RICE UNIVERSITY

THE PERSISTENCE OF ECHOIC MEMORY: EVIDENCE FROM THE EFFECT OF PRESENTATION MODALITY IN IMMEDIATE AND FINAL RECALL TASKS

by

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

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May, 1984

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Abstract

The effect of presentation modality on recall was studied in two experiments. In the first, lists of alternating auditory and visual words were presented at a 15-second rate, with a visual distractor task interpolated between each word. Recall was asked for immediately after each list, and again after all lists had been presented. A large modality effect (auditory advantage) was obtained in immediate recall but no difference between modalities was found in final recall. In the second experiment, this modality effect was attenuated with the use of phonologically similar words, and the effect was replicated with a fast presentation rate. An echoic memory interpretation of the modality effect is offered, in which it is suggested that echoic memory persists until the time of recall to be used directly and not via a long-term modality independent memory system.
I would like to thank my wife Annette for her help during the long year that this project was undertaken. Also, I must thank Michael J. Watkins and Olga C. Watkins, whose contributions ranged from the initial stages in conceiving the experiments to the final re-writing of this thesis.
The Persistence of Echoic Memory: Evidence from the Effect
Of Presentation Modality in Immediate and Final Recall Tasks

Among the myriad questions that we can ask about memory, those regarding verbal memory, or language, would seem to be of fundamental importance. One of the most basic issues in the study of verbal memory concerns our ability to remember spoken versus written information. Stated simply: Does modality of perception influence our ability to remember verbal information?

During the last one hundred years, a considerable research effort has been devoted to the study of human memory, and not surprisingly, some of this work has been relevant to our question. In particular, it has been found that level of recall for spoken words is often greater than that for written words, but only for very short time spans. This finding, now commonly known as "the modality effect," is in fact regarded as one of the most robust effects found in the experimental study of memory (see Penney, 1975).

The modality effect, however, has not always been important in theories of memory; in fact, prior to the 1960's, many theorists held that modality of perception was unimportant to remembering (see Tulving & Madigan, 1970, pp. 457-460). The reason is that earlier generations of researchers were primarily concerned with "permanent" learning (or long-term memory), and did not distinguish between very short-term effects of presentation modality and longer term effects (e.g., see McGeoch, 1942, pp. 168-170). Thus, since no effect of modality of
perception was found in studies of long-term remembering, early findings of the modality effect (e.g. Henmon, 1912) were viewed with some skepticism or perhaps as unimportant.

It was during the 1960's that short-term memory finally became an accepted topic of interest in its own right, and soon afterwards the generality of the modality effect was firmly established. During this period, an advantage of auditory over visual presentation was demonstrated in short term paired-associate tasks (Murdock, 1966, 1967), the Brown-Peterson distractor paradigm (Cooley & McNulty, 1967), free recall of word lists (Murdock & Walker, 1969), and serial recall of word lists (Conrad & Hull, 1968). In short, the modality effect was demonstrated in every major paradigm used in the study of short-term memory.

Recent interest in the modality effect was sparked by a theory proposed by Crowder and Morton (1969). This theory related the modality effect to the suffix effect. In the serial recall task, where subjects attempt to recall the items of a list in their order of presentation, there occurs a modality effect that is largely limited to the last few presented items; however, if an auditory item such as the word "recall" is appended to the end of each auditory list, the enhanced recency is greatly attenuated and recall resembles that which is found with visual lists. This phenomenon is known as the suffix effect.

Although the suffix effect had been demonstrated earlier (Crowder, 1967; Dallett, 1965), Crowder and Morton (1969) were the first to
suggest that the effect does not occur with visual presentation — that
the effect is an auditory memory phenomenon. They proposed that the
modality and suffix effects could be accounted for in terms of a
preliminary stage of memory, which they labeled pre-categorical
acoustic storage (PAS) — also known as "echoic memory" or "sensory
memory for speech." According to their theory, all incoming speech
information is held veridically in PAS until (a) it is displaced by
subsequent audition or (b) it decays with the passage of time. In
modality effect studies, PAS might contribute to recall of
last-presented auditory items by providing extra "read-out" time. An
auditory suffix would automatically displace auditory list items from
PAS and so attenuate the advantage of the auditory mode of list
presentation.

