JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 4, 53-61 (1965)

Acoustic Similarity and Retroactive Interference in Short-Term Memory[1]

WAYNE A. WICKELGREN

Massachusetts Institute of Technology, Cambridge, Massachusetts

The operational distinction between short-term memory (STM) and long-term memory (LTM) is far from precise. However, there is very good agreement that STM is being studied when the list is presented once at a rate of less than 2 sec per item and retention is assessed after less than 30 sec, and LTM is being studied when the list is presented several times over a period of time measured in minutes and retention is assessed after minutes, hours, or days. The principal behavioral approach to the question of whether STM is theoretically distinct from LTM has been to determine whether both are influenced by the same variables. The present study is concerned with one such variable: the similarity of an interpolated list (IL) to the original list (OL).

It is well established that the similarity of an interpolated list to the original list affects the amount of retroactive inhibition (RI) in LTM studies of serial and paired-associate learning (e.g., McGeoch and McDonald, 1931; Osgood, 1949, 1953). In paired-associate learning, when the response items in the interpolated list are either similar or different from the response items in the original list, RI increases with increasing similarity of the stimulus items (Gibson, 1941; Bugelski and Cadwallader, 1956). When the similarity of the stimulus items is held constant, most studies show RI to increase as the similarity of the response items is varied from similar to different (Osgood, 1946, 1948; Young, 1955; Gladis and Braun, 1958). Bugelski and Cadwallader (1956) found a slight reversal in this relationship. With the exception of this latter finding by Bugelski and Cadwallader, the transfer and retroaction surface of Osgood (1949, 1953) describes quite accurately the findings on similarity and RI in paired-associate learning. In serial learning it is impossible to vary stimulus and response similarity independently, but the Osgood surface makes the clear prediction that a similar interpolated list will produce greater RI than a different (less similar, neutral, etc.) interpolated list. Exactly this finding was reported by McGeoch and McDonald (1931) for serial learning.

Attempts to demonstrate an analogous effect in STM have apparently been unsuccessful (Broadbent, 1963). Thus, Broadbent has argued that, in STM, interference from activity interpolated between presentation and recall is essentially independent of the nature of that activity so long as the activity prevents rehearsal for the same period of time. If true, this would be an important difference between STM and LTM. On the contrary, if interference in STM can be shown to depend on the nature of the interfering activity in the same way as in LTM, then it will be plausible to assume that STM and LTM are performed by the *same* system operating in a *quantitatively* different manner under different degrees of learning (or, less parsimoniously, different systems operating on the same principles). It might be well to

[1] This investigation was supported by grant MH 07726-01 from the National Institute of Mental Health, U. S. Public Health Service.

note in passing that the word "system" is used in the theoretically neutral sense of a set of cells functioning according to certain laws. Nothing more specific is intended.

The similarity of two lists can be varied in many different ways, and failure to obtain a relationship between similarity and RI may only mean that one has chosen dimensions of similarity that are inappropriate for the task. A study by Conrad (1962, 1964) of the types of intrusion errors occurring in immediate recall of a list of six letters suggested that the important dimensions of similarity in STM may be *auditory* dimensions, under conditions of either auditory or visual presentation. Conrad found that letters whose pronunciation ends with an "ē" sound (B, C, P, T, V) tend to be confused with each other in *recall*, and letters whose pronunciation begins with "ĕ" sound (F, M, N, S, X) tend to be confused with each other in recall. This was true even though the letters were presented *visually* at the rate of 0.75 sec per letter under conditions where the proability of perceptual error was known to be negligible. Conrad's study shows that an intrusion error in short-term recall tends to be similar to the presented item in acoustic characteristics; it does not show that short-term recall can be differentially affected by interfering lists differing in their acoustic similarity to the original list.

