than V5; VP15 was significantly greater than V15 but not greater than P15; V5 was significantly

greater than C5 but V15 was not greater than C15; and P15 was significantly greater than C15 but P5 did not differ significantly from C5.

These results may be summarized briefly as follows. A release from PI was obtained with change in phoneme class and with change in spatial arrangement. The data indicated that the phoneme change effect was dependent upon retention interval.

EXPERIMENT 2

A second experiment was conducted to assess the possibility, suggested in Experiment 1, that the effect of phoneme change is dependent upon the retention interval.

Method

Subjects. The Ss were 200 University of Connecticut undergraduates. Each S was allocated, in order of appearance at the laboratory, to one of eight groups, with 25 Ss per group.

Materials. Stimulus materials consisted of five trigrams constructed from a set of six letters sharing the vowel sound "ē," and five trigrams constructed from a set of six letters sharing the vowel sound "ē." No letters were repeated within a trigram. Where letters were repeated across trigrams, no letter appeared more than once in the same trigram-letter position.

Design. For a STM test series, the retention interval was either 3 sec or 18 sec for each of five successive tests. In the control condition for each retention interval, S received five STM tests of consonant trigrams from one phoneme class. In the experimental condition for each retention interval, S was presented consonant trigrams from one phoneme class on Tests 1-4 and a consonant trigram from the other phoneme class on Test 5. The control condition for both retention intervals was divided into two subgroups so that S either received a series of "ē" trigrams or a series of "ē" trigrams. The experimental condition for both retention intervals was similarly divided into subgroups in which S either received an "ē" trigram on Test 5 after a series of "ē" trigrams or an "ē" trigram on Test 5 after a series of "ē" trigrams. In each subgroup of both experimental and control conditions, the trigrams were counterbalanced so that each trigram appeared an equal number of times in each STM test position. For a particular trigram order, the trigram presented on Test 5 for an experimental S was the trigram presented on Test 5 for the appropriate control S.

The apparatus and procedure were the same as described for Experiment 1.

Results

Recall was scored by the method

Fig. 3. Mean STM index across tests for the 3-sec retention-interval conditions in Experiment 2.

Fig. 4. Mean STM index across tests for the 18-sec retention-interval conditions in Experiment 2.

described in Experiment 1. The mean STM index scores across tests for the experimental and control conditions are represented in Figs. 3 and 4. Figure 3 represents the functions for the 3-sec retention-interval conditions, and Fig. 4 represents the functions for the 18-sec retention-interval conditions.

The Test 5 recall data were analyzed by means of a 2(phoneme change) by 2(retention interval) analysis of variance. The analysis revealed that the effect of phoneme change was highly significant [$F(1,196) = 10.9$, $p < .001$]. The analysis also yielded a significant retention interval effect [$F(1,196) = 10.9$, $p < .001$]. There was, however, no significant Phoneme Change by Retention Interval interaction ($F < 1$). Experiment 2, therefore, did not support the observation of Experiment 1, that the effect of phoneme change was dependent upon the retention interval.

DISCUSSION

Visual Change

Conrad (1964) observed that substitution errors made in the recall of visually presented letters were the same as those made in identifying letters spoken in a noisy background, which suggested that visually presented verbal items are recoded into an acoustic form for storage. On the basis of Conrad's observation and other related experiments (Sperling, 1963; Wickelgren, 1965), it has been inferred that STM is an acoustic—or at least linguistic—system (Adams, 1967; Neisser, 1967). This notion of STM as a linguistic system implies that visual processes play little or no role in STM for visually presented verbal items.

In Experiment 1, Ss in all conditions read aloud the consonant trigram presented on each test, thereby translating the visual pattern into an articulatory-acoustic pattern. On the assumption that STM is a linguistic system, the storage of TGP presented vertically in Conditions V5 and V15 and the storage of TGP presented horizontally in Conditions C5 and C15 would be identical. The linguistic representation of T, G, and P, and their order in storage, would be the same whether S read the vertical arrangement or the horizontal arrangement of TGP. Given that phonemically similar items interfere in STM (Wickelgren, 1966), PI effects should have been strongly evident in Test 5 recall for both the C5, C15 conditions and the V5, V15 conditions, since T, G, and P shared the vowel sound "ē" with the prior items in the STM test series. Experiment 1 clearly demonstrated, however, that despite the phonemic similarity between the Test 5 consonant trigram and the prior consonant trigrams, the shift from the horizontal arrangement of consonants to the vertical arrangement produced a highly significant release from PI. In other words, the visual difference between the Test 5 item and the prior items in Conditions V5, V15 served to protect the Test 5 item from the PI of the phonemically similar prior items.

