THE VOCALIZATION EFFECT IN SHORT-TERM RECALL

by

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ABSTRACT

The relationship between increases in the vigor with which subjects vocalize to-be-remembered items and improvement in short-term recall was investigated. Of particular interest was whether the effects of vocalization are due to increases in the articulatory input or the auditory input which a subject receives, concommitent to increases in vocalization. Unlike previous investigations, the present study involved an independent manipulation of the auditory and the articulatory input levels. A series of nine-consonant lists was visually presented. One experimental group articulated the lists as they were presented, a second did not. Subjects in both experimental groups heard lists at two levels of auditory intensity. A control group neither articulated nor heard the visually presented list. Neither articulation nor auditory-input intensity affected recall. However, subjects receiving auditory input, regardless of level, recalled more items from the last three serial positions of the lists, and fewer from the middle three serial positions of the lists, than did control subjects. The results were interpreted in terms of an echoic memory system for auditory information, and alternatively, in terms of possible differences in learning or recall strategies between the experimental and control subjects.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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INTRODUCTION

Very generally, recall can be considered to be short-term in nature when the subject is recalling a small number of recently presented items. In this sense, recall in the Brown-Peterson paradigm[1] (Brown, 1958; Peterson and Peterson, 1959) is short-term. Further, in the serial recall, serial probe, and free recall paradigms, recall of the most recently presented items (i.e., those items occupying the last few serial positions of the list) is considered to be short-term in nature, and is superior to recall of items presented earlier in the list. Murdock (1972) discusses the nature of this "recency" effect in some detail. The argument that the recency effect is primarily a short-term recall (STR) effect is based largely on demonstrations that some variables which affect recall of items at the beginning of the list do not affect recall of items at the end of the list, or, vice versa. In particular, Kintsch (1970) mentions rate of presentation, frequency of words, delay of recall, and order of recall. Two additional variables, modality and vocalization, which will be discussed presently, also appear to affect recall of the most recently presented items without influencing recall of the rest of the list.

A phenomenon which has been of interest to researchers of short-term recall is the <u>vocalization effect</u>. Murray and his colleagues (eg. Murray, 1965; Murray, Leung, and McVie, 1973) have demonstrated that serial recall of, at least the last items, of visually presented lists is best when subjects read the lists in a loud voice, somewhat worse when they read them in a soft voice, worse still when they read them in a whisper, worse yet when subjects silently mouth the lists, and still worse (although not significantly so) for silently read, unmouthed items. The result for voicing, whispering, and silent reading was replicated by Tell (1971) and by Tell and Voss (1970) using the Brown-Peterson paradigm.

A second STR effect which is, at least superficially, related to the vocalization effect is the modality effect. The modality effect refers to the finding that regardless of the STR paradigm employed, recall of aurally presented items is better than recall of visually presented items. The effect is well replicated for the Brown-Peterson paradigm (Cooley and McNulty, 1967; Grant and McCormack, 1969; Kroll, Parkinson, and Parks, 1972; Peterson and Johnson, 1971) and for the short-term recall aspects of the serial probe, (Levy, 1971; Murdock, 1967a, 1968) serial recall, (Conrad and Hull, 1968; Corballis, 1966; Craik, 1969; Laughery and Pikus, 1966) paired-associate, (Murdock, 1966) and free recall (Murdock and Walker, 1969) paradigms. Margrain (1967) provides a striking demonstration of the modality effect. Subjects were presented with two lists of digits simultaneously, one aurally, one visually. Recall of the end items of the aural lists was superior to recall of the end items of the visual lists despite the fact that the subjects were required to copy the visual lists during presentation.

The similarity between studies on the modality effect and those on the vocalization effect is, of course, that in both cases the subject receives auditory input. However, what may be a crucial difference between these two procedures is the source of the auditory input the subject receives. In studies of the modality effect, the auditory input is generated by the experimenter. In studies of the vocalization effect, however, the auditory input is generated by the subject. When the auditory input is subject-generated, it is clear that input of a proprioceptive nature from the speech musculature (articulatory input) is also obtained by the subject. Therefore, in order to determine whether the modality effect and the vocalization effect are one and the same, the effect of the articulatory input the subject receives through vocalization must be determined, particularly with regard to its effect on STR.

