

THE MODALITY EFFECT: IS PRECATEGORICAL ACOUSTIC STORAGE RESPONSIBLE? ¹

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Auditory presentation typically gives better performance than visual presentation in short-term memory experiments. This modality effect is theorized to be due to a precategorical acoustic store (PAS). Two experiments were conducted using the suffix procedure with free or serial recall of words. The findings did not support the PAS interpretation of modality effects as it now stands. That is, the suffix did not eliminate the modality effect which it should have according to the PAS interpretation.

The question is a very old one. Does auditory presentation of materials to be learned or remembered result in better learning or memory than those materials presented visually, or vice versa? A corresponding question that has attracted considerable interest is whether some people have primarily auditory memories while others favor the visual modality. This paper is concerned primarily with the initial question. If uncertainty is aroused by the second question then the reader is referred to Jensen (1971) for a partial answer.

A great deal of evidence has been compiled recently that modality of presentation is a potent variable in short-term memory experiments. The usual finding is that retention in immediate memory is much better for auditorily presented materials than for those presented visually. There is also evidence that visual presentation with concomitant vocalization of the material leads to better performance than just visual presentation (Murray, 1966). The supremacy of auditory presentation, known as the modality effect, has been observed using paired-associates (Murdock, 1966) and free recall (Craik, 1969) as well as paradigms involving order information (Murdock, 1967). The modality effect is typically obtained with both recall and recognition type retention tests.

In single-trial free recall situations the auditory superiority is most prominent over the last four or five serial input positions, in other words, the recency items. The earlier list items seem to be affected very little by modality manipulations except that occasionally a slight facilitation is found for the visual group on the primacy items (Craik, 1969; Murdock, 1966).

Craik (1969) and Murdock and Walker (1969) have attempted to delineate the theoretical implications for modality effects in short-term memory. One explanation for the results is that the short-term store is primarily auditory or acoustic in nature and auditorily presented materials enter the STS directly but visually presented materials must be translated into the acoustic code. This notion would predict auditory supremacy for all serial input positions and not, as is typically found, just those at the terminal end of the input list. Therefore, this idea seems to be somewhat discounted.

Another explanation makes use of pre-perceptual or prelinguistic stores. This explanation takes two forms. Crowder and Morton (1969) and Crowder (1970) have proposed that there is a precategorical acoustic store (PAS) similar in nature to the visual icon (Neisser, 1967) except of a longer duration. They argue that PAS is capable of holding information sufficiently long to affect the immediate memory task (on the order of 2 sec.). Information is supposedly lost from PAS due to displacement by subsequent acoustic events and/or decay with the passage of time. Crowder

¹ The experiments were conducted as part of a senior seminar by Glen Camenish, Luke Houchins, Kathy Lane, Terri Macray, Will Kniseley, John Saavedra and Sandy Sharp.

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posits that presence of this prelinguistic information for auditory presentation is responsible for the modality effect. Crowder and Morton see no need for separate long-term and short-term memory stores. They feel that the concept of a PAS coupled with some form of articulatory coding makes the notion of a short-term store counter-productive.

The other attempt to explain the modality effect also relies on the notion of a PAS. Craik (1969) argues that the superiority of auditory presentation over the recency portion of serial position retention curves reflects the output from a post-linguistic or postcategorical short-term store which is itself indifferent with respect to input mode but which can, in some instances, be augmented by relatively unprocessed information still present in the visual and acoustic stores (icon and PAS). The modality effect is viewed as resulting from output from the short-term store being supplemented by the information in PAS for auditory presentation. Since the icon decays too quickly to be of benefit for visually presented items, the recency effect in single-trial immediate free recall is considered to be pure output from the short-term store.

As a phenomenon, the PAS has been studied almost exclusively by something called the suffix technique. The usual procedure, perfected by Crowder and his colleagues, is to present a sequence of items (typically digits) auditorily with a redundant nonrecalled suffix following the last item. This suffix is usually something like the word "zero" spoken at the end of each list. The serial recall data typically take the form of an increase in errors over the terminal (two-three) items in the suffix group as compared to a nonsuffix control group. Theoretically, the acoustic representation of the last few items in the list is still in the PAS at the time the suffix is presented and when the suffix enters the store it overwrites or interferes with the acoustic representation already there.

Since both major theoretic notions regarding modality effects rely on the PAS concept it seemed that the suffix procedure

might be a useful converging operation to tease out those factors involved in the interpretation of the modality phenomenon. The first experiment was set up to be a simple demonstration that the suffix procedure would eliminate the superiority of auditory presentation over the terminal items in single-trial immediate free recall. This did not prove to be the case and thus led to the second experiment.