The early 1970's saw much work on echoic memory, and particularly
on the suffix effect. Indeed, the suffix effect was used as a tool for
determining the properties of echoic memory, and several findings
consistent with the PAS notion resulted from suffix effect research.
This research indicated that an auditory suffix lost its effect if
delayed longer than 2 seconds after list presentation (Crowder, 1971a;
Routh & Mayes, 1974). The meaning of suffix items was found to be
unimportant to the effect (Crowder, 1972), whereas physical qualities
such as the direction from which the list and suffix items were heard
were found to be important (Morton, Crowder, & Prussin, 1971,
Experiments 7-12). These findings were viewed as supportive of the
notion that echoic memory is short-lived and precategorical.
Of course, the contention that these suffix effect findings should somehow bear on our understanding of the modality effect depends upon the validity of conceptualizing the suffix and modality effects in terms of the same memory stage or mechanism. Evidence that these effects are in fact related came from studies of the effect of phonological similarity on the suffix and modality effects. Using a serial recall procedure, Crowder (1971b) found that when list items differed only in their stop consonant sounds, neither a modality effect nor a suffix effect occurred. On the other hand, when list items differed only by vowel sounds, both effects occurred. Darwin and Baddeley (1974) confirmed these findings, and Watkins, Watkins, and Crowder (1974) demonstrated that phonological similarity also attenuated the modality effect found in the free recall paradigm. These findings provide evidence that the suffix and modality effects are in some sense related, and that the remembering of acoustic properties of memory stimuli is somehow important to both effects.

So, by the mid-1970's, the idea of a short-lived acoustic memory store was widely accepted by memory theorists. This development was perhaps not surprising because, in addition to the accumulating supportive evidence, the concept of echoic memory fitted neatly into the information processing approach to the study of memory which had by that time become dominant. Echoic memory was described as a stage of processing, preliminary to memory proper; and to a certain degree, this concept strengthened the viability of the information processing approach as a universal model of human memory. Echoic memory provided
some account of how speech might be perceived (Darwin, Turvey, & Crowder, 1974). It provided an auditory analog to the visual sensory memory store (Sperling, 1960) and could be integrated into a coherent theory of sensory memory (see Crowder, 1976). And most importantly, it derived support from the modality effect, a robust finding that could not be well accounted for solely in terms of the hypothesized "central" structures in the human information processing system.

The Duration of Echoic Memory

Crowder and Morton's PAS theory can still be regarded as prototypical of the conventional notion of echoic memory (see, e.g., Baddeley, 1976; Seamon, 1980). The essential concept is that vocal information automatically perseverates in PAS for some very brief period of time. How does this account for the modality effect? One answer is that although sensory memory for speech may persist for only about two seconds, this is a relatively long period of time when compared to sensory memory for vision (or iconic memory), which is estimated to persist for only 200-300 milliseconds under normal conditions of laboratory illumination (Sperling, 1960). It is argued that, in studies of verbal learning, the relatively longer duration of echoic memory serves to enhance level of recall for auditory recency items by in some way facilitating their registration into some more central, nonsensory memory store (Crowder, 1972; Morton, 1970; Routh, 1976). Thus, while echoic memory might not survive from the time of list presentation to the time of recall in typical verbal learning
experiments, it may nonetheless exert a significant influence on level of performance.

This emphasis on the brevity of echoic memory in explaining the origin of the modality effect can be partly attributed to delayed suffix studies performed in the early 1970's. As already mentioned, researchers found that the standard suffix effect failed to occur when the suffix was delayed for more than 2 seconds after list presentation (Crowder, 1971a; Routh & Mayes, 1974), and this was taken as an indication of the duration of echoic memory. Although some researchers acknowledged that the failure to find a suffix effect could logically be accounted for in terms other than the decay of echoic information (e.g., see Crowder, 1976, p. 58), the decay interpretation was nonetheless viewed as a tenable explanation.