Attempts have been made to assess the role of articulatory input in STR of vocalized lists. The results, however, are inconclusive. Underwood (1964) prevented subjects from articulating to-be-remembered items by having them hold tongue-depressors in their mouths. Gumenik (1969) prevented subjects from articulating by having them hold their tongues between their teeth. In neither study did preventing articulation result in a decrement in STR. On the basis of this result it might be concluded that articulatory input is not crucial to the vocalization effect.

To investigate the role played by auditory input in the vocalization effect, Levy and Murdock (1968) and Murdock (1967b) prevented subjects from making use of the auditory input they received while vocalizing. By delaying the auditory input which the subjects received, subjects were forced to ignore the auditory input in order to continue reading the list. Surprisingly, recall was unaffected, even though the auditory input was useless and possibly interfering. Since it seems unlikely that the vocalization effect is the result of something other than the articulatory input or the auditory input which a subject receives, the suitability of the Underwood, Gumenik, and Levy and Murdock techniques for the evaluation of the vocalization effect is questionable.

A final set of results with regard to the role of articulatory input in the vocalization effect is worthy of note. Murray (1967, 1968) and Tell (1971) had subjects vocalize a statement which conflicted with the proper articulation of visually presented, to-be-remembered items. For example, Tell had subjects say "three consonants" when a to-be-remembered CCC-trigram was presented. He found that recall of items when articulation was "suppressed" in this way was inferior to recall of items which were silently read. The result may be interpreted as evidence that the vocalization effect is, at least in part, due to articulatory input. However, it is, in fact, ambiguous. Vocalizing a conflicting statement clearly prevents articulation of the to-be-remembered item. However, the subject is also prevented from generating the item's appropriate auditory representation. In fact, the subject is generating auditory input which likely interferes with any auditory representation he may be able to produce, even subvocally. Levy (1971) attempted to overcome this difficulty by having subjects silently articulate a conflicting statement ("hi-ya"). Again a deficit in STR was found. However, it is still not possible to conclude that the deficit obtained is only the result of preventing articulation. It is possible that the "irrelevant" mouthing the subject engages in still prevents the subject from generating an auditory representation of the item.

Despite this apparent lack of knowledge concerning the effect of articulatory input on STR, Tell (1971) has interpreted the vocalization effect solely in terms of auditory input: "These vocalization effects are assumed to reflect directly the magnitude of echoic memory and not differences in the strength of which items are encoded...Echoic memory is passive and serves as a temporary holding system for raw (auditory) information." (Tell, 1971, pages 154 and 155, parentheses added). This interpretation is premature on one point, and possibly in error on another. First, while it is obvious that as vigor of vocalization increases so does the subject-generated auditory input, it is quite possible that increases in the amount of articulatory input are also obtained. Thus, the vocalization effect cannot be attributed solely to auditory input, since there is the possibility that increases in auditory input are confounded with increases in articulatory input. The second point, although not of primary concern to the present research, is worthy of mention. Tell, and Crowder and Morton, who originally introduced the concept (Crowder and Morton, 1969), appear to be in error with regard to the nature of the echoic memory system they proposed. They have described the system as a "passive" one, the implication being that the information in the system is "raw" or "precategorical" auditory information which is held in the system for some seconds. The proposed echoic system then, is intended to be the auditory analogue of the visual sensory memory system, iconic memory, described by Neisser (1967). Watkins (1972) and Watkins and Watkins (1973) have interpreted the passive nature of the Crowder and Morton system to mean that verbal information in the system would more likely be on the order of a phoneme (the "raw" verbal unit) than on the order of a word, should the word contain more than one phoneme. With this in mind, Watkins and Watkins (1973) had subjects recall eight-word lists which were either visually or aurally presented, and which were composed of one-syllable or four-syllable words. As expected, the modality effect was obtained for both the one-syllable word lists and the four-syllable-word lists. That is aural presentation resulted in better recall of items occupying the last few positions of the list than did visual presentation, for both the one and the four-syllable-word lists. A more important finding was that the number of words for which the modality effect was obtained was the same, regardless of the length of the words in the list. That is, in the case of the four-syllable-word lists, the number of phonemic units (syllables) for which recall was facilitated by aural presentation, was four-times greater than the number of phonemic units facilitated in one-syllable-word lists. This result clearly indicates that the information in an echoic system, such as that proposed by Crowder and Morton, would not be "raw" but, rather, would be "postcategorical". That is, the precategorical phonemic units have already been categorized into words by the time they reach the echoic system.

