'Trace strength,' modality, and the serial position curve in immediate memory[1]

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Conrad & Hull's (1968) comparison of serial recall for the visual and auditory modalities was shown to involve a confounding of opportunities for strategic rehearsal. The present results, in which written monitoring was used to control rehearsal, were interpreted within the framework of pluralistic coding and storage models advanced by Crowder & Morton Some evidence was obtained to suggest that the act of vocalizing during a visual presentation preempts strategic rehearsal. An adequate modality comparison was defined for further investigation.

Conrad & Hull's (1968) comparison of the effects of vocal and silent monitoring on the serial recall of a visual stimulus, presented element-by-element, is potentially confounded by differences in the intrapresentation opportunities for selective attention and rehearsal. During silent monitoring, both strategic rehearsal (e.g., cumulative rehearsal; see Corballis, 1966) and selective attention are possible, whereas during vocal monitoring, attention is obligatory for all elements, and the paced involvement of the response apparatus may preempt strategic rehearsal. The following experiment was designed to examine such confounding and employed two additional conditions created by imposing a further pacing requirement on the response apparatus, viz, written monitoring. The primary comparison in this revised experiment is between vocal and silent + written monitoring, attention being obligatory and strategic rehearsal being preempted in both conditions. Both vocal and written monitoring have previously been used to achieve such aims (Brown, 1954; Margrain, 1967; Wickelgren, 1965a), and Murray (1968) has investigated what may be a closely related condition of "suppression" in which S is required to emit a paced, irrelevant response during presentation. The main question to be resolved is whether or not a comparison of Conrad and Hull's conditions is adequate as a comparison of the visual and auditory input modalities.

Recent theorists (Crowder & Morton, 1969; Crowder, in press, a; Morton, 1970) have proposed pluralistic trace systems for memory that emphasize differences in the nature of coding at three levels of linguistic processing, viz, prerecognition, recognition, and postrecognition. Such theories are a logical development of Brown's (1959) speculations about general and specific storage space, recoding, and multicomponent traces, and they lead one to seriously consider alternative processing mechanisms to those emphasized by previous theorists (e.g., Waugh & Norman, 1965; Atkinson & Shiffrin, 1968). For example, in Morton's model, there is the possibility that information from the prerecognition stage (sensory-analysis systems) is recoded "semantically" in secondary memory (cognitive system) at a stage prior to the production of the postrecognition component of primary memory (response buffer), i.e., storage in secondary memory need not be exclusively mediated by rehearsal from primary memory (cf. Kintsch & Buschke, 1969). By such a process, the products of sensory analysis might gain access to "programs" for storing the data in an organized fashion in anticipation of retrieval. This could be the basis of Brown's somewhat neglected finding of a "consolidatory" effect of set in the apparent absence of selective attention and rehearsal (Brown, 1954; Brown, 1960). Also, it implies that serial organization might be developed by processes other than strategic rehearsal. In Morton's logogen system, consisting of stable linguistic representations, the threshold of activity needed to send information to the cognitive system is lower than that needed to generate an available response or articulatory token in the response buffer. Thus, it is possible that the information coded in the sensory-analysis systems may continue being stored in the cognitive system during the early stages of serial recall. The available evidence suggests that such recoding could go on for about 2 sec (Crowder, in press, b), and any resulting response competition with available responses generated in the early stages of retrieval could be countered by adopting a higher threshold, e.g., by adopting a high decision criterion. Some of Murdock's (1968) data on the relationship between criterion and SP is suggestive in this respect.

In the above context, results obtained by using written monitoring and suppression are of more than passing interest since they may provide the means of identifying coding processes which are normally overlaid by strategic rehearsal.

SUBJECTS AND DESIGN

The Ss were 24 Newcastle undergraduates and members of staff (mean age, 24.4; range, 19 to 37 years). Each was tested individually in a single hour-long session (approximately) composed of four blocks of 20 trials, and each S received a different permutation of the four presentation conditions (viz, silent, vocal, silent + written, and vocal + written monitoring). Each S recalled the same 80 eight-element stimuli, with stage of practice, presentation condition, and set of stimuli varied orthogonally by means of a set of Greco-Latin squares. In order to counter carry-over effects to be expected with such a repeated-measures design, the first 5 trials in each block were discounted as practice, and a rest period of 2 min separated each block.

STIMULI AND APPARATUS

The four sets of 20 eight-digit stimuli were typed on rolls of paper for digit-by-digit presentation in the center of a well illuminated window of a continuous-motion memory drum. The digits were chosen from the digits 0 to 9, subject to the restrictions that within a stimulus no repetition was allowed and that within a set of stimuli each digit occurred equally often in each SP. A recall sheet had eight cells arranged down one margin, and the remainder was inserted beneath a sheet of dark-blue celluloid and a sheet of carbon paper mounted on a plywood base. This device was used for recording the written monitoring responses and prevented S from using the record as an aid to recall. A shield over the apparatus eliminated any cues to be gained by reflectance from indentations in the celluloid.