EXPERIMENT I

In terms of the PAS explanation, a redundant nonrecalled word at the end of auditorily and visually presented lists should have differential effects. If the suffix eliminates the ancillary information usually available in PAS for auditory presentation then the auditory suffix group should become exactly like the visual suffix and nonsuffix groups over the terminal or recency items. In other words, the prediction of Craik (1969) and Crowder (1970) should be that the suffix would affect the visual groups little, if at all. The auditory nonsuffix group should exhibit the typical supremacy over the visual groups for the terminal items, while the auditory suffix group, as a consequence of having the extra PAS information removed, should be no different than the visual groups. This should yield a Modality $\times$ Suffix and a Modality $\times$ Suffix $\times$ Serial Position interaction effect.

Method

Materials. Twenty-four lists of 12 items each were composed from the Kucera and Francis (1967) norms. The lists were recorded for auditory presentation at a 1-sec. rate and typed on paper for visual presentation by memory drum (also at a 1-sec. rate). Each list was used in both suffix and nonsuffix conditions but never with the same *S*.

Design. Half of the *Ss* received the lists via auditory presentation and half by the visual mode. The visual and auditory groups were further subdivided into within-subjects suffix and nonsuffix conditions. In the suffix condition the lists ended with the word "zero." The "zero" was not to be recalled and *S* was told to either use it as a cue to recall or ignore it altogether if he so desired. The nonsuffix lists, of course, consisted of just the 12 words without the suffix. The *Ss* served in the suffix and nonsuffix conditions in separate half-hour

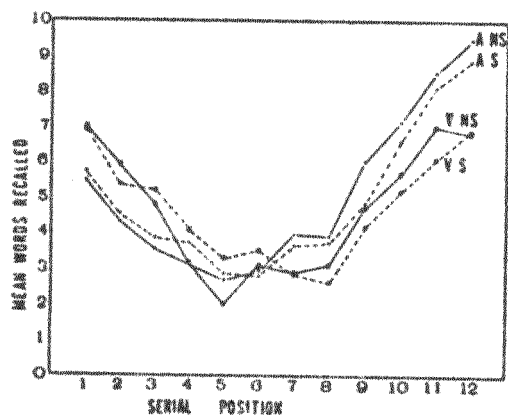


FIGURE 1. Mean free recall as a function of serial position, modality (auditory—A, or visual—V) and presence (S) or absence (NS) of a suffix.

sessions (12 lists per session) separated by 24 hr. The order of the suffix and nonsuffix sessions and set of lists in the two sessions were counterbalanced across subjects.

Subjects. The design above resulted in eight different conditions and since each of the four experimenters ran 1 S in each condition, 32 Ss were needed. The Ss were college sophomores at King College and served as part of a course requirement.

Procedure. The S was seated at a table facing either a Lafayette memory drum or Sony tape recorder depending on the appropriate condition. The S was instructed to recall the words in any order he deemed desirable with 60 sec. allowed for him to write his recall in a prepared booklet.

Results

The data from the first two lists in each session were discarded as practice lists. The recall data for each serial input position were combined across the remaining 10 lists for each of the four major conditions and these are depicted in Figure 1. Analysis of variance on the two modalities, two suffix conditions, and 12 serial positions showed that only the main effect of serial position and the Modality $\times$ Serial Position interaction were significant. The main effect of Serial Position resulted in $F(11, 330) = 56.06$, $p < .001$, and the Modality $\times$ Serial Position interaction resulted in $F(11, 330) = 7.10$, $p < .001$. Neither the Modality $\times$ Suffix nor Modality $\times$ Position $\times$ Suffix interactions were significant, contrary to the predictions of the PAS interpretation of the modality effect. Both interactions resulted in $F < 1$.

The absence of a Modality main effect, $F(1, 30) = 1.36$, $p > .10$, seemed to be due to the nearly perfect crossover of the auditory and visual groups, as is clearly shown in Figure 1. Therefore separate analyses were carried out for Positions 1–4 and 9–12. The analysis on the primacy items (1–4) resulted in significant Position, $F(3, 90) = 32.38$, $p < .001$, and Modality, $F(1, 30) = 5.06$, $p < .01$, main effects. This indicates that, for the four primacy positions, the visual presentation was, in fact, superior to the auditory presentation.