A second set of results further indicates that "raw" information is not likely to exist in such an echoic system. Massaro (1972) found that presenting white noise within 250 milliseconds after onset of a to-be-recognized tone prevented subsequent recognition of the tone. However, if the tone remained on for more than 250 milliseconds, or if there was 250 milliseconds of silence between the tone and the noise, recognition performance was unaffected. These results indicate that information of a "raw" or sensory form is held for at most 250 milliseconds after stimulus offset. Thus, since Massaro has demonstrated that "raw" information is not available to the subject for more than 250 milliseconds, and since Watkins and Watkins have demonstrated that subjects are not using "raw" information for STR anyway, the nature of the information in the

Crowder and Morton system must be considered to be other than "raw", phonemic information.

Regardless of what changes are necessary to make the Crowder and Morton system conform to the data just described, it remains that Tell (1971) appears to be premature in ignoring the role of articulatory input in STR. That is, as the vigor of vocalization increases, concomittent increases in *both* auditory input and articulatory input occur. The respective roles of these two types of input in STR have not yet been evaluated independently. Such an evaluation was undertaken in the present study. That is, the present study was designed to determine whether the vocalization effect is due to increases in subject-generated *articulatory input* or due to increases in subject-generated *auditory input*, or both. The levels of articulatory input and auditory input the subjects received were manipulated independently. Subjects were run in yoked pairs. A nine-consonant list was presented visually, via whole-list presentation, to both subjects simultaneously. In the experimental conditions, one subject read the list aloud, while both subjects heard (over headphones) at one of two intensities, what the vocalizing subject said. Four experimental conditions were used: articulation plus high auditory input (Ar-Hi), articulation plus low auditory input (Ar-Lo), no articulation[2] plus high auditory input (NAr-Hi), and no articulation plus low auditory input (NAr-Lo). In a control condition, subjects were presented with the lists visually, with no instructions to vocalize the items.

As indicated above, in a serial recall task, it is assumed that STR processes are reflected in the recency portion of the serial position curve. That is, the effects of the experimental manipulations here would be expected to be more pronounced at serial positions seven through nine. The results of most importance to the experimental objectives are the interactions between Groups (Ar, NAr, and Control), Intensity, and Serial Position. Clearly, if differences in articulatory input account for the vocalization effect, the Ar group should perform better than does the NAr group. If, as Tell (1971) suggests, differences in auditory input account for the vocalization effect, two predictions can be made. First, the Ar and NAr groups combined should perform better than does the Control group, since both the experimental groups receive auditory input while the Control group does not. Second, performance under conditions involving high auditory input should be better than performance under conditions involving low auditory input, since increases in auditory input accompany increases in the vigor of vocalization. An interaction between Articulation and Intensity would indicate that the vocalization effect is due to a combination of the increases in articulatory input and auditory input.

METHOD

Subjects. The subjects were 30 male and 30 female volunteers, associated with the University of British Columbia. Of the 60 subjects, 19 were graduate students, 30 were undergraduate students, and 11 were faculty and staff employed by the University of British Columbia.

Materials and apparatus. Twenty lists of nine consonants were formed from the consonants, excluding 'w' and 'z'. The lists were constructed so that (1) no consonants were repeated within a list, (2) each consonant was used an equal number of times, (3) alphabetically adjacent letters did not appear together in their alphabetical order, and (4) each consonant appeared in each serial position twice at most.

