SHORT-TERM MEMORY FOR WORD SEQUENCES AS A FUNCTION OF ACOUSTIC, SEMANTIC AND FORMAL SIMILARITY

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Experiment I studied short-term memory (STM) for auditorily presented five word sequences as a function of acoustic and semantic similarity. There was a large adverse effect of acoustic similarity on STM (72·5 per cent.) which was significantly greater ($p < 0{\cdot}001$) than the small (6·3 per cent.) but reliable effect ($p < 0{\cdot}05$) of semantic similarity.

Experiment II compared STM for sequences of words which had a similar letter structure (formal similarity) but were pronounced differently, with acoustically similar but formally dissimilar words and with control sequences. There was a significant effect of acoustic but not of formal similarity.

Experiment III replicated the acoustic similarity effect found in Experiment I using visual instead of auditory presentation. Again a large and significant effect of acoustic similarity was shown.

Introduction

In a series of short-term memory (STM) experiments Conrad (1963, 1964) has shown that sequences of items which are hard to discriminate in noise are also hard to remember, even though presented visually. Analogous effects of intra-list similarity have also been shown in long-term memory (LTM) where several types of similarity have proved to be relevant including similarity of letter structure (Horowitz, 1961) and of meaning (Underwood and Goad, 1951; Baddeley and Dale, 1966). However, Baddeley and Dale (1966) using paired-associate learning failed to show an equivalent effect of semantic similarity in STM and suggested that STM may differ from LTM in relying more on acoustic cues and much less on the meaning of the material to be retained. The present study uses the method of serial recall to explore further the role of similarity in STM.

Experiment I compares the influence of acoustic similarity on ordered STM for word sequences with that of semantic similarity.

Experiment I

Method

Design

A separate group of subjects did each of two conditions, A and B. Both groups attempted to recall 24 sequences of five words. In condition A these comprised 12 drawn from a set of eight acoustically similar words (mad, man, mat, cap, cad, can, cat, cap) and 12 from a control set of acoustically different words of equal Thorndike-Lorge frequency (Thorndike and Lorge, 1944) (cow, day, bar, few, hot, pen, sup, pit). In Condition B, 12 sequences were drawn from a set of eight adjectives with similar meanings (big, long, broad, great, high, tall, large, wide) and 12 from a set of eight semantically different words of equal Thorndike-Lorge frequency (old, deep, foul, late, safe, hot, strong, thin). All sequences were drawn at random with the constraint that no word appeared more than once in the same sequence. Similar and different sequences were presented in the same random order in both conditions.

Procedure

Subjects were tested in groups of about 20. Word sequences were presented by tape recorder at a rate of one word per sec. and subjects were allowed 20 sec. to write their ordered responses. To maximize response availability the relevant sets of words were written on cards and both sets were visible throughout the test session. Subjects were instructed that no sequence would contain words from more than one set but were not told before each sequence which set would be involved. A listening test was given both before and after the memory test to ensure that subjects were hearing words correctly. The 16 relevant words were presented in random order and subjects were allowed 5 sec. per word to copy them. Two Condition A subjects did not score perfectly and were discarded, leaving 20 subjects in Condition A and 21 in Condition B. Housewives from the A.P.R.U. subject panel served as subjects. These were paid for participation and were assigned haphazardly to one of the two conditions.

Results

Performance was scored in terms of percentage correct sequences, and since scores were not normally distributed they were analysed using non-parametric tests.

Acoustic similarity. A mean of 9·6 per cent. of the acoustically similar sequences were correctly reproduced (range 0–33·3), compared with 82·1 per cent. of the control sequences (range 58·3–100). Since there is no overlap between the two distributions, the difference is clearly highly statistically significant, $p < 0{\cdot}001$.

Semantic similarity. The mean score for semantically similar sequences was 64·7 per cent. correct (range 16·7–100), and that for control sequences was 71·0 per cent. (range 16·7–100). Although the mean difference is only 6·3 per cent. a Wilcoxon test indicates that it is statistically significant, $p < 0{\cdot}05$.

Comparing acoustic and semantic similarity. The mean difference between acoustically similar and control sequences was 72·5 per cent. (range 50·0–91·7). The equivalent effect of semantic similarity was 6·3 per cent. (range 0–41·7). Since there is no overlap between the two distributions, the greater effect of acoustic similarity is clearly statistically significant, $p < 0{\cdot}001$.

These results suggest that STM for word sequences shows a massive effect of intra-sequence acoustic similarity compared with only a slight effect of semantic similarity. In fact, however, Experiment I confounds acoustic and formal similarity, since the words which sound alike do so because they have letters in common. Since formal similarity has been claimed to have a marked effect on verbal learning (Horowitz, 1961) it is clearly desirable to separate its effect on STM from that of acoustic similarity. Experiment II attempts to do this.

