The structure of order error in the build-up of proactive interference in short-term memory

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Order errors produced in the generation of proaction in the short-term retention of trigrams were analyzed in terms of their phonemic similarity to the correct items. Employing five successive applications of a short-term memory distractor technique with a 12 sec retention interval it was observed that items transposed within a trigram were phonemically related to the correct items but position intrusions from preceding trigrams were not. Both types of error-production remained invariant across the five trials. The data were considered in the framework of models of order storage in short-term memory.

Two models have recently been proposed to account for the short-term storage of items presented sequentially. Conrad's (1965) model which may be described as a nonassociative model (Wickelgren, 1966), contends that items as they are encoded are placed into an ordered set of locations. The items remain in these fixed locations so that at retrieval they are read out in the order in which they entered. During the storage phase a systematic degradation of the item occurs. Given the observation that an item in short-term memory (STM) is represented as a phonemic pattern (Conrad 1964; Wickelgren 1966) the degradation that occurs is a gradual loss with time of the distinctive aspects of this pattern. Thus in the event of a relatively slight diminution of the pattern Conrad proposes that a reported error-item will be acoustically similar to the input item. With a few additional premises Conrad is able to offer that order errors are in effect item errors and there is, therefore, no need to posit a separate store for order.

Wickelgren's (1966) model, which is an associative model, proposes that short-term associations are established between the internal representatives of items (i.e., internal representatives of the phonemes of the items) presented in close temporal contiguity. In this case, therefore, order of recall is predicated upon these associative connections. In accordance with Conrad, Wickelgren indicates that items which transpose in the recall of sequential information tend to be phonemically similar, i.e., order errors are contingent upon the item structure.

The problem of the generality of his particular nonassociative model has been raised by Conrad. As he indicates, his model might be limited to immediate recall situations and given protracted intervals between presentation and recall filled with other information processing tasks the proposed organization might be disrupted. A similar limitation exists for Wickelgren's model since he has demonstrated (Wickelgren, 1967) that the established interitem associations decay over time.

The present study was conducted to assess the nature of error-production in sequential recall during the build-up of proactive interference (PI). In successive applications of a STM distractor technique (Murdock, 1967) PI builds up rapidly attaining a maximum after three or four trials. With trials constituted by the presentation and recall of trigrams the questions raised in this investigation were: (a) to what extent are intratrigram transpositions of the type considered by Conrad and Wickelgren phonemically related to the presented items after an interval of 12 sec; (b) if intratrigram transpositions are phonemically related to the presented items is this also true of intertrigram position intrusions; and (c) is there any change in the distribution of these errors as PI builds-up?

Method. The design employed was that used for generating PI with a distractor technique (Keppel & Underwood, 1962). Five trials were administered to each of the 100 Ss drawn from a population composed of undergraduates engaged in an introductory psychology program. A trial consisted of the following events presented in terms of a sequence of slides delivered by a Kodak Carousel projector and controlled by a tape-timer: (a) ready signal of 2 sec duration; (b) trigram of 2 sec duration read aloud by S; (c) three-digit number presented throughout the retention interval of 12 sec. S counted backwards aloud from this number in threes to the beat of a metronome set at 60 beats per min. This constituted the interpolated task; (d) recall cue signalling recall of the trigram.

The following trigrams were employed counterbalanced across trials: XFG, PZM, BDL, NSV, WHJ. Items in the first four trigrams contain either the vowel sound ē or the vowel sound ĕ, and the letters in the last trigram contain vowel sounds ŭ, ā, ă, respectively. Ss recorded their responses on a response sheet at the recall point of each trial. The response sheets were structured so that for any trial S did not have visual access to his preceding reports.

Results. A response was considered correct when the item reported was reported in the position in which it had appeared in the display. The errors generated at recall were classified in the following manner: (a) A transposition error was committed when an item in the to-be-recalled trigram appeared in an incorrect position. Since omissions were allowed, a single transposition was defined as the case in which only one item, correct for that particular trigram, appeared in an incorrect location. If two items changed positions this was classified as two transpositions and if all those items changed position this was classified as three transpositions. Thus transpositions in this particular scheme had a possible range from 0 to 3. (b) An intertrigram position error occurred when an item which had appeared in a particular position in a previous trigram appeared in that same position in the trigram being recalled. (c) An item error which did not meet either of the above criterion was classified as an "extra" error. (d) An omission error occurred when no item was reported for a particular position.