Four practice lists were constructed from the vowels plus 'y'. Letters were unavoidably repeated in the practice lists. The same order of presentation of the practice lists was used for all the training sessions.

All lists (typed in lower case), the ready signal (three asterisks) and the recall signal (three question marks) were mounted as horizontal arrays on 2x2 inch slides. The slides were presented by means of a Kodak Carousel-850 projector, with the duration of presentation controlled by an eight-bank Lafeyette timer. The sound system consisted of two Sony F-32 microphones, a Sony TC-630 tape recorder (only the amplification system was used), and two Sharpe HA-660 stereo headsets.

Table 1 A Schematic Representation of the Experimental Design.

		Intensity-high			Intensity-low		
	Serial positions	(sp) 1-3	sp 4-6	sp 7-9	sp 1-3	sp 4-6	sp 7-9
Experimental Group 1 (Articulation)	Order 1	First ten trials			Second ten trials		
	Order 2	Second ten trials			First ten trials		
Experimental Group 2 (No Articulation)	Order 1	First ten trials			Second ten trials		
	Order 2	Second ten trials			First ten trials		
Control Group							

The two levels of amplification used were brought about in the following manner: the volume control of the tape recorder was set to maximum and adjustments were made on the recording level control. For the low level of auditory input, the "record" control was set at "1". For the high level of auditory input the "record" level control was set at "7". No attempt was made to measure the absolute volume of input, since it would have been unworkable in view of the number of subjects involved and the amount of variation that occurs within a single subject. Both headsets were connected to the "listen" jack on the tape deck.

Experimental design: Depicted in Table 1 is the schematic of the design. Four experimental conditions result from a factorial combination of two levels of articulation (between subjects) and two levels of auditory input (within subjects). Order of presentation of the two levels of intensity was counterbalanced across subjects within each of the articulation conditions. Twenty subjects were randomly assigned to the control group, and ten were randomly assigned to each level of Articulation by Order, on the basis of a predetermined assignment schedule. Serial position (in blocks of three positions) was a within-subjects variable. All subjects performed one recall trial for each of the four practice lists and for each of the 20 test lists. For the experimental subjects ten lists were presented under the high-intensity condition and ten were presented under the low-intensity condition. For each pair of subjects the order of presentation of the 20 test lists was a different random order.

All subjects performed the recall tasks in same-sex pairs. Subjects in the experimental conditions were yoked in that, while one subject was required to articulate the visually presented list, the corresponding yoked subject was not. However, both members of the pair heard, over headsets, what the articulating subject was saying. The intensity of what they heard was at one of the two intensities described above. The low-intensity input (setting "1") was essentially amplification free. The high-intensity input (setting "7") resulted in auditory input at approximately the level of a shout.

Procedure. In the experimental conditions the Ar subject was seated at a table to which the microphones had been attached (three feet from the subject). The yoked -NAr subject was seated at an adjoining table. The pair of subjects was then instructed as to the nature of the task. They were told to remember as many of the letters in each list as they could and to write them in the proper serial order in the answer booklet provided. It was explained that the Ar subject was to read each list aloud as it was presented, from left-to-right, in a normal voice (regardless of the degree of amplification). Both subjects were told that they would both hear what the Ar subject said over the headsets, and that, after ten trials, the intensity of what they heard would be changed. Further, the Ar subject was told to "group" the items in a way that would best facilitate recall. The corresponding NAr subject was instructed to try to coordinate his silent reading of the items with the vocalizing of the Ar subject so as to avoid interference. The pair of subjects was instructed to confer during the break between the practice lists and the test lists, so as to determine a system of reading that was satisfactory to both. Control subjects were instructed only as to the nature of the task.

