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Does Echoic Memory Develop?

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A series of experiments is reported on the stimulus suffix effect with the primary variables being age of the subject (7 and 11 years), rate of presentation, and list length. While the suffix effect was larger for younger subjects at a slow rate of presentation, the effect was nearly identical across age groups with a fast presentation rate. It was concluded that when the contaminating effects of more central processes are reduced, there is no developmental change in the capacity of echoic memory. An interesting effect of rate of presentation is reported with younger subjects performing better at faster rates of presentation and adults performing better at slower rates.

Sensory memories play a pivotal role in nearly all contemporary models of cognition because they represent one of the initial stages of coding and categorization and one of the earliest internal representations of the external world. There has been considerable work on developmental aspects of the visual sensory memory with most of it suggesting no developmental differences in either capacity or duration (viz., Morrison, Holmes, & Haith, 1974). However, there is very little work directed at the auditory sensory memory, or as we refer to it here, echoic memory, and those studies that have been reported suffer from problems limiting their interpretability.

The properties of echoic memory in the adult have been detailed by Crowder and Morton (1969), Crowder (1972), and Crowder (1978) using a procedure called the stimulus suffix technique. The technique consists of presenting lists of verbal items auditorily for immediate serial recall in the same general way one would conduct a memory span task except that the experimental condition also receives a redundant nonrecalled suffix after the last list item. For example, a list of digits might be followed by the suffix "Go" with the subject told beforehand that the Go could be ignored if desired since it need never be recalled. The suffix generally causes a large increase in errors over the last few positions

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when compared with a nonsuffix control condition. As determined by this technique, some of the properties of echoic memory appear to be: (1) it is specific to human speech since nonspeech sounds such as buzzes, taps, and tones cause no suffix effect, (2) it seems to be coded according to physical features such as pitch and voice quality, (3) it is indifferent to semantic content since any nonsense speech sound will result in a suffix effect, (4) it retains only vowel sounds and not stop consonants, and (5) it is immune to changes in attentional strategy.

It is surprising that so little work has been conducted on the developmental aspects of echoic memory since it is an apparently necessary structure for speech perception and comprehension and probably plays a crucial role in early stages of the development of reading as well (Sanders, 1977). A few studies have compared recall performance with auditory and visual presentation. For example, Murray and Roberts (1968) presented six-digit strings either auditorily or visually to children aged 7 to 10 years. Their results suggest that there is less of a developmental difference in recall with auditory presentation than with visual presentation. This is another way of saying that auditory presentation improved recall more for the 7-year-olds than for the 10-year-olds, suggesting that younger children might have larger-capacity echoic memories. One potential problem for studies comparing auditory with visual presentation across ages, however, is that younger children are not as likely as older children to recognize and encode auditory and visual items with equal facility.

Frank and Rabinovitch (1974) conducted a developmental study of echoic memory using the suffix technique. Their subjects, third, fifth, and seventh graders, heard six-digit lists presented at a 2/sec rate for immediate serial recall. The lists in the suffix condition were followed by the redundant, no-to-be-recalled digit "zero" from 0.5 to 2.0 sec after the last digit. The slope of the decrease in magnitude of the suffix effect as a function of suffix delay was fairly constant across age groups, which seemed to indicate no difference in the rate at which information is lost from echoic memory as a function of age. But, Frank and Rabinovitch found a much larger overall suffix effect from the third graders than from the other two groups. While this might suggest a larger-capacity echoic memory or possibly greater dependence on the echoic memory by the younger subjects, there is a rather serious problem with this study. Because the procedure only entailed a single list length, six items long, the variability of the data from the fifth and seventh graders was limited by a ceiling effect, i.e., near perfect performance. It is thus difficult to compare the decrease in recall resulting from the suffix across age groups.

Another developmental study of echoic memory using the suffix procedure was conducted by Engle (1977) who presented five- and seven-item lists to second graders, average IQ sixth graders, and low IQ sixth

graders at a one-item per second rate. This study also demonstrated a larger suffix effect for the younger subjects, but only at the shorter list length. With the seven-item lists, the suffix caused the same decrement for all three groups. However, this study suffered from the same potential problems with boundary effects as the Frank and Rabinovitch study. The sixth graders were limited by ceiling effects for the short lists while the second graders were limited by floor effects for the longer lists.

The problem addressed in the present research, and which appears to be common to most developmental research, was to measure the suffix effect in children of various ages while keeping the difficulty of the task as similar as possible across groups. Our solution was to determine the subjects' digit span and to vary the list length with respect to that span. An attempt was made to measure the suffix effect at various levels of list difficulty with difficulty equated across subjects at each level. It is unlikely that this method completely justifies the above assumptions but it comes closer than methods previously used. Two experiments are reported here, the first an investigation of several variables that might interact with the suffix effect in children, and the second a study using adults to allow a more direct comparison between the results of Experiment 1 and the existing literature on echoic memory.

EXPERIMENT 1

In this experiment second graders, mean age 7 years, 5 months, and sixth graders, mean age 11 years, 4 months, received a test to determine their digit span and then received auditorily presented lists of digits for serial recall. The lists were of three different lengths and occurred at either a fast or slow rate. In addition, the order of suffix and nonsuffix lists was varied. A third of the subjects received the block of suffix lists of a given length prior to the nonsuffix lists, a third received the reverse order, and a third received the suffix and nonsuffix lists randomly ordered.

