Bulletin of the Psychonomic Society
1976, Vol. 8 (2), 76-78

Confusions in memory for tactile presentations of letters

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This investigation explored the possibility of a tactile as well as acoustic component for short-term memory by tactilely presenting groups of letters on subjects' backs. Letters varied in phonetic similarity and spatial location. Recall error rates were assessed according to Wickelgren's (1965) ordered, item, and position recall criteria. Spatial location showed no effect. High phonetic similarity produced more errors than low phonetic similarity by ordered and position recall criteria. This effect was attributed to translation to acoustic representations for storage in short-term memory. The results suggest that shape coding may also function along with acoustic coding as an additional strategy for aiding recall of tactilely presented letter sequences.

The acoustic nature of representations in short-term memory (STM) has been demonstrated by several investigators (Conrad, 1972; Sperling, 1963; Wickelgren, 1965). Baddeley (1966) has shown that semantic features can determine memory codes in some situations. Conrad (1972) assumes that a multicode system might be a more accurate description of human functioning. He concludes that, for the reading process at least, phonological coding is just one alternative (although a more efficient) means of coding. Norman (1972) has pointed out that nonlinguistic material is probably *not* transformed into acoustic representations.

Crowder (1972) lists a number of memory systems related to specific bodily functions—vision, audition, and kinesthetic. Kinesthetic or tactile, memory has not been explored extensively. Bliss, Crane, Mansfield, and Townsend (1966) have established the existence of a tactile storage (on the order of a sensory buffer) for nonverbal materials. Kirman (1973) has reviewed a large body of literature concerning tactile presentation of verbal material. While Kirman was concerned with the problem of communicating speech, his review suggests that there have been no attempts to determine whether STM for tactile presentations of verbal materials suffers from phonological interference.

The present study is concerned with the nature of coding systems used for letters presented tactilely. It is hypothesized that, if letters presented tactilely are recoded phonologically, a large number of acoustic confusions will be detectable. A second hypothesis is that, if a tactile buffer is used prior to acoustic coding, letters presented in the same spatial location on the skin could produce greater error rates than letters presented to different locations.

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METHOD

Subjects

Twenty-four subjects were used. They were enrolled in an introductory psychology class at the University of Minnesota at Duluth. The range in age was from 18 to 25 years. Course credit was given for participation in the experiment.

Design

This was a completely within-subjects 2 by 3 factorial design. One factor was intralist similarity, either two (E2) or six (E6) similar phonemes. The other variable was spatial location of letters, either overlapping, three rows of two, or two columns of three. Each subject received 36 lists.

Materials

Thirty-six lists were constructed, each list containing six consonants. The E2 lists contained two consonants from the following list: B, C, D. G, P, T, V, Z. The other four consonants were chosen from those remaining in the alphabet. E6 lists were composed of six consonants from the set given above. All lists were randomly constructed in a manner similar to that used by Wickelgren (1965).

Procedure

Each session lasted 50-60 min. Each subject received one practice trial in identifying all letters. (On this occasion the alphabet was traced on the subject's back using the overlapping presentation condition while the experimenter simultaneously verbally identified each letter.) Every subject then received all 36 lists. Spatial location was counterbalanced among subjects and intralist similarity was randomized with blocks for spatial location.

Each subject was seated facing away from the experimenter after having put on a tee-shirt with a grid on the back. (Any interfering undergarments were removed.) The grid was composed of 6-in. squares. Capital letters 5 in. high were traced in the grid at the rate of 4 sec per letter. After presentation, a 20-sec recall period was given the subjects. Data sheets were provided and all subjects wrote their responses in a column of six vertically arranged boxes for each trial. Instructions to guess were given to subjects if they were not certain.

At the end of the session, subjective data were taken from the subjects. They were asked which treatment was easiest, how they remembered the letters, whether they had any difficulty identifying the letters, whether any spot on the back was more difficult, and whether there were any acoustic confusions.

RESULTS

For each subject the number of errors was assessed according to three criteria, following Wickelgren (1965). The three criteria were (1) item recall—an item was incorrect if it did not appear anywhere in the subject's recall list; (2) ordered recall—an item was incorrect if it did not appear in the correct order; and (3) position recall—calculated by the following formula: (ordered recall-item recall)/(number of items correct by item recall criteria.)