How can this PI release effect of visual change be interpreted? There are two major views as to how PI operates in STM. The trace-comparison view, ascribed to by both decay (Brown, 1958) and interference theorists (Melton, 1963), assumes that PI operates via competition between similar traces at recall. The trace-interaction or "acid-bath" view (Posner, 1966), on the other hand, assumes that PI operates through the interaction of similar traces during storage. Both views imply that items upon entry into STM are classified along dimensions of similarity. Both offer ready explanations of PI release. For the

trace-comparison view, the difference between the new item and the previous items provides a means, other than recency, of discriminating between the stored items at recall. In the case of the trace-interaction view, the new item is classified and stored independently of the preceding items and is, therefore, relatively unaffected by those items during storage. If STM is a linguistic system, and TGP in Conditions V5, V15 was stored only in a linguistic form, then neither the trace-comparison interpretation nor the trace-interaction interpretation can account for the PI release produced by visual change. For STM as a linguistic system, the representation of the vertical arrangement of TGP in storage would be similar to the representation of the other items in storage and could, therefore, not facilitate discrimination at recall, as demanded by the trace-comparison view or afford a protection against corrosion during storage, as required by the trace-interaction view.

Another possible interpretation of PI release is one that may be referred to as a novelty-arousal interpretation (cf. Turvey, 1968). The item presented on the shift test of the PI release procedure is a novel item with respect to S's recent experimental history. A postulated correlate of novelty is arousal (Berlyne, 1960). It has been suggested that increased arousal contiguous with the presentation of an item facilitates the reception of that item and its retention (Maltzman, Kantor, & Langdon, 1966). The novelty-arousal interpretation suggests that the strength of a novel item in storage is greater than that of a nonnovel item. Therefore, in the framework of STM as a linguistic system, the linguistic trace of TGP in Conditions V5, V15 of Experiment 1 would be stronger, i.e., more resistant to interference or more resistant to decay, than the linguistic trace of TGP in Conditions C5, C15. Wickens (in press), however, has questioned a novelty-arousal interpretation of PI release. First, Wickens reports that PI release can occur without S being aware of a change in the presented material. As Wickens indicates, the concept of novelty seems to require some conscious recognition of change. Second, Wickens refers to a study by Wittlinger (1967) that failed to find a correlation between phasic arousal, as measured by the GSR, and release from PI. If the novelty-arousal interpretation of PI release is invalid, as these considerations might suggest, then it must be argued that the data of Experiment 1 indicate that spatial dimensions and visual encoding play an important role in STM for verbal material. In other words, rejection of a novelty-arousal interpretation of PI release

with visual change would argue for a reexamination of the inference that STM is a linguistic system.

Phoneme Change

The data of Experiments 1 and 2 demonstrated that a release from PI obtains following a shift from one phoneme class to another. On the assumption that STM is a linguistic system, this effect of phoneme change was expected. The significant Phoneme Change by Retention Interval interaction of Experiment 1 was, however, unexpected and is somewhat puzzling. Figure 1 clearly indicates that in the 5-sec retention-interval condition, P5, the effect of phoneme change was insignificant. On the other hand, Experiment 2, as revealed in Fig. 3, clearly showed a release from PI in both a 3-sec and 18-sec retention-interval STM test series. Consideration of Experiment 2, and previous research demonstrating the relation between phonemic similarity and PI (Wickelgren, 1966), suggests that the Phoneme Change by Retention Interval interaction of Experiment 1 was due to chance. However, it is notable that, in Experiment 1, the release from PI in the VP5 condition could be accounted for, almost entirely, by the effect of visual change, suggesting that the phonemic difference between the Test 5 item and prior items in Condition VP5 was not operating. Apparently, therefore, not only was the effect of phoneme change absent in the P5 condition, but it was also absent in the VP5 condition. For the present, therefore, it may be stated that a change in phoneme class produces a release from PI in a STM test series, with the provision added that the effect of phoneme change might be dependent upon the retention interval.

On the basis of previous experiments demonstrating that phonemically similar items interfere, and phonemically dissimilar items do not interfere in STM, a novelty-arousal interpretation of PI release with phoneme change is unwarranted. The effect of phoneme change in Experiments 1 and 2 can be easily accommodated by either the trace-comparison or trace-interaction interpretation of PI release.

Visual and Phoneme Change Combined

The insignificant Phoneme Change by Visual Change interaction in Experiment 1 indicates that the effect of phoneme change was independent of the effect of visual change, and vice versa. Furthermore, a comparison of the VP conditions with the V and P conditions at the two retention intervals suggests that recall in the VP conditions was an additive function

of the effect of visual change and the effect of phoneme change.

In conclusion, it may be stated that if a novelty-arousal interpretation of release from PI is found wanting, then the results of the present investigation imply that the short-term storage of visually presented verbal items involves both visual and phonemic representation and that these modes of representation in STM are independent of each other.

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NOTES

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