Recent studies, however, have shown that the suffix effect is not confined to conditions of very short delays between list and suffix presentation. Watkins and Todres (1980) performed a series of delayed suffix experiments in which the interval between presentation of the last list item and the suffix item was either left unfilled or else filled with a distractor task. Without distraction, level of recall for the last few items in a standard "suffix" condition increased as a function of the time delay between list and suffix presentation, such that no suffix effect occurred with longer delays. However, with distraction, a standard suffix effect resulted even when the delay period lasted for fully 20 seconds (see also Watkins & Watkins, 1980). Thus, it appears that previous failures to find the suffix effect with
delayed suffixes can be attributed to earlier researchers' use of tasks which permitted the build-up of suffix resistant, non-echoic memory. When precautions are taken to preclude such build-up, as by using a distractor task, the delayed suffix procedure yields evidence that echoic memory may persist for far longer than previously thought.

Another reason for emphasis on the brevity of echoic memory in explaining the modality effect concerns basic time parameters of the modality effect. During the 1970's, the vast majority of demonstrations of the modality effect occurred with list learning procedures in which list items were presented at rates such as 1 or 2 items per second, with the recall period immediately following the last presented item of each list. The standard finding from this procedure was that a modality effect occurred for the last few presented list items with serial recall and the last several presented list items with free recall. Thus, for the most part the modality effect was found only for very brief presentation-to-recall time spans.

Similar to the described pattern of suffix effect findings, recent studies have shown that the modality effect is not confined to such short time spans. For example, using a slight modification of the standard free recall paradigm, Gardiner and Gregg (1979) found a modality effect which survived presentation-to-recall spans of just over 30 seconds. They used a "through-list distractor procedure" in which items were presented at rates such as one item every 12-20 seconds, with a distractor task designed to prevent rehearsal during the time lags between presentation of items. And more recently, the
longest duration of all for a modality effect has been reported by Engle and Roberts (1982). Using a free recall procedure, they presented items at a more typical rate, one every 1.2 seconds, but delayed the recall period for up to 60 seconds after list presentation. A modality effect was found for the last three serial positions.

Furthermore, there is some evidence of a suffix effect in this delayed free recall procedure. Several recent studies have shown that when the delay period before free recall is filled with auditory as opposed to visual distraction, the modality effect is attenuated or removed (Broadbent, Vines, & Broadbent, 1978; Engle et al. 1982; Watkins & Watkins, 1980) Gathercole, Gregg, and Gardiner (1983) showed that such auditory suffixing occurs even when the auditory distraction begins 15 seconds after the start of the delay period. This indicates that the echoic information may persist for at least 15 seconds in the delayed free recall paradigm.

There is also some evidence of the expected influence of auditory suffixing with the through-list distractor procedure, but the evidence is perhaps more ambiguous. Gardiner and Gregg (1979) found that although the size of the modality effect was reduced when the distraction between list items involved spoken information, a reliable though small modality effect still occurred. Gardiner and Gregg (1979) suggested that this latter finding is inconsistent with any "echoic" explanation of the modality effect in their slow presentation rate procedure. However, more recently, Gregg and Gardiner (in press) have found that the modality effect that occurs with noisy distraction may
be different in some sense from the one that occurs in silence. They found that when silent distraction is used in the through-list distractor procedure, list items differing only in stop consonants fail to show a modality effect just as in the brisk presentation rate procedure (Watkins, Watkins, & Crowder, 1974); but when sound accompanied the distraction between items, phonological similarity did not influence the modality effect.