To summarize, a single trial involving the experimental subjects proceeded as follows. First the ready signal appeared on the screen for three seconds. Following the ready signal, the consonant list was presented visually to both subjects as a horizontal array, and remained on the screen for 5.5 seconds. The Ar subject read the list aloud from left-to-right while it was on the screen, and both subjects heard over headsets what the Ar subject said. The NAr subject read the list silently to himself, in coordination with the Ar subject's reading. Immediately after the list was removed from the screen, the recall signal appeared. Both subjects then attempted to recall as many of the letters as they could. The answer booklet provided one space for each item in a list and contained one page for each list. The subjects were instructed to write the items they could remember in the appropriate spaces in their answer booklets. If a subject could not remember a particular item he was instructed to leave the appropriate space blank or to guess. Subjects were given ten seconds for recall, followed by an inter-trial interval of nine seconds. A single trial for the control subjects was carried out in an identical fashion, with the exception that neither subject read the list aloud, and neither subject was provided with a headset.

A single session consisted of four practice trials (performed at the low-intensity input by the experimental subjects), followed by two ten-list blocks of test trials. A short break between the blocks was necessary so that the experimenter could (where appropriate) adjust the intensity of the amplification and change the slide tray.

RESULTS

An item was scored as correct only if it was recalled in the correct serial position. Depicted in Figure 1 is the mean number of items recalled correctly at each serial position, in ten trials, for each of the four experimental conditions and the control condition. There were no noticable differences in recall among any of the experimental conditions, at any serial position. However, the Control group appears to have performed better at the middle positions, and worse at the last positions, than did the subjects under the experimental conditions.

The mean number of items recalled correctly (out of 90), over all serial positions, was 56.8 for condition Ar-Hi, 58.0 for condition Ar-Lo, 58.1 for condition NAr-Hi, and 58.2 for condition NAr-Lo. The mean number of items recalled correctly by the control subjects was 57.6.

An analysis of variance was carried out on the number of items correct over ten trials, in each block of three serial positions. Groups (Ar, NAr, and Control) and Order of presentation of intensities were between-subjects variables, Intensity and Serial position were within-subjects variables.

The analysis revealed no differences in recall due to Articulation, either alone, $F(1,55)<1$, or in interaction with Serial position, $F(2,110)<1$. The mean number of items recalled correctly for the Ar group was 57.4 and the mean for the NAr group was 58.2. Nor, was there any difference in recall due to