Of more importance to the present study was the analysis of the terminal positions (9–12). Auditory presentation was superior to visual presentation, $F(1, 30) = 8.58$, $p < .001$, showing the usual modality effect for the recency items. The Suffix and Serial Position main effects were also significant, with $F(1, 30) = 5.05$, $p < .01$, and $F(3, 90) = 54.49$, $p < .001$, respectively. None of the interactions were significant including the predicted Modality $\times$ Suffix interaction which resulted, again, in $F < 1$. This means that auditory presentation was superior to visual presentation for all four terminal positions and that the suffix did hinder recall for these terminal items. But it also means that the suffix was equally effective on these terminal items for both auditory and visual groups.

A further post hoc analysis was conducted in an attempt to ascertain the locus

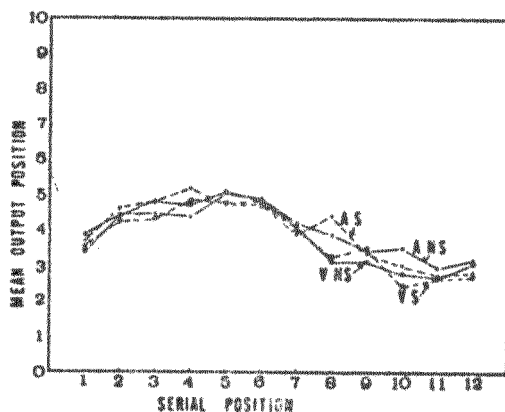


FIGURE 2. Mean output position as a function of serial position, modality (auditory—A, or visual—V) and presence (S) or absence (NS) of a suffix.

of the rather surprising experimental results. Following the lead of Murdock and Walker (1969) the output order of the recalled items was analyzed. Figure 2 shows the mean output position as a function of the recalled items input position. As can be seen from this Figure there are no major between-groups differences.

Discussion

Let us first dispense with the superiority of the visual groups to the auditory groups for the primacy items. As was mentioned in the introduction to this paper, this is an occasional result of modality experiments. Murdock (1966) used four or six paired-associates with one of the pairs being tested for retention. For his six item lists he found superiority for the visual presentation on the primacy items. Craik (1969), among others, has obtained this result with free recall, i.e., better performance on positions 1-3 for visual presentation than auditory presentation. Jensen (1971) has also reported data in which visual presentation is superior to auditory presentation. He used the memory span procedure and presented digits either visually or auditorily. The *Ss* recalled either immediately after presentation or after a delay of 10 sec. filled with a rehearsal preventative task. Jensen found that, with immediate recall, auditory presentation was slightly superior to visual presentation. However, the delayed recall results exhibited much better performance for the visual group than for the auditory group.

A probable explanation is that visual superiority in these situations is due to differential cumulative rehearsal strategies. Waugh (1960) has suggested that digit series are rehearsed cumulatively and Rundis and Atkinson (1970) have demonstrated that *Ss* in a free recall task do rehearse in a cumulative manner. Corballis (1966) found that with digit strings presented visually *Ss* did cumulatively rehearse but with auditorily presented strings there was very little cumulative rehearsal. Many subjects report a kind of "echo box" phenomenon with auditory presentation which would fit the PAS model. This quite likely leads the *S* in auditory groups to rehearse less or at least differently than the *S* in a visual group. The auditory *S* would be a great deal more passive and rely on the "echo box" while the visual *S* would need to rehearse in some manner. This would explain the differences for the primacy positions. This would

also explain Jensen's (1971) findings since the PAS ("echo box") would decay leaving the auditory *S* with very little remaining information. The visual *S*, on the other hand, would be better off on delayed recall since he rehearsed the items. Other possible support for the rehearsal differences notion come from the fact that in free recall situations, facilitated primacy for visual items is usually observed when the subject serves in only the visual group or only the auditory group, i.e., between-*Ss* designs, and is not observed in within-*Ss* designs. See Craik's (1969) two experiments as evidence for this informal observation.

With respect to the analysis of the terminal positions, the prediction of the PAS explanation of modality effects seemed to be that the suffix should have eliminated any superiority for the auditory group over the visual group. The suffix did hinder recall but it did so for both the auditory and visual groups. And the suffix did not bring the auditory group down to the level of the visual nonsuffix group. This clearly does not support the PAS interpretation. One possibility for the contradiction between present findings and prior suffix procedure results might be that prior experiments using the suffix have typically used serial recall whereas the present experiment made use of free recall.

EXPERIMENT II

Since most previous experiments using the suffix procedure to study PAS have used serial recall, a second experiment was conducted to test the possibility that type of retention test contributed to the failure to support the PAS interpretation of modality effects.