So, to summarize, it appears that in some sense we now know more about the modality and suffix effects than was known by researchers when the conventional view of echoic memory was developed. Contrary to what was assumed by researchers in the mid-1970's, the upper limits of the time spans of the modality and suffix effects are yet to be determined. We do know that the modality effect found in the list learning paradigm can endure for presentation-to-recall spans of at least 60 seconds, and we know that the suffix effect can occur for list presentation-to-suffix presentation spans of at least 20 seconds. It is now unclear whether the conventional conception of echoic memory provides an adequate account of these effects. While the conventional view suggests that the modality effect originates from a short-lived echoic memory that does not survive from presentation to recall in typical list learning experiments, recent findings of persistent modality effects and delayed suffix effects suggest that echoic memory might indeed survive from presentation to recall. That is, the time span of echoic memory could be conceived as consonant with
The present study sought to further investigate whether the modality effect found with slow presentation might be best conceived as the result of echoic memory facilitating the registration of information into a more permanent memory system or from echoic memory persisting until recall and thus influencing recall directly. A through-list distractor procedure was used, with recall tests occurring after two retention intervals: one test was given directly following the presentation of each memory list, and the other at the end of the session. If the modality effect occurs in both tests, this would suggest that it results from some relatively long-lasting, non-echoic form of memory. If the effect occurs in the immediate test but not in the final test, then this would suggest that the modality effect results from the direct use of echoic memory at the time of recall.

The primary purpose of the first experiment was to address this issue. In the second experiment, the variable of phonological similarity was introduced in order to provide a test of the functional similarity between the modality effect found with the procedures used in this study and that found with more conventional procedures.

**Experiment 1**

In Experiment 1, the through-list distractor paradigm was extended to a procedure in which auditorily and visually presented words were alternated within each memory list. Murdock and Walker (1969) showed that with brisk presentation rates this "mixed-mode" procedure yields a
modality effect of greater magnitude than that produced by the more conventional method of varying presentation modality between lists. Thus, since an enhanced modality effect might also occur with slow presentation rates, the mixed-mode procedure was used. The persistence of any such modality effect was tested for both short-term and long-term remembering — with short-term remembering being operationalized in terms of recall following the presentation of each list, and long-term remembering being operationalized as recall following the presentation of all the lists.

Method

Subjects. Subjects were 20 Rice University students participating for course credit or pay. They were tested in groups of up to five.

Design. Eleven 10-word lists were constructed. All words were common and of two-syllables (e.g., Steady, Final, Against, Useful, Indeed). Each subject received all 11 lists of words. The first list was for practice and was not scored. For the remaining 10 lists, both lists and words within lists were presented in one order for half of the subjects and in the reverse order for the other half.

Presentation modality for the words within each list was alternated word-by-word, so that for any given list presentation the words in odd-numbered serial positions occurred in one modality and those in even-numbered serial positions occurred in the other. The modality of words presented at odd-numbered and even-numbered serial positions was alternated list-by-list, so that for any given subject the first word
of each odd-numbered list was presented in one modality and the first word of each even-numbered list was presented in the other. The modality of words was balanced across subjects for each of the two list orderings, so that each word occurred equally often auditorily and visually.

Procedure. Words were presented at the rate of one every 15 seconds. The visual words appeared on a screen by means of a Kodak carousel slide projector, for 2.5 seconds. Auditory words were spoken by the experimenter and were accompanied by the presentation of a blank slide for 2.5 seconds. Following each word, whether visual or auditory, a distractor slide was presented for 12.5 seconds. Each distractor slide showed a column of five mixed addition and subtraction problems, involving pairs of two-digit numbers (e.g., 97 − 14 = , 88 + 26 = ).

The slide projector was placed 1.5 meters from the screen producing a projection area of about 50 cm. square. The size of an individual word letter or distraction digit was about 4 by 5 cm. Subjects sat 2 to 4 meters from the screen, and the experimenter sat just behind the subjects.

Subjects were told that they would be computing math problems while performing a memory task. They were first shown some sample math problems, and then the memory task was explained, and a practice list given. Subjects were told to attend to each presented word only at the time of its presentation and to correctly answer as many math problems as possible during the presentation of each math slide. Immediately
following the last math slide of each list, the beginning of the recall period was signaled by a row of asterisks. Subjects were allowed 60 seconds to write down as many of the words as they could, without regard to order. They wrote their answers for both the math problems and the recall task in prepared booklets.

After all the lists had been presented and tested in this way, the experimenter collected the answer booklets and briefly chatted with the subjects, thanking them for their cooperation. He then announced a surprise final recall test. Blank sheets of paper were passed out, and the subjects were asked to recall as many words as possible from all of the presented lists. They were allowed five minutes for this test.