Given that 1500 items were presented (three items per trial for five trials to each of 100 Ss) there were 1500 "items" at recall which could be partitioned into correct items, error items, and

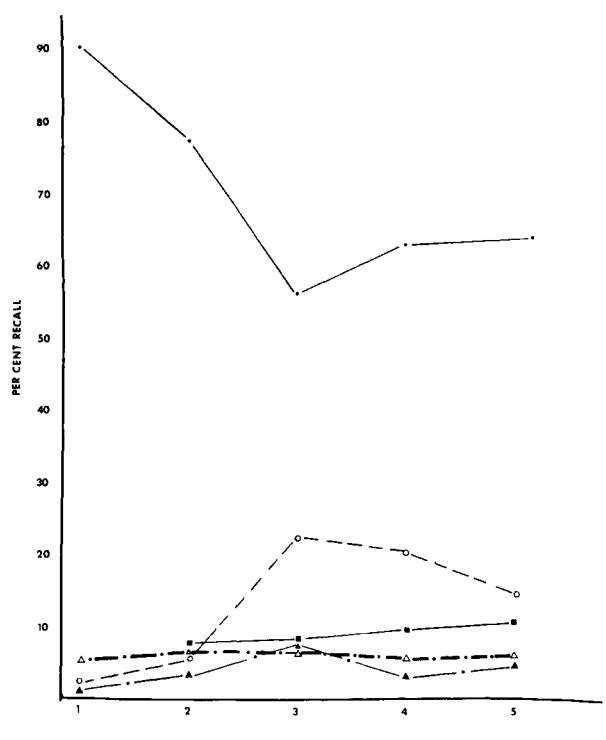

Fig. 1. Correct recall and error production across trials: Correct •——•; omissions ○——○; intratrigram transpositions △•——•——△; intertrigram intrusions ■——■; other error ▲——•——▲.

omissions. Such partitioning revealed that 70% of the items were correctly recalled, 5.8% of the items were intratrigram transpositions, 7% were intertrigram position errors, 3.9% were extra errors and 13.3% were omissions. Figure 1 shows the distribution of these outputs over trials. Observation of Fig. 1 shows clearly that PI build-up was obtained.

With respect to the question of the phonemic basis of intratrigram transpositions analysis of the error matrix revealed that the transpositions were significantly related to the correct items on the basis of phonemic similarity ($\chi^2 = 12.00$, df = 1, $p < .001$). A similar analysis of the intertrigram position errors, however, revealed no such relationship ($\chi^2 = 3.08$, df = 1, $p > .05$). In regard to changes in frequency of occurrence over trials these two classes of error were similar in that they displayed invariance across trials (for transpositions $\chi^2 = 1.23$, df = 4, $p > .05$; for position errors $\chi^2 = 2.13$, df = 3, $p > .05$). It is notable that the extent to which an item in a particular trigram maintains its ordinal character upon intrusion into a subsequent trigram rather than intruding in some other position was shown by χ^2 analysis to be highly significant ($p < .001$).

Discussion. As the results indicate, items which transpose in the recall of sequential information tend to be phonemically related even after an interval of 12 sec. This observation complies with the models proposed by Conrad (1965) and Wickelgren (1966). However the observation that intertrigram position intrusions do not tend to share a common phoneme with the replaced items seems to raise difficulties for both of these models.

In Conrad's model it is contended that for a location there is a continuum of potential errors systematically related to the degree of attrition in the phoneme pattern representing the item. This continuum ranges from homophones at one end to guesses and omissions at the other. Yet he does indicate that sometimes the representative pattern of an item previously and recently placed into the location may still be discriminable from the noise of the location, but not discriminable from the pattern of the present item. This supposedly accounts for position intrusions. However, if the pattern of the previous item is indiscriminable from the pattern of the present item this would seem to suggest that intertrigram position intrusions should have some phonemic compatability with the replaced item. Also if the pattern of the previous item has been degraded somewhat such that it is indiscriminable from the pattern of the present item one would not expect to find the position intrusion occurring in its exact state but in some form of phonemic variation of that state. It is notable that in the present data out of a total of 250 errors (excluding omissions) 105 were position intrusions, 34 were intrusions from previous trigrams occurring in a different position, and only 24 errors were constituted by items not employed in the presentations. This suggests that if a previous item is going to intrude it is going to intrude in its intact state.

For Wickelgren's model the problem is not so acute. In this model the ordering of recall is based upon the short-term associations between the internal representations of these items. During the retention interval these item-to-item associations decline in strength (Wickelgren, 1966, 1967). Maintaining the associative framework of Wickelgren's model it may be conjectured that the retrieval system finding one retrieval-cue ineffective, in this instance item-to-item associations, employs an alternate retrieval-cue such as serial position-to-item associations. In the usage of this latter cue the retrieval system has a built-in constraint placed upon it by the monitoring of the temporal values of items, i.e., how recently they occurred (Yntema & Trask 1963). The positing of this temporal retrieval-cue is necessary to account for the invariance over trials of position intrusions and the fact that the position intrusion tends to come from the immediately preceding sequence (Murdock, 1961). The problem, therefore, for Wickelgren's model would be to explicate how one type of retrieval-cue (or one type of association) may relate to another type in the ordering at recall. Since transposition errors are based on phonemic similarity and since position intrusions also occur it seems feasible to propose that both types of retrieval cues are involved in the ordering process.

Finally, in terms of the production of PI, the invariance of intertrigram position intrusions over trials despite the decrement in recall is congruent with similar observations by Conrad (1960) and Peterson & Gentile (1965). As these investigators have argued, the lack of a systematic relationship between degree of forgetting and frequency of position intrusions poses a problem for a strict interference theory of forgetting.

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