Auditory and visual short-term memory with successive syllable presentation in both modalities

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Three groups of 20 Ss processed CCC trigrams by the Peterson and Peterson method. The consonants were presented successively for 0.5 sec each, the input being visual for one group and auditory for another. The third group received half of their trigrams in a visual mode and half in an auditory mode. Recall was a decreasing function of length of retention interval, with materials presented in the auditory mode being better recalled than those in the visual mode, especially at the shorter retention intervals. In light of these and other findings, it was concluded that the more pronounced recency effect for the auditory modality is a stable phenomenon, being obtainable under successive as well as under simultaneous visual presentation and being invariant with respect to choice of experimental design.

In short-term memory settings, recall is a decreasing function of length of retention interval (e.g., Peterson & Peterson, 1959), with materials presented in an auditory mode being better recalled than those in a visual mode at the shorter retention intervals (Murdock, 1966, 1967). This more pronounced recency effect for the auditory modality is consistent with the notion that visual and auditory information may be stored and processed in characteristically different ways (Murdock, 1966). Cooley & McNulty (1967) argued that this interaction of modality with input position of the recalled item, as observed by Murdock, might well reflect retroactive interference from other items in the list operating differentially in the two modes of presentation. These investigators minimized the possibility of this type of intralist interference by using the Peterson & Peterson (1959) technique, whereby no items would intervene between the presentation of any item and its recall. Their results, however, exhibited the same general trend as those of Murdock, a more pronounced recency effect being observed for the auditory modality.

Two aspects of the Cooley and McNulty study led the present investigators to question the generality of their findings. The more evident recency effect for auditory presentation may have reflected either inequalities at input or set-shift

phenomena arising from S being required to process both visual and auditory information within a single session. Cooley and McNulty presented the three consonants of their trigram materials simultaneously in the visual and successively in the auditory mode. In the present investigation, all consonants were given successively so that input would be equated for the two modalities. Cooley and McNulty also designed their study so that the modality comparison would be within-Ss. The present investigation provided both within- and between-Ss comparisons in order to determine whether or not the more pronounced recency effect for the auditory modality is characteristic only of situations where S is required to process information from both modalities in a single session.

SUBJECTS AND MATERIALS

The Ss were 60 students of introductory psychology, 20 being assigned at random to each of three groups. The materials were 48 CCC trigrams of from 0% to 33% association value taken from the Underwood & Schulz tables (1960, Appendix B, pp. 312-329). These trigrams were divided into two lists of 24, the first two sets of the Cooley & McNulty (1967) study. The Ss of Group 1 were presented with one list of 24 CCCs, were given a 90-sec rest, and then were required to process a second list of 24 CCCs. This group was divided into two subgroups, half of the Ss being given List 1, then List 2, and the other half being given List 2 and then List 1. These two subgroups were then partitioned so that half of each processed trigrams in an auditory and then in a visual mode, while the other half was subjected to a visual-auditory sequence. The Ss of Group 2 processed the CCCs in a visual mode while Ss of Group 3 processed the trigrams in an auditory mode. Half of each group was given List 1 CCCs while the other half processed List 2 trigrams. For all Ss, the retention intervals were 0, 3, 6, and 18 sec, each interval appearing once in each block of four trigrams, with the intrablock position being random. The recall period for each CCC was 15 sec, during which time S attempted to verbally emit the three consonants in correct order.

APPARATUS AND PROCEDURE

All Ss, wearing earphones, were seated approximately 1 m from a translucent white glass screen and were given

instructions for the appropriate modality. For *visual* presentation, the three consonants were successively back-projected to the screen for 0.5 sec each by means of a 16-mm film-strip projector. Under this visual condition, S first saw the word "item" on the screen. The trigram was then presented successively by letters over the next 1.5 sec. Immediately at the disappearance of the third letter, S began counting backwards by threes from some preexperimentally determined, visually presented three-digit number until the word "recall" signaled that he had 15 sec in which to attempt to verbally recall the trigram. This procedure continued until the 24 CCCs were exhausted. The procedure for *auditory* presentation was similar to that of the visual condition, with the exception that all materials were introduced binaurally through the earphones from a tape recorder. These tapes were prepared by a male E reading from the film-strip materials of the visual condition. The Ss thus *heard* the signals "item" and "recall," the three-digit numbers for backward counting, as well as the 24 trigrams themselves, the components of which were presented successively for 0.5 sec each.

RESULTS AND DISCUSSION

The major dependent variable was number of trigrams correctly recalled. The data were also analyzed in terms of number of correct consonants, regardless of their position, and number of correct consonants in proper position. All data were examined by means of analysis of variance techniques. Departure from normality was evident, this being most pronounced in the between-Ss analysis of the major dependent variable. For these data, the same effects were shown to be statistically dependable with and without a square-root transformation. All analyses were therefore performed on untransformed data, and, with one exception, only those F ratios that reliably exceeded their expected values under the null hypothesis are reported.

