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NOTE

1. Nelson, D. Personal communication, October 1969.

Acoustic interference with redundant elements*

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The acoustic similarity and neutrality of letters was varied as response prefixes and stimulus suffixes and as members of a memory series in an immediate memory task. Each of 32 Ss vocalized 160 visually presented lists composed of randomly selected letters from an acoustically similar subset (BCDGPTVZ) and a neutral subset (HJLNRXQY), followed by ordered vocal recall. Half the Ss received each letter from the acoustically similar subset five times as a redundant element (additional letter) in a response prefix, a stimulus suffix, and a modified stimulus suffix condition, while the other half correspondingly received letters from the neutral subset. Predictions based on retroactive interference explanations of the similarity of the redundant letters to members of a memory series failed to be supported. In addition, the extent to which a stimulus suffix interferes with the final items in a series is independent of the spatial separation of that suffix.

Investigations of redundant elements in an immediate memory task involving the occurrence of a predictable element between the visual or aural presentation of a stimulus string and the beginning of recall have resulted in performance impairments (Dallet, 1964; Crowder & Morton, 1969; Hintzman, 1967). The addition of a predictable element to every stimulus string without requiring it in recall has been termed a stimulus suffix, while the addition of the predictable element to the beginning of the recall string without having been in the stimulus has been termed a response prefix. Although their effects upon performance are of comparable magnitude, their seemingly equivalent nature is negated by their differential effects on the serial position function. The stimulus suffix has been found to selectively affect the recall of the final items in a list, while the response prefix affects the recall of all the items to the same extent (Crowder, 1967; Morton, 1968).

Crowder & Morton (1969) have proposed a subsystem of human memory called precategorical acoustic storage (PAS), which accounts for the serial position effects. Their model of information flow postulates a precategorical holding mechanism receptive to information only from Ss' ears. The material within PAS is subject to both overwriting and decay, with a maximum useful life of about 2 sec. The interpretation placed on the stimulus suffix position-specific effect is that hearing the redundant element displaces PAS traces S would otherwise be able to use during rehearsal. Since, at the time the suffix is presented, there are no PAS traces still existing for the earlier serial positions, the effect is selective in impairing performance for the late positions.

While PAS accounts for the position-specific effects of the stimulus suffix, the effects of the response prefix are not directly suggested by the data which Crowder and Morton used to substantiate their information-flow model. They do, however, propose that the nonselective overall effect on errors with a response prefix is due to articulatory interference, since articulatory coding is a perceptual consequence for all elements in the list. Crowder (1969) has noted that the response prefix may be said, on operational grounds, to exemplify retroactive inhibition (RI) by virtue of its location between input and output. If the response prefix effect can be accounted for by basic laws of RI, then the similarity of the prefix element to the members of the memory series should be directly related to the size of the prefix effect.

Crowder (1967, Experiment 3) rejected the RI interpretation of the prefix effect, but in a more recent study (1969) has confirmed an RI account of the prefix effect by showing that when the dominant phoneme in a memory list was "e," a larger decrement was obtained when the prefix was the letter "v" than when it was "k." The present experiment sought to test further the hypothesis that the prefix effect is directly associated with the degree of phonic similarity between the memory series and the prefix element, by representing a more complete range of

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phonic similarity as both redundant elements and members of the memory series.

Related interpretations of the effects of redundant elements have been proposed by Neisser (1967, p. 235) which call attention to Ss' ability to plan and execute an articulate rhythmic structure of a memory series. The redundant element represents the same load on memory as a nonredundant element, such that Ss include the redundant element as part of the perceived string. Neisser, Hoenig, & Goldstein (1969) concluded that a stimulus prefix cannot be ignored when it is included in the active construction of the memory series by the listener. It becomes ineffective when experimental conditions allow Ss to deal with it separately from the other members of the string. Morton, Crowder, & Prussin (1969) indicate that the extent to which a suffix interferes with the final items in a list is a function of the degree of physical similarity between the stimulus list and the suffix. They showed that the stimulus suffix effect was either not obtained or greatly reduced when the suffix was delivered in a different voice from the informational channel, or when the intensity of the suffix was increased until it was subjectively twice as loud as the stimulus items. Another aim of this experiment was to extend Neisser's principle of cognitive separation along a physical dimension by means of spatially separating the stimulus suffix from the memory series during presentation, such that Ss' ability to plan and execute the rhythmic structure might not be altered by the redundant suffix.

METHOD

Thirty-two students enrolled in an introductory psychology course at the University of Richmond participated in the experiment as part of a course requirement.

A Kodak Carousel Model 800 slide projector was used in conjunction with a Hunter interval timer to govern slide changes. Slides were typed in uppercase letters on Radio-Mat transparencies mounted in Kodak ready mounts. A 12 x 12 in. projection screen was mounted 10 in. above the surface of a table such that the central point of the screen was at S's eye level. Centered below the screen was a row of 1-in. cubes, mounted 1½ in. apart, representing the respective serial positions.