Results

Consider first the results of the immediate recall test. A modality effect was found, and it appeared to be larger than that typically found with more frequently used procedures. Overall, 68.6% of the auditory words were recalled, compared with 36.0% of the visual words. Figure 1 shows level of recall with respect to presentation modality and serial position. Although the words of each modality occurred only at either the odd or even serial positions for any given list presentation, for the sake of completeness, recall performance is presented as a function of modality at all ten serial positions. The modality effect occurred over all serial positions but was most pronounced over the recency positions.

It should be noted that since the auditory advantage extended back to the first presented word in a list, it persisted for a
Figure 1. Serial position functions of auditorily and visually presented words when presentation rate is 1 word every 15 seconds and the test is immediate recall.

Figure 2. Serial position functions of auditorily and visually presented words when presentation rate is 1 word every 15 seconds and the test is final recall.
presentation-to-recall time span of 2.5 minutes, making it of longer duration than any modality effect reported in the research literature.

Of critical concern is whether non-echoic forms of memory are directly involved in this effect, and it was to address this issue that a final recall test was included. If, in fact, the modality effect resulted from the better registration of auditory words into a central, non-echoic memory system, we might expect at least some hint of a modality effect in final recall. However, as shown in Figure 2, no appreciable effect of presentation modality occurred. Overall, 12.9% of all auditory words were recalled, compared with 13.7% of all visual words.

Statistical analyses supported our observations that the modality effect occurred in immediate recall but not in final recall. In immediate recall, there was a significant difference between the mean number of auditory and visual words recalled (t(19)=10.90, p < .001), and this difference was statistically reliable at every serial position except the second (p < .05); but in final recall, there was no significant effect of Presentation Modality (t(19)=-0.52), and the interaction of Presentation Modality by Recall Task was significant (t(19)=12.13, p < .001).

Finally, it should be noted that, although the modality effect appeared across all serial positions in immediate recall, it was significantly larger for the second half of lists, t(19)=6.86, p < .001. In final recall, there was no significant interaction of Presentation Modality with List Half, t(19)=1.64, p > .10.
Experiment 2

In Experiment 1, the mixed-mode slow presentation procedure was shown to yield a modality effect of far longer duration than is found with more typical procedures. Furthermore it was shown that the effect does not survive to a final recall test. It is of some interest to pursue further the relation between the modality effect found in Experiment 1 and that found with more frequently used brisk presentation procedures. In particular, are these findings best conceived of as two qualitatively different modality effects or as manifestations of a single, general effect? The obvious way of addressing this question is to determine whether the effect obtained with slow presentation and the effect obtained with brisk presentation respond in the same way to other variables. One variable that has been previously shown to influence the modality effect with brisk presentation procedures is phonological similarity. Thus, in Experiment 2, phonological similarity was varied with both brisk and relatively slow presentation rates. For brisk presentation, we might expect phonological similarity to attenuate the advantage of auditory presentation (Watkins, Watkins, & Crowder, 1974). If a similar attenuation occurs with slow presentation, it would suggest that this modality effect is functionally similar to that found with brisk presentation.
Method

**Subjects.** Subjects were 64 Rice University students participating for course credit or pay. They were tested in groups of up to four.

**Lists.** Twenty-four sets of 12 rhyming words were used, along with a practice list. All words were common, monosyllabic words.

From these 24 sets, two 12 by 12 matrices of words were formed (see Appendix A). The words within a given row of each matrix all rhymed, whereas those within a given column did not. From these two matrices, four sets of word lists were formed, with each subject receiving one of the four sets. Each set consisted of six rhyming lists (rows) from one matrix and six non-rhyming lists (columns) from the other. One fourth of the subjects received the first six rows of matrix 1 and the first six columns of matrix 2, another fourth of the subjects received the first six rows of matrix 2 and the first six columns of matrix 1, and so on. Thus, each subject received only half of the words from the complete pool, and of course never received a word more than once. Across subjects, each word occurred equally often in the rhyme and non-rhyme conditions.