Previous studies of RI in STM have demonstrated that there is greater RI with a greater amount of interpolated material when delay covaries with amount of interpolated material (Peterson and Peterson, 1959; Murdock, 1961; Hellyer, 1962), and when delay is held constant (Peterson and Peterson, 1962). Greater amount of interpolated material or greater difficulty of the interpolated material should cause more RI according to decay theories of forgetting in STM. Trace decay theories, such as those of Brown (1958) and Broadbent (1963), assume that *S*s keep renewing the trace by rehearsal. The more difficult the interpolated task, the more time it takes away from rehearsal and the more the trace decays. What is important is to demonstrate whether the similarity of the interpolated task affects RI in STM, even when the difficulty of the interpolated task is presumed to be constant. Of course, one could always argue that two interpolated tasks differing in similarity to the original task were also different in difficulty, despite an equal number of interpolated items and equality on some finite number of performance measures, but such arguments would be grossly *ad hoc* without supporting evidence. The purpose of the following experiment is to determine whether interfering lists of equal difficulty but different similarity to the original list produce different amounts of RI.

Method

Procedure. The procedure was similar to that developed by Peterson and Peterson (1959). A list of 4 letters was presented at the rate of 2 letters per second followed immediately by a tone, which was followed immediately by a list of 8 letters presented at the rate of 2 letters per second which the *S*s were instructed to write down as they were presented, followed immediately by a tone, followed immediately by recall of the first 4 letters. Twelve sec was allotted for recall of the 4 letters, followed by a "ready" signal for the next trial. The *S*s were instructed that correct recall consisted of filling-in 4 boxes with the correct 4 letters in the correct order.

Presentation was auditory, and the entire experiment was recorded on tape. Each trial required about 20 sec (there were 135 trials) and the experiment lasted 45 min. The *S*s had the copy sheets in front of them at the time of recall but were instructed to cover what they had written immediately after finishing the copying task and before beginning recall.

There were three different types of 4-letter lists: (4 ē) Four *different* letters were selected randomly from the consonants whose pronunciation ends in ē (B, C, D, G, P, T, V, Z). (4 ĕ) Four different letters were selected randomly from the consonants whose pronunciation begins with ĕ (F, L, M, N, S, X). (2 ē, 2 ĕ) Two letters were randomly selected from each of the two auditory confusion classes and randomly ordered. The interfering 8-letter lists were composed of different combinations of letters that were: (I) *identical* to the letters presented in the original 4-letter lists, (S) *similar* to the letters in the original 4-letter lists in the sense of being from the same auditory confusion class, and (D) *different* letters, from a different auditory confusion class.

Design. The present experiment involved 15 different conditions determined by the type of 4-letter list and type of 8-letter interfering list. Five conditions were devoted to determining whether similar or different interpolated letters produce greater RI. In conditions (4 ē) (8 S), and (4 ē) (8 D), OL consisted of 4 ē letters, and IL consisted of 8 similar letters or 8 different letters, respectively. In conditions (4 ĕ) (4 S, 4 D), (4 ĕ) (2 S, 6 D), and (4 ĕ) (8 D), OL consisted of 4 ĕ letters and IL consisted of 8 letters, some similar and some different, in the proportions indicated. In none of these five conditions were any identical items used in the IL. Since there are only eight ē letters and six ĕ letters, the removal of four identical letters from either set reduces the number of possible similar letters to four and two, respectively. Thus, in order to fulfill the specifications listed above, it was necessary to use the similar letters twice in the IL of conditions (4 ē) (8 S) and (4 ĕ) (4 S, 4 D), but no similar letter was presented twice in immediate succession. With this exception, all selection and ordering of the interpolated letters was done randomly without replacement. The assumption was made that nonadjacent repetition of a similar letter in a list of eight letters would produce almost as much RI as two similar letters and certainly not more RI than two similar letters. Comparison of (4 ĕ) (2 S, 6 D) with (4 ĕ) (8 D) provides a check on this assumption since no letter is repeated in either of these two conditions. If this comparison yields findings different from the other comparisons, then this will indicate that the assumption is incorrect.

When OL consists of 2 ē letters and 2 ĕ letters, it is possible to determine whether IL consisting of similar ē letters or similar ĕ letters (but not both) interferes more with the similar letters or the different letters in the OL. Two conditions were devoted to answering this question: (2 ē, 2 ĕ) (8 Sē) and (2 ē, 2 ĕ)(8 Sĕ). Since the comparison of interest is the error rate for similar vs. different letters in the same condition, there is no possible confounding in the fact that it was necessary to draw the 8 Sē letters from a population of six and the 8 Sĕ letters from a population of four.