Three variables were manipulated in a 2 (redundant letters) by 4 (experimental conditions) by 8 (serial position) factorial design with repeated observations on experimental conditions and serial position. The experimental conditions were a control (8:8), response prefix (8:08), stimulus suffix (80:8), and modified stimulus suffix (80′:8), their order counterbalanced across Ss by means of a systematic method of randomization (Underwood, 1949). The 80′:8 condition was distinguished from the 80:8 condition by a three-space break between the main string and the suffix, in addition to the suffix being typed in lowercase. Half the Ss received every letter from the subset BCDGPTVZ (H) as a redundant letter five times in the 8:08, 80:8, and 80′:8 conditions, while the other half received each of the letters from the subset HJLNRXQY (L) as redundant letters in these same conditions. Each S therefore received 40 series within each experimental condition. The eight-letter memory stimuli were composed of randomly selected letters from both H and L. Each letter from both subsets appeared randomly in each serial position an equal number of times over 40 memory series, without conforming to any specific alternating pattern. A redundant letter was allowed to appear in the memory series. The same ordered list of memory stimuli were used for all Ss so as to avoid confounding both order and individual stimuli with conditions. As an illustrative example, 1 of the 40 memory series in the control condition was BNXCTQVH. Examples for Ss receiving H letters as redundant elements in the other experimental conditions were: 8:08 = RLGHZDYP . . . (C)RLGHZDYP; 80:8 = DGNBVHJTV . . . DGNBVHJT; 80′:8 = GRDXHZBQ p . . . GRDXHZBQ.

The memory series were presented visually, all eight (nine within-suffix conditions) letters at once, for a period of 3.2 sec. After disappearance of the stimulus slide, a period of 8.8 sec was allowed for ordered verbal recall. Ss were instructed to point to the corresponding cube as they recited each letter during recall in order to indictate to E the position of unknown letters. A similar procedure was employed by Neisser, Hoenig, & Goldstein (1969). The Ss were also instructed to vocalize the series during both presentation and recall phases. Five practice trials were given to each S prior to the beginning of the experiment to insure that Ss completely understood their task and were able to pronounce the memory series within the 3.2 sec. Clarifying instructions were also given prior to each of the experimental conditions, along with three additional practice trials. Instructions generally included: emphasis on the ordered recall of letters, a demonstration as to pointing to the cubes as they recited letters, and the pronouncement of the word "blank" as they pointed to a cube, the corresponding letter to which they could not recall.

RESULTS

Two analyses were carried out. The first involved scoring performance in terms of total errors as a function of serial position, with H and L letters pooled within each serial position. The results were analyzed in a 2 by 4 by 8 factorial design with repeated measures on experimental conditions and serial position. An analysis of variance showed no differential main effects for redundant elements, indicating that the acoustically similar (H) or neutral (L) letters led to no differences in total errors when H and L letters were pooled within each serial position. The analysis of variance did show significant main effects for experimental conditions, $F(3,186) = 35.79$, $p < .01$, and serial position, $F(7,434) = 36.83$, $p < .01$. The only significant interaction was that between experimental conditions and serial position, $F(21,1302) = 7.73$, $p < .01$, indicating that the experimental conditions affected the form of the serial position functions. An analysis of variance for simple interaction effects confirmed differences in the experimental conditions at all levels of serial position. A Newman-Keuls procedure testing differences between ordered means showed that, in addition to the control condition's differing from the experimental treatments in total errors at all serial positions, error frequency differed significantly between each of the experimental treatments only at the terminal position. The lack of differential error effects between the stimulus suffix and modified stimulus suffix conditions suggest that physically separating the suffix from the memory series does not reduce or negate the suffix effect and may only possibly reduce the selective effects of PAS at the terminal position.

Of relevance to the initial hypothesis were comparisons represented in the second analysis of variance, including as factors: acoustic similarity of the redundant letters (H and L), experimental conditions (8:8, 8:08, 80:8, 80′:8), and the acoustic similarity and neutrality of the letters used in the memory series (H and L). Analysis of variance indicated significant main effects for experimental conditions, $F(3,186) = 35.7$, $p < .01$, and acoustic similarity-neutrality of the memory series, $F(1,62) = 41.2$, $p < .01$. Once again, there were no differential effects upon total errors of acoustically similar and neutral letters when used as redundant elements, even when performance was scored separately for H and L letters in the memory series. A significant reduction in errors did result, however, with the use of acoustically neutral (L) letters within the memory series.