**Design and Procedure.** A 2 X (2 X 2) design was used, with the variables being presentation rate, presentation modality, and phonological similarity. Presentation rate was a between-subjects variable, and presentation modality and phonological similarity were within-subjects variables.
For any given subject, rhyming and non-rhyming lists were alternated, so that odd-numbered lists were always of one type and even numbered lists were of the other type. Also, two of the four sets of lists began with rhyming lists, and two began with non-rhyming lists.

For any given list, the words of either odd-numbered or even-numbered serial positions were presented auditorily, along with their visual presentation. Auditory presentation of words at odd-numbered and even-numbered serial positions was alternated after every two lists, so that for each subject, an equal number of auditory presentations occurred at each serial position for each type of list. Furthermore, the modality of specific words was counterbalanced across subjects for each of the four sets of lists at each presentation rate.

Words were presented at a 2.5-second rate for some subjects, and a 15-second rate for others. For both groups, each word was presented by a Kodak carousel slide projector for 2.5 seconds, with alternate words being spoken by the Experimenter. For the 15-second presentation rate group, a distractor slide was presented for 12.5 seconds following each word presentation. These distractor slides were exactly as in Experiment 1. The size of projections, the seating of subjects, the directions, and the general procedure were also as in Experiment 1. The duration of the experiment was about 30 minutes for subjects in the brisk presentation condition and 1 hour in the slow presentation condition.
Results

Consider first the results from the brisk presentation rate condition. A clear modality effect was found in immediate recall, with 65.1% of all auditory words being recalled compared with 53.1% of all visual words. A statistically reliable modality effect was found both for words within non-rhyming lists and for words within rhyming lists ($t(31)=7.03, p < .001; t(31)=4.98, p < .001$, respectively). As shown in Figures 3 and 4, the modality effect appeared greater for non-rhyming words than for rhyming words, and indeed this difference was statistically reliable, $t(31)=3.36, p < .01$. Thus, this experiment replicates an established finding — that is, with brisk presentation, the modality effect is attenuated when the list items are phonologically similar. As can be seen in Figures 5 and 6, no appreciable effect of presentation modality was found in final recall. Overall, 22.8% of auditory words were recalled, compared with 23.2% of visual words.

These findings for the brisk presentation condition were of course predicted based on previous research, and the more important issue for present purposes concerns the slow presentation rate condition. In particular, we were interested in whether phonological similarity would also influence the modality effect found with slow presentation.

As in Experiment 1, a clear modality effect was found in immediate recall with the mixed-mode, slow presentation procedure. Overall, 53.8% of the auditory words were correctly recalled, compared with 39.5% of the visual words. A statistically reliable modality effect
Figure 3. Serial position functions of auditorily and visually presented non-rhyming lists when presentation rate is brisk (1 word every 2.5 s) and the test is immediate recall.

Figure 4. Serial position functions of auditorily and visually presented rhyming lists when presentation rate is brisk (1 word every 2.5 s) and the test is immediate recall.
Figure 5. Serial position functions of auditorily and visually presented non-rhyming lists when presentation rate is brisk (1 word every 2.5 s) and the test is final recall.

Figure 6. Serial position functions of auditorily and visually presented rhyming lists when presentation rate is brisk (1 word every 2.5 s) and the test is final recall.
Figure 7. Serial position functions of auditorily and visually presented non-rhyming lists when presentation rate is slow (1 word every 15 s) and the test is immediate recall.

Figure 8. Serial position functions of auditorily and visually presented rhyming lists when presentation rate is slow (1 word every 15 s) and the test is immediate recall.
Figure 9. Serial position functions of auditorily and visually presented non-rhyming lists when presentation rate is slow (1 word every 15 s) and the test is final recall.

Figure 10. Serial position functions of auditorily and visually presented rhyming lists when presentation rate is slow (1 word every 15 s) and the test is final recall.
was found both for non-rhyming lists and for rhyming lists ($t(31)=12.42, p<.001; t(31)=6.13, p<.001$, respectively). As shown in Figures 7 and 8, the modality effect was greater for non-rhyming words than for rhyming words, and indeed this difference was statistically reliable $t(31)=3.26, p<.01$. Thus, this experiment showed that phonological similarity attenuates the modality effect found with slow presentation, just as it does with brisk presentation. As can be seen in Figures 9 and 10, no appreciable effect of presentation modality was found in final recall. Overall, 18.3% of auditory words were recalled, compared with 18.2% of visual words.