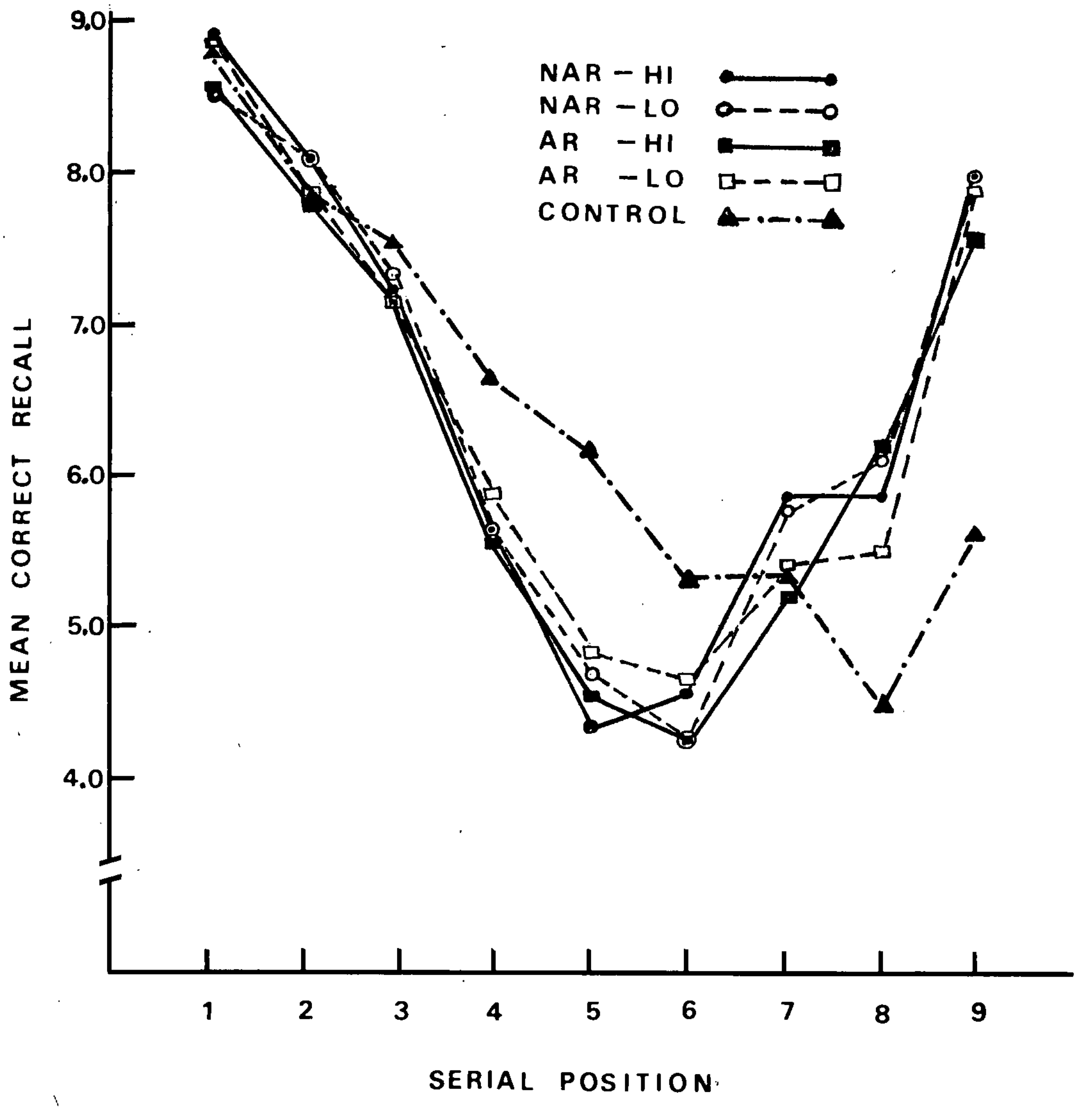

Figure 1: Mean Number of Items Recalled Correctly (out of 10) at Each Serial Position by Each of the Four Experimental Groups and by the Control Group.

Intensity, either as a main effect, $\underline{F}(1,36)<1$, or, in interaction with Serial position, $\underline{F}(2,72)<1$. The mean number of items recalled correctly under the Hi condition was 57.4, and the mean for the Lo condition was 58.1. The interactions among Intensity, Articulation, and Serial position, and between Intensity and Articulation were also found to be nonsignificant, $\underline{F}(2,72)<1$ and $\underline{F}(1,36)<1$, respectively.

Comparison of the two experimental groups (combined) to the Control group indicated that there was no overall difference in recall due to the addition of auditory input. The mean number of items recalled correctly for the combined experimental groups was 57.8, the mean for the Control group was 57.6, $\underline{F}(1,55)<1$. When considered in interaction with Serial position, however, the combined Ar and NAr groups differed significantly from the Control group, $\underline{F}(2,110)=9.00$, $p<.001$. Analysis of the simple effects involved in this interaction indicated that the groups differed at serial position blocks two, $\underline{F}(1,110)=20.55$, $p<.001$, and three, $\underline{F}(1,110)=13.13$, $p<.001$. The mean number of items recalled by the Control group on block two was 18.0, as compared to 14.7 for the combined Ar and NAr groups. On the third block, the mean number of items recalled correctly by the experimental subjects was 19.2, as compared to 15.4 for the Controls. There was no difference in recall at positions one to three.