Four additional conditions plus condition (4 ĕ) (8 D) were devoted to determining whether identical or different interpolated letters produce greater RI. The OL consisted of ĕ letters in all of these conditions, and the IL consisted of different proportions of identical (ĕ) and similar (ĕ) letters: (4 ĕ) (8 I), (4 ĕ) (6 I, 2 D), (4 ĕ) (4 I, 4 D), (4 ĕ) (2 I, 6 D), and (4 ĕ) (8 D). Letters were used twice in non-adjacent positions when it was necessary to fulfill the specifications as to proportions of I and S letters. All three paired comparisons of the conditions (4 ĕ) (4 I, 4 D), (4 ĕ) (2 I, 6 D), and (4 ĕ) (8 D) are unconfounded by differences in repetition structure and provide another check on the assumption that small differences in the repetition structure of the IL are of no significance in this experiment.

Four additional conditions plus condition (4 ē) (8 S) were used to determine whether identical or similar interpolated letters produce more RI. Since the relationship between identical and similar letters is, in principle, derivable from the relationships between similar and different letters and between identical and different letters, this comparison provides a check on the reliability of the other comparisons. To make this check more stringent, the OL for these conditions consisted of 4 ē letters and the IL consisted of different proportions of identical (ē) and similar (ē) letters: (4 ē) (8 I), (4 ē) (6 I, 2 S), (4 ē) (4 I, 4 S), (4 ē) (2 I, 6 S), and (4 ē) (8 S). Again, letters were used twice in non-adjacent positions when it was necessary to fulfill the specifications as to proportions of I and S letters. The comparisons of (4 ē) (8 I) with (4 ē) (8 S) and of (4 ē) (6 I, 2 S) with (4 ē) (2 I, 6 S) are unconfounded by differences in repetition structure and provide yet another check on the assumption that small differences in the repetition structure of the IL are of no significance in this experiment.

There were nine replications of each of the 15 different conditions, making 135 lists of 4 and 8 letters given to each *S* in a 45-min session. The lists were randomly ordered in nine blocks of 15; each block containing one list from each condition.

Subjects. The *S*s were 28 M.I.T. undergraduates taking courses in psychology. Participation in experiments was part of their course requirements.

RESULTS

Copying 8 letters presented at the rate of 2 letters per second was a task of intermediate difficulty for these *S*s. In the first set, 57% of all the interfering lists were copied with no mistakes; by the ninth set, the figure was 67%, indicating a small practice effect. Explanation of why *S*s make errors in copying is beyond the scope of this study. However, it is perfectly clear that *S*s differ in how fast they can copy letters, and if one is to use one rate of presentation for all Ss and prevent almost all rehearsal on the part of the "fast copiers," it is necessary to use a rate of presentation such that the "slow copiers" make errors. Perfect performance on the copying task would indicate not that all Ss were refraining from rehearsal, but that the task was so easy that many Ss had time to rehearse in addition to copying. On the other hand, an IL task that was impossibly difficult might induce Ss to give up on the IL and rehearse the OL. Analysis of variance of the number of interpolated lists correctly copied for each S for each condition showed that differences among conditions were insignificant in every case. Therefore, the following analysis is confined to differences between the conditions in recall of the original 4-letter list.

Each S's data for each condition was analyzed for ordered recall, item recall, and position recall for items (letters). An S's report of an item is correct by an ordered-recall criterion if and only if the correct item is recalled in the correct position. An S's report of an item is correct by an item-recall criterion if and only if it appears anywhere in his report of the list in question. The ordered- and item-recall error rates for a condition for an S are the ratio of the ordered- or item-recall errors, respectively, to the total number of opportunities for error ($4 \times 9 = 36$). Position recall, independent of item recall, is obtained by subtracting the item-recall errors from the ordered-recall errors, reducing the total number of possible errors by the number of item-recall errors when computing the error rate for position recall. Item recall and position recall are statistically independent, and ordered recall reflects the combined operation of the recall of items and the recall of the correct position for items. Ordered recall is not statistically independent of item recall, and therefore is not as suitable for the assessment of the recall of order as is position recall. Position recall is statistically independent of item recall because only the items that are correct by an item-recall criterion are scored by the position-recall criterion. This experiment and other experiments (e.g., Wickelgren, 1964; Wickelgren, 1965) demonstrate that item recall and position recall may be affected in either the same or different ways by an independent variable, justifying the separate computation of item- and position-recall error rates. Ordered-recall error rates are also reported because they are familiar and because they provide an overall measure of memory.