PROCEDURE

In all conditions, the presentation rate was just over 2 digits/sec, and the stimulus "on" time was about 420 msec. A warning signal was provided by a red line in the window 1½ sec before the onset of the first digit, and ½ sec after the onset of the final digit, there was a row of three black dots and a green line. The dots served as a signal for E to switch off the memory drum and for S to begin serial recall. A new trial was begun after recall and reloading of the monitoring apparatus. The instructions for the conditions emphasized that the monitoring responses were to be synchronized as nearly as possible with the appearance of a digit in the window. The recall instructions emphasized that S was to report the digits as quickly as possible and strictly in order of presentation, without omissions and with guessing where

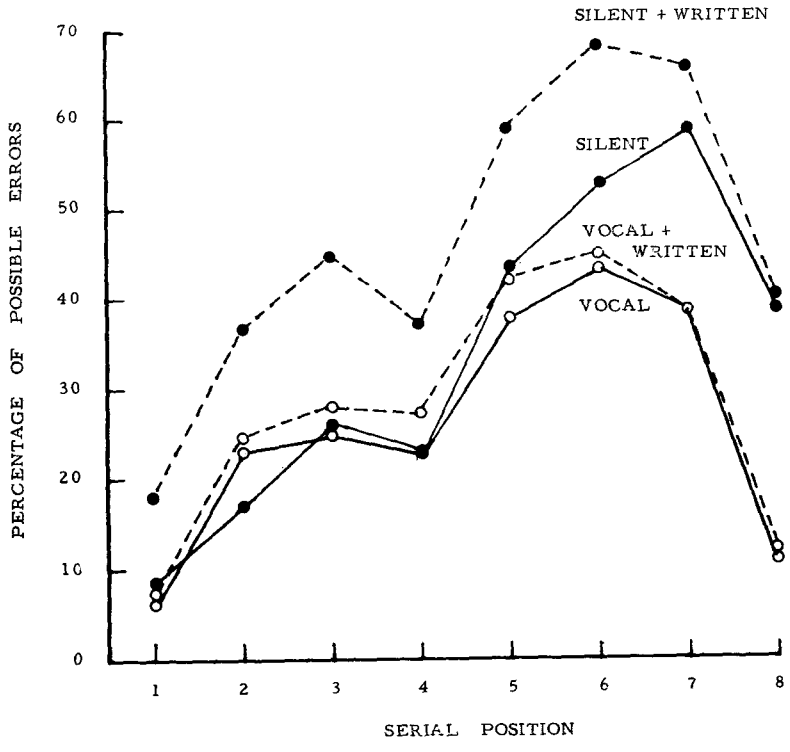

Fig. 1. The effect of the monitoring conditions on the serial-position curves for order errors.

necessary. Each recall attempt was monitored by E to ensure that the instructions were being followed. The data was scored using Wickelgren's (1965b) measures of errors in ordered, item, and position recall.

RESULTS AND DISCUSSION

The SP curves obtained for each condition scored on the ordered-recall criterion (error for each digit absent in recall or recalled in an incorrect SP) and pooled over Ss are shown in Fig. 1. An analysis of variance at each SP gave the following pattern of significance levels: Greco-Latin squares, n.s.; conditions at all SPs, $p < .001$, except SPs 4 and 5, $p < .01$; stage of practice blocks at all SPs, n.s.; sets of stimuli at SPs 4 and 7, $p < .05$, and at SPs 3 and 5, $p < .025$; and only 2 out of 24 interaction terms involving squares and the other variables were significant ($p < .05$).

Next, the comparisons of interest were evaluated by means of t tests ($df = 18$) using a standard error derived from the ANOVA.[2] (One-tailed significance levels are reported unless otherwise stated.) Conrad and Hull's conditions of vocal and silent monitoring showed a significant advantage for the former over the last three SPs–SP 6 ($p < .05$), and SPs 7 and 8 ($p < .001$)–confirming their basic finding. However, in the revised comparison, in which the effect of strategic rehearsal was eliminated, vocal monitoring showed a consistent advantage over silent + written monitoring at all SPs ($p < .001$) except SP 2 ($p < .005$), as expected on the confounding hypothesis advanced in the introduction. This suggests that the Conrad and Hull comparison is not adequate as a modality comparison, and the fact that it yielded the theoretical functions for serial recall postulated by Crowder & Morton (1969) and Morton (1970) seems to have been fortuitous. It seems clear that an adequate test of the theoretical modality functions requires a further experiment in which written monitoring of visual and of an auditory presentation are compared. Such an experiment is in progress.