Experiment II

Method

Design

All subjects attempted to recall 24 five-word sequences, comprising eight sequences drawn at random by sampling without replacement from each of three sets of words. Set A comprised five words which were acoustically similar but relatively dissimilar in letter-structure (bought, sort, taut, caught, wart), Set B comprised five words with similar letter structure but relatively dissimilar pronunciation (rough, cough, through, dough, bough) and Set C comprised five words of approximately equal Thorndike-Lorge frequency to sets A and B, presenting a roughly equivalent degree of spelling difficulty due to unusual letter structure or occurrence of homophones (e.g. caught–court, dough–doe), but which both sound and look relatively dissimilar (plea, friend, sleigh, row, board).

Procedure

The 24 sequences were presented in random order to a group of 17 housewives. As in Experiment I presentation was auditory, the rate was one word per sec. and subjects were allowed 20 sec. to write their responses. To maximize response availability the three sets of words were written on cards which were visible throughout the test session. To prevent the use of position on the card as a cue, four cards were used, each with a different order and were interchanged frequently. Again listening tests were given before and after the main experiment. In each test, the 15 words were read out in random order and the subject was allowed 5 sec. to write down what she heard. All 17 subjects scored perfectly on both tests.

Results

Mean recall scores were as follows, acoustically similar words 36·5 per cent. correct sequences (range 0–100), formally similar 55·8 per cent. (range 25·0–100), control words 63·5 per cent. (range 12·5–100). Comparison using the Wilcoxon test showed that performance on acoustically similar sequences was significantly poorer than performance on either control sequences, $p < 0{\cdot}001$, or formally similar sequences, $p < 0{\cdot}01$. There

was no significant difference between performance on formally similar and control sequences, $p > 0{\cdot}05$.

The general level of performance differs from Experiment I in being higher for acoustically similar sequences but lower for control sequences. The acoustically similar sequences are probably easier for two reasons. First, they are selected from a set of five instead of eight items, which seems likely to reduce both degree of inter-item confusion and information load. Secondly the items differ only in terms of the initial sound, so that if the subject remembers only the initial letter, she can easily reconstruct the sequence. This latter point also holds for the other two word sets since neither has more than one word starting with the same letter, although reconstructing the control words might take slightly longer since the latter part of these words have neither a common sound nor a similar letter structure. The fact that the words used in this study were less frequent than those used in Experiment I and presented more difficulties due to spelling and competition from homophones probably accounts for the rather lower performance on control sequences.

Although the set of acoustically similar words are more formally similar than would be ideal, and the formally similar words are probably not as acoustically distinctive as the control list, it nevertheless seems fairly clear that acoustic rather than formal similarity was the principal source of difficulty.

However, both Experiment I and Experiment II have used auditory presentation so that both results are open to the objection that some of the acoustic effect may be due to perceptual error. The listening tests used suggest that it is unlikely that very much of the acoustic similarity effect is due to mishearing, but the possibility exists that some of the effect may be due to the interaction of perceptual and memory loads. The following experiment therefore attempts to replicate the acoustic similarity effect using visual presentation.

Experiment III

Method

Material

Twenty-four five-word sequences were prepared comprising 12 sequences drawn at random from a set of 10 acoustically similar words (mad, man, map, mat, max, can, cad, cap, cat, cab), and 12 from a control set (pen, rig, day, bar, cow, sup, pit, hot, few, bun). Each word was typed on a $4\frac{1}{2} \times 3\frac{1}{2}$ in. card.

Procedure

Subjects were tested individually; the experimenter presented the material manually at a rate of one word per sec. after which the subject attempted to write down the sequence in the appropriate order. The two sets of words were visible throughout the experiment to maximize response availability, and again several different arrangements of each set were used. Ten young enlisted men served as subjects.

Results

The mean recall score for acoustically similar sequences was 1·7 per cent. (range 0–8·3) and for control sequences was 58·3 per cent. (range 8·3–91·7). The clear difference between the two types of sequence was shown by all 10 subjects and is thus highly statistically significant, $p < 0{\cdot}001$.

The overall level of performance was lower than that shown in Experiment I. The question of whether this is due to the different method of presentation, the selection of sequences from 10-word instead of eight-word sets or to the different type of subject used is, however, beyond the scope of the present study.

Discussion

All three experiments agree in showing a large and consistent adverse effect of acoustic similarity on ordered STM for words, and Experiments I and II show that neither semantic nor formal similarity has an effect of comparable magnitude. The relative unimportance of semantic similarity shown in Experiment I together with the failure of Baddeley and Dale (1966) to find an effect of semantic similarity among stimuli on STM for paired associates suggests that subjects show remarkable consistency and uniformity in using an almost exclusively acoustic coding system for the short-term remembering of disconnected words. There is abundant evidence that this is not true of LTM (Underwood, 1951; Underwood and Goad, 1951; Baddeley, 1966; Baddeley and Dale, 1966).

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