When any two conditions are compared by any of the three measures of recall, the error rate in each condition for each S is computed, and one is subtracted from the other to give a difference score favoring one condition or the other. Superiority of one condition over the other is determined by applying the Wilcoxon Matched-Pairs Signed-Ranks test to the 28 difference scores. There are three substantive questions by which the comparisons of conditions in this experiment can be organized: (1) interference from similar vs. different items, (2) interference from identical vs. different items, (3) interference from identical vs. similar items.

Interference from Similar vs. Different Items. Table 1 presents the ordered-recall, item-recall, and position-recall error rates for the five conditions in the experiment that were designed to determine whether items from the same auditory confusion class (similar items) produce more RI than items from a different auditory confusion class (different items). Table 1 shows that similar items produce much more interference than different items. All nine comparisons are in the same direction, and seven of them are significant. The error rate is higher for (4 ē) (8 S) than for (4 ē) (8 D) in ordered recall ($p < .05$), item recall ($p < .01$), and position recall (n.s.). The error rate is higher for (4 ĕ) (4 S, 4 D) than for (4 ĕ)(2 S, 6 D) in ordered recall ($p < .001$), item recall ($p < .01$), and position recall ($p < .05$). The error rate is higher for (4 ĕ) (2 S, 6 D) than for (4 ĕ) (8 D) in ordered recall ($p < .01$), item recall ($p < .001$), and position recall (n.s.). It is clear that the principal effect is in item recall, but there is also some effect on position recall.

In order to determine more precisely the nature of the RI produced by similar vs. different items, consider the frequency of extralist intrusions from the ē confusion class, extralist intrusions from the ĕ confusion class, omissions, and intralist instrusions (repetition of an item in the OL) as reported in Table 2. Since the principal difference in the RI of similar vs. different items is in the recall of

TABLE 1
INTERFERENCE FROM SIMILAR VS. DIFFERENT ITEMS

Condition	Error rate (%) Ordered recall	Item recall	Position recall
(4 ē) (8 S)	55.7	43.0	22.3
(4 ē) (8 D)	47.0	32.8	21.1
(4 ĕ) (4 S, 4 D)	50.2	27.9	30.9
(4 ĕ) (2 S, 6 D)	39.5	22.7	21.7
(4 ĕ) (8 D)	31.6	13.8	20.7

items, not the recall of position, this analysis of error types uses *item recall* scoring. This accounts for the low frequency of intralist intrusion errors; misplacement of a correct item does not count as an intralist intrusion error unless that item was recalled in more than one position. Extralist intrusions of letters other than those used in the experiment (namely, A, E, H, I, J, K, O, Q, R, U, W, and Y) were very rare (error rate less than 0.05%). No relevant comparison of conditions shows significant differences in omissions, intralist intrusions, or extralist intrusions of letters not used in the experiment. It is clear from Table 2 that the major interfering effect of similar items is to increase the frequency of extralist intrusion errors that are *similar* to the items presented in the original list. Extralist ē intrusions are more frequent in (4 ē) (8 S) than in (4 ē) (8 D) ($p < .001$); extralist ĕ intrusions are more frequent in (4 ĕ) (4 S, 4 D) than in (4 ĕ) (2 S, 6 D) ($p < .05$); and extralist ĕ intrusions are more frequent in (4 ĕ) (2 S, 6 D) than in (4 ĕ) (8 D) ($p < .001$). The frequency of extralist intrusion errors that are *different* from the items presented in the original list does not vary in a consistent manner. It is definitely *not* correct to say that the extralist intrusion errors tend to be the items presented in the interfering list. In *all* conditions the extralist intrusion errors tend to be from the same auditory confusion class as the items presented in the original list, but the magnitude of the interference from similar items increases when similar items are used in the interfering list.