The main effect of Serial position was significant, $\underline{F}(2,110)=55.06$, $p<.001$, as was the interaction between Articulation,

Table 2 Summary of Groups x Intensity x Serial Position ANOVA on the number of items correctly recalled.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F
Total	299	15342.20		
Subjects (Ss)	59	3566.03		
Articulation (Ar)	1	4.01	4.01	<1
Experimental (Exp) vs Control (C)	1	0.50	0.50	<1
Order (O)	1	18.71	18.71	<1
Ar x O	1	73.70	73.70	1.17
error	55	3469.11	63.07	
Within Subjects	240	11776.17		
Intensity (I)	1	2.61	2.61	<1
Serial position (Sp)	2	4262.96	2131.48	55.06*
I x Ss/Exp	39	248.89		
I x Ar	1	2.20	2.20	<1
I x O	1	1.83	1.83	<1
I x Ar x O	1	30.11	30.11	5.05**
error	36	214.75	5.97	
Sp x Ss	118	5110.71		
Sp x Ar	2	13.63	6.82	<1
Sp x Exp vs C	2	696.58	348.29	9.00*
Sp x O	2	71.63	35.82	<1
Sp x Ar x O	2	70.44	35.22	<1
error	110	4258.44	38.71	
I x Sp x Ss/Exp	78	2146.97		
I x Sp x Ar	2	4.13	2.07	<1
I x Sp x O	2	30.10	15.05	<1
I x Sp x Ar x O	2	0.63	0.32	<1
error	72	2112.10	29.33	

* $p < .001$

** $p < .05$

Intensity, and Order, $F(1,36)=5.05$, $p<.05$. The latter effect represents the finding that the non-articulating subjects performed better under the high-intensity condition than under the low-intensity condition when the high-intensity condition came second, but not when it came first (the reason for this is not clear). The low-intensity condition was better for the articulating subjects regardless of the order of presentation. All remaining sources of variance resulted in nonsignificant F-ratios. The summary of the analysis is presented in Table 2.

DISCUSSION

The major focus of the present study was on the roles of articulatory and auditory input in the vocalization effect. Of particular interest was whether the increases in articulatory input or the increases in auditory input which accompany increases in the vigor of vocalization could be considered to account for the resultant increases in STR. The finding that the experimental subjects (i.e., those who received auditory input) recalled more items from the last three serial positions than did the control subjects suggests that differences in auditory input are more likely to account for the vocalization effect. However, one major prediction in this regard was not borne out in the results: STR did not vary with the intensity of auditory input.

If increments in STR associated with increments in vocalization are due to associated increments in subject-generated input of an articulatory nature, the articulating subjects should have recalled more than did the non-articulating subjects. Although no attempt was made to inhibit articulation by NAr subjects, it seems reasonable to assume that the vocalizing Ar subjects received more precise (or a greater amount of) proprioceptive feedback from the speech musculature than did the NAr subjects. Thus, if articulatory input made an independent contribution to STR, the Ar subjects should have recalled more than did the NAr subjects. This was not the case. Recall in the two groups was essentially equivalent.

However, the finding that the experimental subjects recalled more at the end of the list than did the control subjects indicates that the vocalization effect is, at least generally, due to the auditory aspect of vocalization. That is, since articulatory input did not contribute to the STR of the Ar subjects, the only difference between either of the experimental groups and the control group, in terms of input, was that the experimental subjects received auditory input and the control subjects did not. Thus, differences in the recall of vocalized and unvocalized lists can be seen as being due to differences in the level of auditory input the subject receives. On the other hand, if increments in STR are due to increments in subject-generated auditory input, performance under the hi-intensity condition should have been better than performance under the low-intensity condition. However, no differences were obtained due to intensity.

The lack of difference between performance under the two intensity conditions may be due to certain aspects of the procedure used to vary the intensity level. For example, not only appropriate input, but also extraneous and inappropriate noises, were amplified. In addition, since a majority of subjects in the experimental conditions reported being quite distracted during the high intensity portion of the task, it is possible that the high-intensity input was too loud for optimum performance. This possibility appears likely in view of the result that performance under the low-intensity condition was generally better than performance under the high-intensity condition (except for the non-articulating subjects receiving the high-intensity condition second), in contrast to Cohen's (1967) finding that increments in recall were associated with increments in auditory input. Therefore, the present result with regard to Intensity may be misleading. If so, Tell (1971) may have been correct in interpreting the vocalization effect solely in terms of auditory input.