For the between-Ss analysis of number of trigrams correctly recalled, the Modality (auditory vs visual) by Retention Interval interaction was statistically dependable [$F(3,108) = 7.93, p < .001$], as were the main effects of modality [$F(1,36) = 15.62, p < .001$] and retention interval [$F(3,108) = 75.77, p < .001$]. The within-Ss analysis resulted in similar findings: for interaction, $F(3,116) = 3.02, p < .05$; for modality, $F(1,116) = 36.12, p < .001$; and for retention interval, $F(3,116) = 70.14, p < .001$. This analysis also revealed a statistically reliable main

Fig. 1. Percentage of trigrams correctly recalled as a function of retention interval and mode of presentation.

effect for the auditory-visual vs visual-auditory sequence, superior performance being observed under the former condition [$F(1,16) = 6.76$, $p < .025$]. The requirement that S process both visual and auditory information within a single session might well have been responsible for this finding. Since both designs produced similar results, these within- and between-Ss data have been pooled and are represented in Fig. 1, where percentage of trigrams correctly recalled is shown as a joint function of retention interval and mode of presentation. The auditory function is depicted by solid circles with unbroken lines, while open circles with broken lines represent the visual function. Although the overall level of performance is somewhat depressed with respect to that observed by Cooley & McNulty (1967), the nature of the interaction in the two studies is the same. It is apparent that this more pronounced recency effect for the auditory modality is a stable phenomenon, being obtainable under conditions of successive as well as simultaneous visual presentation and being invariant with respect to choice of experimental design.

Phenomena similar to those revealed by the trigram analysis were observed, where the dependent variable was number of correct consonants in proper position. For the between-Ss design, the Modality by Retention Interval interaction was statistically reliable [$F(3,108) = 4.26$, $p < .01$] as were the main effects of modality [$F(1,36) = 11.60$, $p < .005$] and retention interval [$F(3,108) = 91.69$, $p < .001$]. These three effects were also

statistically dependable for the within-Ss design: $F(3,116) = 4.20$, $p < .01$; $F(1,116) = 44.83$, $p < .001$; and $F(3,116) = 60.41$, $p < .001$, respectively. The requirement that Ss process information from both modalities was likely responsible for a reliable modality-sequence main effect [$F(1,16) = 4.64$, $p < .05$], performance again being superior under the auditory-visual condition.

The analysis of number of correct consonants, regardless of whether or not they were emitted in proper sequence, showed no evidence of interaction in the between-Ss design. The relevant statistics for this analysis for interaction, modality, and retention interval, respectively, were: $F(3,108) = 2.27$, $p > .05$; $F(1,36) = 6.76$, $p < .025$; and $F(3,108) = 86.23$, $p < .001$. The corresponding values for the within-Ss data were: $F(3,116) = 3.88$, $p < .025$; $F(1,116) = 46.39$, $p < .001$; and $F(3,116) = 71.76$, $p < .001$. Also, the difference between the modalities in the between-Ss design appeared to be less pronounced than in any of the other analyses. Improved recall of visual information was primarily responsible for this reduced difference. These findings are not particularly surprising, since the ear is a temporal and the eye a spatial analyzer (cf. Aaronson, 1967). With the elimination of the requirement for the consonants to be scored correct only if in proper position, the visual function might be expected to exhibit an upward shift with respect to the ordinate.

The between-Ss data were subjected to a fourth analysis, whereby recall of individual consonants was examined as a function of the three positions in which they appeared. Recall was best at Position 1 and poorest at Position 3 [$F(2,418) = 14.49$, $p < .001$]. These data are contrary to any "bumping" notion (cf. Atkinson & Shiffrin, 1968) that would conceive of later consonants replacing earlier ones. However, with only three syllables to be held in a buffer store at any given moment, this notion is not very applicable to the present data. The effect is also inconsistent with a decay notion, unless consonants in Position 3 are subject to more decay because of not having to be recalled until late in the 15-sec interval. This primacy phenomenon is probably most consistent with the notion of a delay in the perception of consonants in the second and third positions (Aaronson, 1967; Davis, 1959), since the syllables were

presented successively under essentially 0-sec interconsonant-interval conditions.

The data of the present investigation, as well as those of Cooley & McNulty (1967) and Murdock (1966, 1967), are compatible with the notion that visual and auditory information are stored and processed in different ways. The mechanisms responsible for the superior recall of materials presented in an auditory mode, especially at the shorter retention intervals, are as yet poorly understood. Perhaps proactive interference from earlier items in the list operates differentially in the two modalities, as Cooley & McNulty (1967) have already suggested. An alternative interpretation of the data would be one that stresses easier access to auditory information, since this type of input presumably enters an auditory information store directly, while visual information arrives in AIS through a more circuitous route (Sperling, 1963; Turvey, 1966).

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NOTES

1. This research represents an MA thesis by the senior investigator. The manuscript was prepared by the junior author while on sabbatical leave at the Human Performance Center, University of Michigan.