Table 3 presents the ordered-recall, item-recall, and position-recall error rates for the two conditions designed to answer a question closely related to the question answered in Table 1. The question is whether an interfering list composed of items from one auditory confusion class will interfere more with similar items than with different items in the original list, when the original list is composed of two items from each confusion class. Table 3 also reports some differences in ordered recall, item recall, and position recall for letters from the ē and ĕ confusion classes. The two lines of *totals* are averages over both conditions that show differences in

TABLE 2
TYPES OF ITEM RECALL ERRORS

Condition	Error rate (%) Extralist intrusions ē	ĕ	Omissions	Intralist intrusions	Total item recall
(4 ē) (8 S)	26.3	7.5	8.1	1.1	43.0
(4 ē) (8 D)	13.7	11.0	7.0	1.1	32.8
(4 ĕ) (4 S, 4 D)	7.4	15.6	4.5	0.4	27.9
(4 ĕ) (2 S, 6 D)	4.8	13.5	3.8	0.6	22.7
(4 ĕ) (8 D)	3.3	7.4	2.5	0.6	13.8

TABLE 3
INTERFERENCE WITH SIMILAR VS. DIFFERENT ITEMS

	Error rate (%)					
	Ordered recall		Item recall		Position recall	
Condition	Similar items	Different items	Similar items	Different items	Similar items	Different items
(2 ē,2 ĕ) (8 Sē)	50.0	33.9	44.8	23.0	9.4	14.2
(2 ē,2 ĕ) (8 Sĕ)	52.0	47.6	39.1	37.9	21.2	15.7
Total	51.0	40.8	42.0	30.5	15.6	14.8
	ē	ĕ	ē	ĕ	ē	ĕ
Total	48.8	43.0	41.4	31.1	12.7	17.3

recall of similar vs. different items or differences in recall of ē vs. ĕ items, that are independent of the other factor. The totals are obtained from the results for the two conditions by averaging the two percentages in the same column in the first case and diagonally in the second case. The average is weighted by the number of opportunities for error, which is equal for the two conditions in ordered recall and item recall, but not in position recall. The number of opportunities for a position-recall error depends on the number of items recalled correctly by an item-recall criterion, which is unequal for the two conditions.

It is clear that items from the same confusion class as the interfering items are interfered with more than items from the other confusion class, when the original list is composed of items from *both* confusion classes. The effect is primarily in item recall ($p <$ .001), with an insignificant effect in position recall. The difference in ordered recall is significant at the .001 level. This completely confirms the results of Table 1 for differences in interference with original lists composed of items from only *one* confusion class.

There are some differences between the two confusion classes. Apparently, it is easier to remember items from the ĕ confusion class than items from the ē confusion class ($p < .001$), but it is easier to remember the position of items from the ē confusion class than items from the ĕ confusion class ($p < .01$). Comparison of the first two conditions in Table 1 with the last three conditions in Table 1 supports the same conclusion regarding the differences between the two confusion classes, as does a comparison of Tables 4 and 5. Explanation of these differences is beyond the scope of this study.

Interference from Identical vs. Different Items. Table 4 presents the ordered-recall, item-recall, and position-recall error rates for the five conditions that were designed to investigate differences in the RI of identical vs. different items. The results for position recall are quite regular, identical items producing greater interference with the recall of position than different items. Subjects by conditions analysis of variance showed a significant effect due to conditions ($F = 6.94$, $df = 4/108$, $p < .01$). The position-recall error rate in (4 ĕ)(8 I) is significantly higher than the position recall error rate in any of the other four conditions ($p < .001$). The middle three conditions are not significantly different from each other, and the average of these three conditions is significantly greater than (4 ĕ)(8 D) ($p < .05$). Item recall appears to be better the greater the proportion of identical items to different items, but the effect is not very regular. Analysis of variance showed the effect of conditions was significant at the .01 level ($F = 8.60$, $df = 4/108$).

Interference from Identical vs. Similar Items. Table 5 presents the ordered-recall, item-recall, and position-recall error rates for

TABLE 4
INTERFERENCE FROM IDENTICAL VS. DIFFERENT ITEMS

Condition	Error rate (%) Ordered recall	Item recall	Position recall
(4 ĕ) (8 I)	44.2	11.2	37.2
(4 ĕ) (6 I, 2 D)	35.8	13.0	26.2
(4 ĕ) (4 I, 4 D)	41.6	19.3	27.5
(4 ĕ) (2 I, 6 D)	40.3	19.2	26.0
(4 ĕ) (8 D)	31.6	13.8	20.7