Interpretation of the vocalization effect in a manner similar to that of Tell (1971), therefore, does not appear to be inappropriate. However, as previously noted, Tell appears to be incorrect in assuming that an "echo-like" memory system, such as he proposed, would involve information of a "raw" or sensory nature. While the results used to question Tell's interpretation were concerned with aural presentation of materials (Watkins and Watkins, 1973), rather than with vocalized visually-presented materials, the criticism is still valid. Further, in the case of vocalized visually-presented items, it is even more clear that echo-like information would not be "raw" or phonemic in nature. Upon visual presentation of a list, the subject probably encodes list items not in visual but rather, in auditory terms, and, moreover, not as phonemes but as meaningful units, for example words. That is, the subject may vocalize the items. Depending on instructions, such vocalization will be either <u>overt</u>, resulting in auditory input, or <u>covert</u>, resulting in a subvocal auditory representation. Thus, vocalization effects can be attributed to the different amounts of auditory input the subject receives; in general the louder the input, the better the recall (unless the input is so loud as to be distracting). Presumably, the auditory input is reproduced in an echo-like system in a manner reflecting all aspects of the auditory input, hence short-term recall is best for loud vocalization because the auditory reproduction is louder, and therefore clearer to the subject. A limit to the number of items that can be held in such an echo-like system is suggested by the finding that the vocalization effect extends over only the last two or three items in a list (Murray, Leung, and McVie, 1973). Further, Tell (1971) has suggested that the reproductions fade after a few seconds.

An important point with regard to comparison of the modality effect and the vocalization effect should be made. In both cases it would appear that the auditory input the subject receives facilitates STR, and, in both cases, such input can be seen as being reproduced in an echo-like system at a level of analysis at least beyond integration of raw, phonemic units into words. However, it is interesting that such integration probably occurs before auditory input when visual materials are vocalized, and necessarily occurs after auditory input of items which are aurally presented.

The results of the present study may be interpreted in a way that has nothing to do with the vocalization effect. The finding that the control subjects recalled more from the middle of the list than did the experimental subjects may indicate that the differences at the end of the list were due to differences in learning or recall strategies employed by the groups rather than due to the experimental manipulations. In terms of learning strategies, the control subjects were free to attend to some items more than others (they may have attended more to the middle items), whereas the experimental subjects were forced to attend to all items more or less equally. With regard to recall strategies, Tulving and Arbuckle (1963) demonstrated that the recency effect was diminished when subjects were forced to recall the lists in a set order, from beginning to end. The present results may indicate, then, that the control subjects were recalling in a somewhat different order.

In summary, the results of the present study suggest that (1) the vocalization effect is not due to concomittent increases in articulatory input, but (2) that it may be due to concomittent increases in auditory input. However, point (2) is tenuous for two reasons. First there was no difference in performance due to intensity, and second, the possibility exists that the important differences in STR were due to effects other than the experimental manipulations. These problems could be easily solved by using lower intensities of auditory input and by using single-item rather than whole-list presentation, or by specifying order of recall. A further refinement of the procedure would involve the use of well-practiced subjects in order to minimize the possibly distracting effects of hearing one's own voice.

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FOOTNOTES

1. The Brown-Peterson paradigm is an operationally defined three stage STR paradigm consisting of the presentation of the TBR items, followed by a subject-performed rehearsal prevention task, followed, in turn, by recall.

2. Since there was no attempt to prevent articulation on the part of subjects in the no-articulation condition it would be unreasonable to assume they were not articulating to some degree. However, since it is unlikely that these subjects were overtly articulating, as were the subjects in the articulation condition, it does not seem unreasonable to assume that the articulation engaged in by the subjects in the no-articulation condition was both quantitatively and qualitatively different from that engaged in by the subjects in the articulation condition.