Method

The same materials and design were used as in Experiment I with the exception that *Ss* were instructed to recall the items in the order they were presented. The *Ss* were 32 introductory psychology students who served as part of a course requirement.

Results

Again, the first two lists in each session were discarded as practice lists. The serial position curves are shown in Figure 3. The overall analysis of variance resulted in significant effects of Serial Position, $F(11, 330) = 18.28, p < .01$, Modality $\times$ Suffix, $F(1, 30) = 12.76, p < .01$, and Mo-

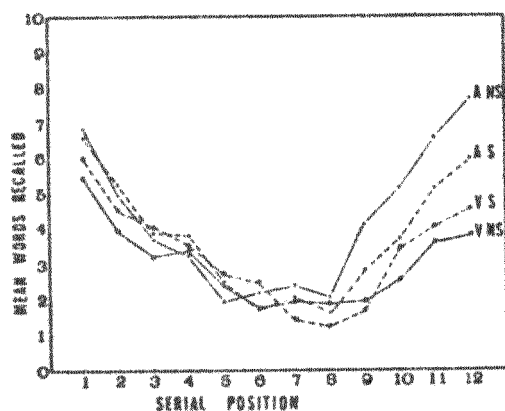


FIGURE 3. Mean serial recall as a function of serial position, modality (auditory—A, or visual—V) and presence (S) or absence (NS) of a suffix.

modality $\times$ Serial Position, $F(11, 330) = 1.78$, $p < .05$. Since the thrust of the study was aimed at the terminal positions, a further analysis was performed on Positions 9–12. This analysis resulted in a significant effect of Modality, $F(1, 30) = 5.36$, $p < .05$, showing that, for the terminal positions, auditory presentation was superior to visual presentation. The main effect of Suffix was not significant, $F(1, 30) = 3.84$, $p > .05$, but the Modality $\times$ Suffix interaction was significant, $F(1, 30) = 13.77$, $p < .01$. Paired comparisons showed the auditory suffix group to be lower than the auditory nonsuffix group, $t(30) = 2.40$, $p < .05$, but still significantly higher than the visual nonsuffix group, $t(30) = 2.29$, $p < .05$. So the suffix was effective, as the PAS interpretation predicts, in decreasing recall for auditorily presented terminal items. However, it still was not so effective as to make the auditory group identical to the visual group.

Another point of interest is that inspection of Figure 3 shows the visual superiority for primacy items found in Experiment I, to be absent in the present experiment. This supports the observation that the visual supremacy over the primacy positions is usually obtained with free recall.

Discussion

The PAS interpretation of modality effects seemed to predict that the addition of a re-

dundant nonrecalled suffix to an auditorily presented list would result in recall curves very much like those of a visually presented list. While the suffix did have derogatory effects in both Experiment I and Experiment II it did not eliminate the superiority of auditory presentation over the recency positions.

There are several problems inherent in using the present data to argue about the contribution of PAS to the modality effects. As previously mentioned nearly all previous research on the PAS has made use of serial recall of short lists of digits. The current experiments used lists of words which were 3–4 items longer than the typical suffix procedure list. Even though the second experiment used serial recall, there is a great difference between serial recall of an 8 or 9-item list of readily available digits and that of a 12-item list of words of considerably less availability and more semantic content than the 10 digits.

Nevertheless, the precategorical acoustic store, as proposed by Crowder and Morton (1969), should not be affected by the availability of the items stored therein or their semantic content. Also, the modality effect is certainly found in nonordered recall tasks. Therefore, these tasks should be amenable to study.

One alternative might be to say that the suffix is not completely effective in eliminating the trace of those items in PAS or that the PAS is of longer duration than is typically suggested. Data pertinent to this point were reported by Murdock and Walker (1969). They randomly switched from auditory to visual within a single list and observed auditory superiority over a full 10-item list. This represented five full seconds and if PAS is responsible for their findings it must be of, at least, 5-sec. duration.

The Murdock and Walker (1969) study used words and free recall, as did the present research. This raises the completely speculative possibility that PAS is physical in nature but its duration and capacity may depend on the type of material presented, i.e., phonemes, digits, words, etc., and the type of task being used. This, of course, suggests some strategic control over the PAS.

One last word of caution should be mentioned with regard to the decrease in performance for the visual suffix group on terminal items. There is no obvious reason why this could have happened and Crowder and Morton (1969) found no such effect of suffix on recall

of a visually presented string of digits. It may, therefore, be a spurious result.

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