Two ANOVA's were performed: one on the immediate recall data and one on the final recall data. Each was a 2 X (2 X 2) ANOVA on the total number of words correctly recalled by each subject with respect to the variables of presentation rate, presentation modality, and phonological similarity.

In immediate recall, significant main effects were found for presentation rate ($F(1,62)=9.90, p<.005$), presentation modality ($F(1,62)=190.80, p<.001$), and phonological similarity ($F(1,62)=70.81, p<.001$). Level of recall was greater for briskly presented lists than for slowly presented lists, for auditorily presented words than for purely visual words, and for rhyming lists than for non-rhyming lists. The only other significant effects in immediate recall were the interactions between presentation modality and phonological similarity ($F(1,62)=21.30, p<.001$) and between
presentation rate and presentation modality \( (F(1,62)=4.56, p < .05) \). The former is an indication that the modality effect was greater for non-rhyming lists than for rhyming lists, and the latter is an indication that the modality effect appeared greater for slowly presented words than for briskly presented words. The interaction between presentation rate and phonological similarity was not significant \( (F(1,62)=0.37) \), and neither was the interaction between presentation rate and phonological similarity and presentation modality \( (F(1,62)=0.34) \). This latter F-test is important, because a significant effect would have indicated that the attenuation of the modality effect from phonological similarity might vary according to presentation rate.

Because the modality effect is often studied with respect to recency positions only, the results of the immediate recall ANOVA are presented in Appendix B with list half included as a fourth variable. This analysis revealed that there was a significant presentation modality by phonological similarity by list half interaction \( (F(1,62)=10.21, p < .005) \), indicating a greater attenuation of the modality effect by phonological similarity for the second half of lists than for the first half. The third order interaction was not significant, so there was no evidence that this second order interaction varied with presentation rate.

The ANOVA for final recall (see Appendix B) showed significance only for the main effect of phonological similarity \( (F(1,62)=35.54, p < .001) \). This effect reflects a higher level of recall for rhyming lists than for non-rhyming lists. The main effect of presentation rate
was not significant \((F(1,62)=2.27, p>.10)\), and neither was the main effect of presentation modality \((F(1,62)=0.08)\). No significant effects were found for the interactions of presentation rate by presentation modality \((F(1,62)=0.36)\); of presentation rate by phonological similarity \((F(1,62)=1.60, p>.20)\); of presentation modality by phonological similarity \((F(1,62)=1.36, p>.20)\); or of presentation rate by presentation modality by phonological similarity \((F(1,62)=0.49)\). Thus, presentation modality produced no significant effects or interactions in final recall, indicating that its effects in immediate recall were specific to short-term remembering.

**General Discussion**

The conventional explanation of the modality effect holds that spoken words are more likely to be recalled than written words by virtue of a very brief mental echo that follows auditory presentation and facilitates registration into a non-echoic form of memory. The suffix effect is attributed to an overwriting of this brief mental echo.

The present study can be viewed as part of an emerging body of research (including Broadbent, Vines, & Broadbent, 1978; Engle & Roberts, 1982; Gardiner & Gregg, 1980; Watkins & Watkins, 1980) indicating that the modality effect occurs over far longer durations than formerly assumed. Although the vast majority of previous modality effect studies have involved brisk presentation rates and undelayed recall, it has become apparent that the effect also occurs with
relatively slow presentation rates and with procedures involving a silent delay between presentation and recall.

As mentioned earlier, Watkins and Watkins (1980) have suggested that these recent findings of persistent modality effects, along with those of delayed suffix effects, are inconsistent with the conventional view of echoic memory as being of very brief duration. As an alternative explanation of the modality effect, they suggest that echoic memory might persist from presentation to recall and directly influence level of performance at the time of recall. This view holds that there is currently a lack of empirical evidence to suggest that some modality-independent form of memory is involved in the effect, and that it is parsimonious to conclude that echoic memory directly influences level of performance.