A 2 by 3 repeated measures analysis of variance was performed for each type of error score. To adjust for repeated measures, the alpha level was set at .01. The intralist similarity effect was significant in the ordered recall analysis ($F(1,23) = 52.09$, $p < .001$) and in the position recall analysis ($F(1,23) = 104.24$, $p < .001$). For the ordered recall analysis the mean error rates were .383 for E6 and .241 for E2. The comparable error rates for the position analysis were .232 for E6 and .068 for E2. The intralist effect was not significant in the item recall analysis ($F(1,23 = 6.05$, $p > .01$).

The spatial location of the letters showed no significant variation in any of the analyses, nor were there any significant interactions.

A further attempt to assess the contributions of similar shapes and sounds was made. Each position error was placed in one of four categories: high and low shape similarity crossed with high and low sound similarity. The similarities were judged with respect to the stimulus item. The error rates were then weighted for frequency of occurrence. (Weighting was necessary since this analysis was a post hoc method of assessing shape vs. sound confusions.) The four error rates were: high sound, high shape (e.g., P,D/C,G) 3.13%; high sound, low shape (e.g., Z,C/C,T) 1.62%; low sound, high shape (e.g., R,B/O,Q) .91%; and low sound, low shape (e.g., X,O/C,F) .69%.

DISCUSSION

The evidence from this study strongly suggests that phonological coding is a predominant factor in STM for the tactile presentation of phonemically similar letters. In regard to the second hypothesis, the use of a tactile buffer prior to acoustic coding was not demonstrated, since neither overlapping nor spatially distributed letter sequences showed statistically significant differences.

The significant intralist effects by both ordered and position recall criterion essentially replicate the findings of Wickelgren (1965) for verbally administered phonemically similar and dissimilar lists of letters, the main difference for this investigation being the mode of transmission of stimulus items. It appears that the pervasive acoustic component associated with speech coding is still preferred even via a tactile mode of transmission.

One must interpret with caution the negative findings regarding the use of a tactile buffer prior to acoustic coding. Complete presentation of each stimulus item took approximately 1½ sec. Approximately 2½ sec elapsed between the completion of one stimulus item and the presentation of the next. Though this rate of presentation insured the uniform tracing of letters, it also left ample time for the phonological recoding of tactual data between presentation of stimulus letters. Any confusion resulting from tactual coding may have, in this case, been masked by the more often utilized alternative—acoustic coding. Subjective data taken after each testing session suggested a heavy reliance on a phonological rehearsal strategy. All subjects reported using various forms of covert articulation as a means of strengthening the memory trace. Similar sounding letters were more easily confused and, hence, more difficult to rehearse than different sounding letters.

The post hoc analysis exploring the possibility of masked tactile coding by stimulus shape must be interpreted with customary caution though the results bear further examination. Conrad (1972) has shown that optical coding of letters by profoundly deaf subjects appears an effective alternative to acoustic coding for serial STM. Alwitt (1974) suggests that the reaction time for verbally identifying visually presented letters that vary orthogonally in visual and name similarity "is a function of the feature that is more easily extracted from the stimulus." In the tactile transmission of letters, stimulus shape might be manifest either through coding via visual imaging of the tactile stimuli or through the retention of unchanged tactile data. The Watkins and Watkins (1974) demonstration of a tactile suffix effect led them to suggest a representational tactile memory via the retention of "raw tactile information."

The post hoc analysis for this investigation suggests that both acoustic and shape coding may simultaneously occur. The largest position error rates are reflected in those letter combinations possessing both high acoustic and shape similarities (3.51%). For those position errors involving letter pairs with high phonemic similarities but low shape similarities, the error rate is approximately one-half that for the high shape/high sound category (1.62%). That phonological coding is the more often used, and hence more influential, factor may be demonstrated here by the relatively lower percentage of shape confusions for phonemically dissimilar letter pairs (.91%). Position errors involving low sound/low shape letter pairs occur least often (.67%) and suggest that other elements contribute to overall error scores, though in relatively smaller proportion to overall sound and shape contributions.

Whether shape coding occurs primarily through visual imaging or through direct tactual retrieval remains unanswered by this study. What does appear possible, however, is that shape coding may also function with acoustic coding as an additional strategy for aiding recall of tactilely presented letter sequences.

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(Received for publication April 7, 1976.)