the five conditions that were designed to investigate differences in the RI of identical vs. similar items. The results for item recall are quite definite: identical items in the interfering list produce much better item recall than similar items in the interfering list. Analysis of variance showed the effect of conditions was significant at the .01 level ($F = 29.15$, $df = 4/108$). The item-recall error rates in (4 ē) (8 I) and (4 ē) (6 I, 2 S) are each significantly less than the item-recall error rates in each of the other three conditions ($p < .001$), and the item-recall error rates in (4 ē) (4 I, 4 S) and (4 ē) (2 I, 6 S) are each significantly less than the item-recall error rate in (4 ē) (8 S) ($p < .01$). Position recall appears to be worse the greater the proportion of identical items to similar items in the interference list, but the effect is not very regular. Analysis of variance showed the effect of conditions was significant at the .01 level ($F = 13.21$, $df = 4/108$).

The paired comparisons of identical, similar and different interference items are consistent with each other. Both identical and similar items produce more RI in position recall than do different items, but the difference appears to be greater between identical items and different items than between similar items and different items. Accordingly, the comparison between identical and similar items with respect to RI in position recall shows only a slight difference in the direction of greater RI from identical items. In item recall similar items produce more RI than either different or identical items, the greater difference being between similar and identical items. Accordingly, the comparison between identical and different items shows that identical items produce less RI than different items in item recall, but the difference is slight and irregular. The comparison of identical and different items in item recall is also the only comparison in which the unconfounded comparisons gave different results from the confounded comparisons. In all of the other comparisons, including all those that showed large, definite differences, the confounded and unconfounded comparisons gave the same results, indicating that the confounding was not serious.

TABLE 5
INTERFERENCE FROM IDENTICAL VS. SIMILAR ITEMS

Condition	Error rate (%) Ordered recall	Item recall	Position recall
(4 ē) (8 I)	50.7	22.3	36.5
(4 ē) (6 I, 2 S)	35.6	20.0	19.0
(4 ē) (4 I, 4 S)	47.9	31.5	23.9
(4 ē) (2 I, 6 S)	53.7	33.1	30.7
(4 ē) (8 S)	55.7	43.0	22.3

Discussion

The findings of this investigation of RI in STM as a function of similarity are completely consistent with the analogous findings in LTM. In STM, RI clearly does vary as a function of the nature of the intervening material and cannot be explained solely by interruption of rehearsal. These findings make the assumption more plausible that STM and LTM are performed by the same system (or possibly different systems operating on the same principles), but this assumption requires much more testing in many different experiments before a definite conclusion can be reached. For example, visual similarity (Gibson, 1941) and semantic similarity (McGeoch and McDonald, 1931) are important determinants of interference in LTM. One suspects that these dimensions of similarity will turn out to be less important determinants of interference in STM, but this has never been investigated and reported. Such a difference from LTM, if obtained, might suggest that STM is a *subsystem* of LTM, the auditory subsystem. There are many complex theoretical possibilities intermediate between the simple extremes that STM is performed by the same system as LTM or a different system from LTM, and it is far too early to do more than speculate on this question.

Therefore, consider what these findings on RI as a function of similarity indicate about the nature of STM, irrespective of the relationship between STM and LTM. Conrad's (1962) finding that intrusion errors tend to be from the same auditory confusion class as the original items strongly suggests that partial forgetting of an item is possible in STM and that perceptually similar items are coded in a similar way in STM. Conrad's results do not distinguish between the following two ways in which an item might be coded in STM:

Pattern-of-firing theory of coding: The representative of an item in STM is a pattern-of-firing in any of several large sets of neurons. Call each set of neurons a cell in STM. There are several cells in STM, each capable of storing any one item (letter, number, word, etc.) by a different firing pattern for every different item that can be represented. Perceptually similar items are represented by similar firing patterns.

Specific-neuron theory of coding: The representative of an item in STM in an *increase* in firing of a specific, relatively small, set of neurons. There are as many different sets of neurons in STM as there are items that can be represented. Perceptually similar items are represented by *overlapping* sets of neurons.

The pattern-of-firing code economizes on the number of neurons by using a more complicated code. The specific-neuron code is wasteful of neurons, but uses a very simple code, namely, "Which neurons were fired above their spontaneous firing rate?" Each of these two theories of coding in STM can account equally well for Conrad's results, but only the specific-neuron theory *explains* the results obtained in the present study.