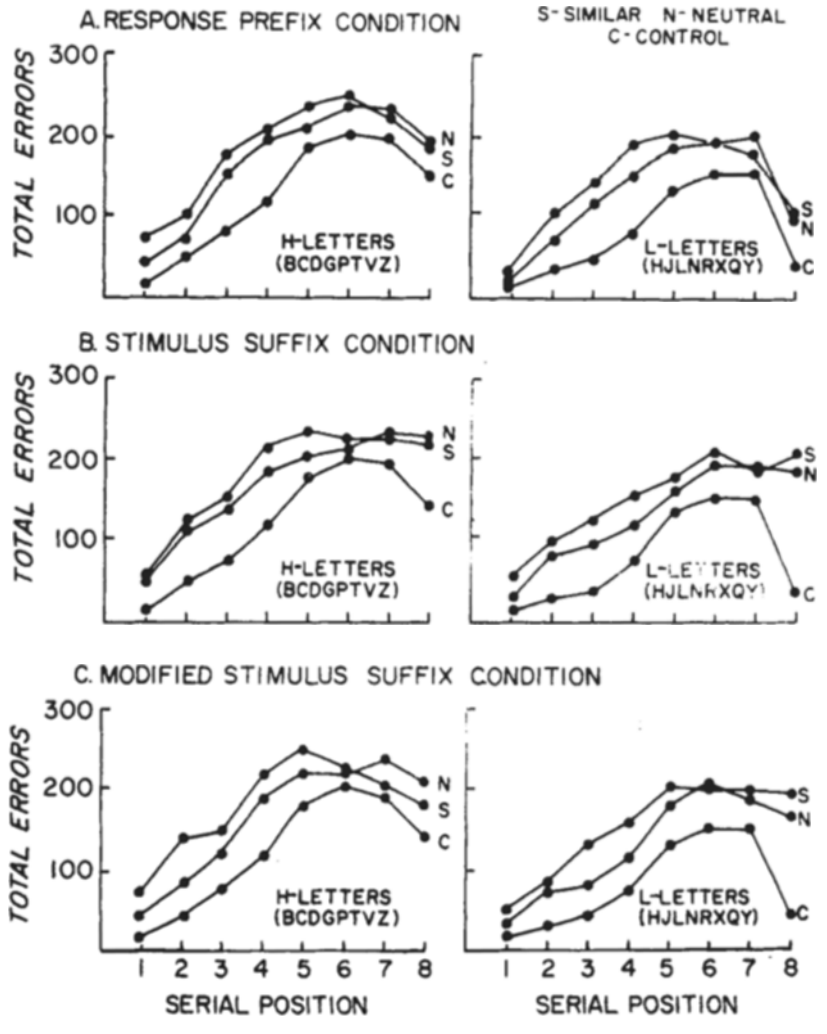

Fig. 1. Error frequency of experimental conditions as a function of serial position, combined over patterns of similar (H) and neutral (L) letters.

Figure 1 shows separate plots of performance on H and L letters for each of the experimental conditions with its corresponding control. While there are no significant differential effects of a similar or neutral redundant element on an H or L series, a small consistent difference appears in the first six serial positions, with the difference between the controls and all redundant conditions being larger for the similar set of letters than for the neutral set. This small yet consistent difference within the first six positions suggest that, regardless of the similarity-neutrality construction of the memory series, acoustically similar redundant letters yield more errors in recall than do neutral letters, with the exception at the terminal positions.

DISCUSSION

The lack of differential error effects between the suffix conditions (Figs. 1B and 1C) suggest that the extent to which a suffix interferes with the final items is independent of the physical separation of that suffix, when a visually presented list is vocalized. The spatially separated stimulus suffix apparently did not successfully introduce a break in cognitive structure between the suffix and the main string, thereby not fulfilling the conditions allowing the S to deal with it separately from the other members of the string. The physical separation may, however, have altered the selective effects of PAS at the terminal position. While functioning as an additional stimulus item reducing overall retention, the physically separated suffix somewhat increased the availability of the final item.

The absence of differential effects of acoustically similar and neutral letters with these data, coupled with Crowder's earlier data (1967, Experiment 3), suggest that RI does not participate in the effect redundant letters have on the retention of a memory series in an immediate memory task. It is suspected that the particular letters (v vs k) chosen by Crowder (1969) insufficiently represented, as he suggested, the full range of acoustic similarity and neutrality and, therefore, was not a thorough test of the effects of the operation of RI with redundant elements.

Of note is the small consistent difference which occurred within the first six serial positions illustrated in Figs. 1A, 1B, and 1C. When performance was scored separately for H and L letters in the memory series, acoustically similar letters used as redundant elements produced more errors than did neutral letters in both sets. In addition, acoustically similar letters within a series are in error significantly more frequently than neutral letters. These findings suggest that acoustically similar letters, whether used as redundant elements or randomly distributed within a memory series, yield more errors in performance than do neutral letters. It is, therefore, inappropriate to appeal to RI explanations of the detrimental effects of redundant elements, since the degree of similarity between the redundant element and the letters of the memory series was not related to the detrimental effect of the redundant element upon the immediate memory task. Acoustic similarity is a dimension independent of the inhibitory effects of redundant elements.

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