The present study provided a test of the conventional "indirect" explanation of the modality effect. Two recall tests were given: one directly after the presentation of each memory list, and the other at the end of the session. If auditory stimuli were indeed better registered into some central, modality-independent memory store, the auditory superiority might have been expected to occur in both tests of retention. On the other hand, if auditory stimuli were not better registered into a more permanent memory system, one would expect to find a modality effect only in the immediate test.

A large modality effect was found in the immediate test; it extended back to the first presented word of each list. This means that the effect was found for a presentation to recall time span of up
to 2.5 minutes, making it not only a "persistent modality effect" but of longer duration than any previously reported. Nevertheless, no modality effect was found in the recall test that followed presentation of all lists, and therefore we may conclude that the advantage of auditory presentation was eliminated by the presentation of subsequent memory lists and/or the passing of time. Thus, it seems that echoic memory directly influenced level of performance in the recall test that followed each list, and did not facilitate registration into non-echoic forms of memory.

The question arises as to whether or not these findings are relevant to interpretations of the modality effect found with the more frequently used procedures, in particular those that involve brisk presentation. Some researchers (e.g., Morton, Marcus, & Ottley, 1981) have suggested that modality effects found with even slight variations of procedures can occur because of different "mechanisms," owing to the complexity of the human information processor. Perhaps the most reasonable method for making a determination of whether the present modality effect is best conceived as qualitatively different from or as essentially the same as that found with brisk presentation is to establish whether it is influenced by the same variables that affect the modality effect with brisk presentation rates.

The variable of phonological similarity has been previously shown to attenuate the suffix effect and the modality effect with both serial recall and free recall procedures, at least with brisk presentation (Crowder, 1971b; Watkins, Watkins, & Crowder, 1974). So, in Experiment
phonological similarity was manipulated for both brisk and slow presentation rates. An attenuation of the modality effect was found with each rate of presentation, and there was no apparent difference in the degree of attenuation. Thus, we can conclude that acoustic properties of stimuli are somehow important to the modality effect for both presentation procedures and that a functional similarity between the modality effects obtained with brisk and slow presentation has been established.

A second variable that was tested in Experiment 2 was again that of delay of recall task. As in the first experiment, one test was given after each list presentation and a second following presentation of all lists. Once again, performance in the slow presentation condition was comparable to that in the brisk presentation condition. For each presentation rate, a sizeable modality effect was found in the immediate test and no modality effect was found in the final test.

Finally, the present study provides at least some evidence that the mixed-mode procedure yields a modality effect of greater magnitude than that produced by the more conventional pure-list method, with both brisk and slow presentation. The effects obtained in Experiments 1 and 2 appeared substantially larger than those obtained by Gregg and Gardiner (in press) who used a very similar procedure, but with pure-list presentation. Although no firm conclusions can be reached since this variable was not manipulated in a single study, we can at least speculate that our enhanced modality effect occurred because a mixed-mode procedure was used. It seems likely that mixed-mode
presentation of lists enhances the modality effect found with relatively slow presentation rates, just as it does with brisk presentation (Murdock & Walker, 1969).

In short, the present experiments indicate that variables that are important to the modality effect may be important regardless of whether brisk or slow presentation rates are used, at least when subjects are distracted from extensive rehearsal and when the distraction is silent. With both brisk and slow presentation rates, the modality effect is attenuated by phonological similarity, it fails to extend to a final recall task, and it is enhanced with the mixed-mode procedure.

It would be non-parsimonious at this point to construct two different explanations of the modality effect found with brisk presentation and the effect found with slow presentation or to construct still more explanations to account for the effect found with pure-list procedures and the effect found with mixed-mode procedures. The similarities between the effects obtained with these different procedures would seem to warrant a single coherent theory. Indeed, when we consider the consistency with which the modality effect is found across virtually every procedure used in studying short-term memory, it is perhaps not surprising that variables such as presentation rate can be of little consequence to the effect found with free recall.

The experiments reported here indicate that the modality effect might be best conceived as resulting from an echoic form of memory that persists throughout the presentation-to-recall interval. Such an
explanation allows us to conceive of various modality effect findings as resulting directly from the same underlying cause.
References


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