In a specific-neuron theory the basis for greater interference from similar items is clear and simple; the similar items must activate *some,* but not all, of the same neurons that were activated by the items in the original list. This establishes new interfering associations to some of the neurons representing an item in the original list. Different items leave the original associations relatively undisturbed.

By the same reasoning, identical items should activate identical internal representatives. Therefore, having items in the interfering list that are identical to items in the original list ought to facilitate the recall of items, but interfere with the recall of order, since one is essentially rehearsing the same items in a different order. Although the results were less regular than one would have desired, this was the general result obtained in the present experiment.

It seems very difficult to account for the findings of the present experiment in terms of the pattern-of-firing theory of STM in which identical items or similar items can be encoded in two different (nonoverlapping) cells in memory, simply on the basis of the pattern-of-firing of the neurons composing the memory cell. Computer models of STM tend to be of this latter type: a number of cells are set aside as buffer storage, and any item can be encoded into any cell, thus permitting identical or similar items to be stored in different cells. If human STM were this type of system, there would be no explanation of RI being a function of acoustic similarity.

Summary

Short-term memory for a list of four letters, followed by a list of eight letters that the *S*s copied as they were presented, followed by immediate recall of the original four-letter list, was shown to be a function of the acoustic similarity of the intervening list to the original list. An interfering list whose letters have similar pronunciation to the letters in the original list produces greater RI than an interfering list whose letters have a very different pronunciation from the letters in the original list. An interfering list composed of items identical to items in the original list, but in a different order, tends to produce less RI in the recall of items and more RI in the recall of the correct position of these items than an interfering list composed of similar items. These findings for STM are completely consistent with analogous studies of RI as a function of similarity in LTM.

References

Broadbent, D. E. Flow of information within the organism. *J. verb. Learn. verb. Behav.*, 1963, **2**, 34-39.

Brown, J. Some tests of the decay theory of immediate memory. *Quart. J. exp. Psychol.*, 1958, **10**, 12-21.

Bugelski, B. R., and Cadwallader, T. C. A reappraisal of the transfer and retroaction surface. *J. exp. Psychol.*, 1956, **52**, 360-366.

Conrad, R. An association between memory errors and errors due to acoustic masking of speech. *Nature*, 1962, **193**, 1314-1315.

Conrad, R. Acoustic confusions in immediate memory. *Brit. J. Psychol.*, 1964, **55**, 75-84.

Gibson, E. J. Retroactive inhibition as a function of the degree of generalization between the tasks. *J. exp. Psychol.*, 1941, **28**, 93-115.

Gladis, M., and Braun, H. W. Age differences and retroaction as a function of intertask response similarity. *J. exp. Psychol.*, 1958, **55**, 25-30.

Hellyer, S. Frequency of stimulus presentation and short-term decrement in recall. *J. exp. Psychol.*, 1962, **64**, 650.

McGeoch, J. A., and McDonald, W. T. Meaningful relation and retroactive inhibition. *Amer. J. Psychol.*, 1931, **43**, 579-588.

Murdock, B. B. The retention of individual items. *J. exp. Psychol.*, 1961, **62**, 618-625.

Osgood, C. E. Meaningful similarity and interference in learning. *J. exp. Psychol.*, 1946, **36**, 277-301.

Osgood, C. E. An investigation into the causes of retroactive inhibition. *J. exp. Psychol.*, 1948, **38**, 132-154.

Osgood, C. E. The similarity paradox in human learning: a resolution. *Psychol. Rev.*, 1949, **56**, 132-143.

Osgood, C. E. *Method and theory in experimental psychology*. New York: Oxford Univer. Press, 1953. Pp. 530–533.

Peterson, L. R., and Peterson, M. J. Short-term retention of individual verbal items. *J. exp. Psychol.*, 1959, **58**, 193-198.

Wickelgren, W. A. Size of rehearsal group and short-term memory. *J. exp. Psychol.*, 1964, **68**, 413-419.

Wickelgren, W. A. Short-term memory for repeated and nonrepeated items. *Quart. J. exp. Psychol.*, 1965, in press.

Young, R. K. Retroactive and proactive effects under varying conditions of response similarity. *J. exp. Psychol.*, 1955, **50**, 113-119.

(Received February 10, 1964)