The comparison of vocal and vocal + written monitoring yielded no significant effects at any SP; this supports the idea that in vocal monitoring strategic rehearsal is preempted by the act of speaking. Further support for this idea has been obtained by Crowder (in press, a). The comparison of silent and silent + written monitoring gave the following results, showing an advantage in favor of the former at SPs 1 to 3 ($p < .001$), at SPs 4 to 6 ($p < .005$), at SP 7 ($p < .05$), and at SP 8 (n.s.). These results are in the direction expected on the hypothesis that written monitoring does eliminate strategic rehearsal, especially of the cumulative type (Corballis, 1966). In an unpublished experiment, the author has shown that for an auditory presentation of 9-digit sequences at a 0.75-sec/item rate there is a significant increase in errors at all SPs, except the last three, when written monitoring is introduced. Taking these results together with those for a visual presentation, we seem to have found in written monitoring a convenient means of demonstrating storage differences in these modalities that may be associated with differences in the persistence of information in the sensory analysis systems. The exact mechanism underlying this effect will be difficult to pinpoint. On the one hand, the difference could reflect a differential input to the cognitive system during the early stages of recall, but, on the other hand, it might simply indicate that S can give an intensive rehearsal to the last item in a visual presentation and to the last three items in an auditory presentation, in a brief pause between presentation and recall. If we assume that written monitoring effectively clears the response buffer during presentation, then, either way, the difference will be a function of the properties of the sensory analysis systems. Written monitoring errors were rare (less than 1% of the possible) so that the results cannot be explained in terms of perceptual difficulties.

The results obtained for the item- and position-error scores showed a similar pattern of relationships to those depicted in Fig. 1, apart from a change in the elevation of the SP curves. As Wickelgren has pointed out, the item and position measures are statistically independent; however, it is by no means clear that they reflect different psychological mechanisms (cf. Conrad, 1965). But for what it is worth, the results for these measures show that the differences illustrated in Fig. 1 arise from differences in the availability of items and in the information about the position of items. Thus, in preempting rehearsal, written monitoring increases the frequency of positioning and item errors.

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NOTES

1. I am grateful to many people who kindly commented on an earlier report of this experiment circulated in Autumn 1968. Special thanks are due to Professor John Brown, Dr. John Morton, and Dr. Robert G. Crowder for their encouragement.

2. The results of all t tests were confirmed by means of Wilcoxon tests as a precaution against any serious breakdown in the continuity of the scores.

Associative productivity as a function of creativity level and type of verbal stimulus

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High creative (HC) and less creative (LC) Ss, selected on the basis of the Remote Associates Test (RAT), gave word associations to abstract and concrete word stimuli. HC individuals produced more associations over a longer period of time than did LC Ss, but creativity level did not interact significantly either with type of word stimulus or with associative output across time. Concrete words elicited more associations, but associations evoked by abstract words were more evenly distributed across time. Creativity groups did not differ in degree of stereotypy of the associations produced.

According to Mednick's (1962) associative conception, creative thinking requires grouping a number of individual associations into new combinations. The more remote the origins of the various associative elements, the more creative the effort. Mednick & Mednick's (1967) Remote Associates Test (RAT) has been used to discriminate among individuals who differ in ability to think creatively. Each item of the test requires the S to supply a single association appropriate to three unrelated stimulus words. For example, the "correct" association to the three stimulus words, RAT, BLUE, and COTTAGE, would be CHEESE.

On the assumption that ability to generate a large number of associations increases the probability of producing a creative solution, Mednick, Mednick, & Jung (1964) predicted that creative individuals would give a larger quantity of associations to a stimulus than would less creative persons. Their Ss associated continuously for 2-min periods to each of a variety of stimulus words. The more creative Ss gave more associations, irrespective of the type of stimulus used (noun or adjective, high or low Thorndike-Lorge frequency, or flat or steep associative hierarchy).

The present study investigated the associative output of high and low creativity groups to abstract and concrete stimulus words over longer time periods (3 min). Consistent with Mednick's (1962) conjecture of individual differences in the nature of associative hierarchies, it was predicted that creative Ss would emit a large number of associations at a slow but steady rate across time (flat hierarchy), while less creative Ss would respond frequently, at first, and then rapidly reduce their response rate (steep hierarchy), producing a lower total number of associations. It was further predicted that differences in the slopes of the associative hierarchies between the two groups would be greater when Ss associated to abstract than when they associated to concrete stimulus words. Finally, for all Ss, associative output was predicted to be greater in response to concrete than in response to abstract words.

METHOD

The Ss were 30 men selected from the extremes of a group of 300 junior college students who had taken the RAT 4 months prior to the start of the experiment. The 15 Ss in the high-creative (HC) group had RAT scores in the top 14% of the distribution of RAT scores; Ss in the low-creative (LC) group had scores in the bottom 13%.

Stimulus materials were eight words of medium associative hierarchies, selected from Bilodeau & Howell's (1965) association norms. In contrast with steep or flat hierarchy words, a word with a *medium* associative hierarchy elicits some dominant associations and many subsequent associations of gradually declining response strength. All words had a high Thorndike-Lorge (1944) frequency, designated AA MMM in the word count. Half the words were designated as abstract (HOPE, THOUGHT, FRIEND, COLOR) and the other half as concrete (CHILD, FLOWER, PLANT, WATER). Two additional words, APPLE and CARROT, were used as examples.

Each of the 10 words was projected on a screen in front of the S, who was instructed to give as many associations as he could to each stimulus word and to avoid chain-associations. Each word appeared for 3 min and was immediately replaced by the next word in the sequence. Word order was randomized from S to S. All associations were tape-recorded and later transcribed.