Method

Subjects. After receiving parental permission, children in grades 2 and 6 were tested to determine their digit span. This test was conducted with groups of 4 children in a room in the school. Over earphones, they heard 50 lists which varied from four to eight digits in length presented at a 2 digit/sec rate. The lists were grouped into 10 blocks ascending in length and 10 blocks descending in length. The digit span was determined by rounding off to the nearest integer the mean of the lengths of the longest list recalled perfectly in each block. A total of 108 children with digit spans of 4, 5, or 6 were used in this study. The second-grade group consisted of 10 children with a four-digit span, 36 with a five-digit span, and 8 with a six-digit span, whereas the sixth-grade group consisted of 26 children with a five-digit span and 28 with a six-digit span

Design. After screening for digit span, the children were randomly assigned to conditions with the constraint being an approximately equal distribution of digit spans to conditions within grades.

There were two within subject variables; the lists were followed by either a tone in the control condition or the suffix Go spoken in cadence with the digits in the experimental condition. List length was also varied as a within-subject factor, and was defined with respect to each child's digit span. The lists were of three lengths: span length ($LL = 0$), span plus one digit ($LL = 1$), and span plus three digits ($LL = 3$). The order of the length conditions was balanced by a Latin Square design.

The between-subject variables were grade (2 or 6), rate of presentation (one digit per second or four digits per second), order of list length (3), and order of suffix/nonsuffix lists (3). This last variable was designed to test for any interaction of expectancy or bias with the suffix effect. Subjects either received the lists blocked by suffix condition with either the suffix lists of a given length all occurring first or the nonsuffix lists all occurring first or with the suffix and nonsuffix lists occurring randomly within a block of a given list length (list length was blocked to avoid unduly confusing the youngest subjects). This last condition was designed for the subject not to be able to predict whether a list was suffix or nonsuffix until the tone or suffix actually occurred. These between-subject variables produced a $2 \times 2 \times 3 \times 3$ design with 36 cells and three subjects per cell.

Apparatus. The digit lists for the experimental phase of the study were compiled from a table of random numbers with no digits repeated in a list. The stimuli were spoken by a female who attempted to read all digits in a monotone with no inflection change at the end of the list and to produce digits of the same duration independent of presentation rate. The digits were first recorded, blocked by suffix condition, then the lists for the condition in which suffix condition was randomized were copied one at a time from the tape of the blocked lists so that, for a given suffix condition, the lists occurred in the same order across all three orders of suffix–nonsuffix condition.

Procedure. The children were tested in a room in the school or in a travel trailer modified for use as a laboratory. Each child was tested individually and heard the 54-digit lists through stereo earphones. The subjects received one practice list representing each of the six conditions and these data were not analyzed, leaving 48 lists or 8 lists for each condition for the final analysis.

Because a pilot study had demonstrated no age by response mode interaction in the magnitude of the suffix effect, we required the child to write the digits on response sheets prepared with the same number of lines for each list as there were digits. A 20-sec period was allowed for recall and the child was instructed to write the recalled digits in a

left-to-right fashion and to guess if uncertain about a response. The response was closely monitored by the experimenter to insure that all subjects followed the instructions for serial recall.

Two different scoring procedures were used. One method, the one most commonly used in suffix effect experiments, gives a score of 1 for each position with a correctly placed digit and a 0 if the correct digit was not in the correct serial position. The other method was a modification of the procedure used by Huttenlocher and Burke (1976) allowing partial credit to a position if the correct digit was recalled up to three positions removed from the correct one. Analyses performed on data from the two scoring procedures yielded identical conclusions, thus, all further discussion will be for analyses using the strict scoring procedure.

Results

The fact that different subjects in the same condition could receive lists of different actual length (but of the same length with respect to their digit span) meant that the standard dimensions of data reduction could not be used. While many different methods were used there was close correspondence in the conclusions reached across methods.

An analysis on the proportion correct for each of the six conditions for each subject led to virtually the same conclusions described here but did not allow evaluation of the serial position variable. The method which appeared to best capture the effect of the suffix mask on echoic memory was to analyze the recall performance from the last four serial positions of each list. This means, of course, that for some of the youngest subjects (those with a span of four digits) the analysis included all data for the shortest list length and for some of the oldest subjects of Experiment 2 (those with a span of seven digits) the analysis included only 4 of 10 positions for the longest list.

The proportion correct for each of the last four serial positions for each of the six within-subject conditions was entered into a six-way ANOVA with the variables being grade (2), rate (2), order of suffix and nonsuffix lists (3), presence of suffix or tone following the list (2), list length (3) and serial position (4). Order of suffix and nonsuffix lists resulted in neither a significant main effect, $F < 1.0$, nor an interaction with any other variable and will not be discussed further. It can be assumed that any main effect or interaction not described was either not germane to the current discussion or was nonsignificant with a p value of greater than .10 and that any difference between means described below was verified by a Tukey HSD test at the .05 level.

The results of the analysis are presented in Figs. 1 and 2 for the second and sixth graders respectively, and the percent suffix effect (difference between nonsuffix and suffix conditions multiplied by 100) for all subjects is shown in Table 1. The most striking aspect of the data is that there

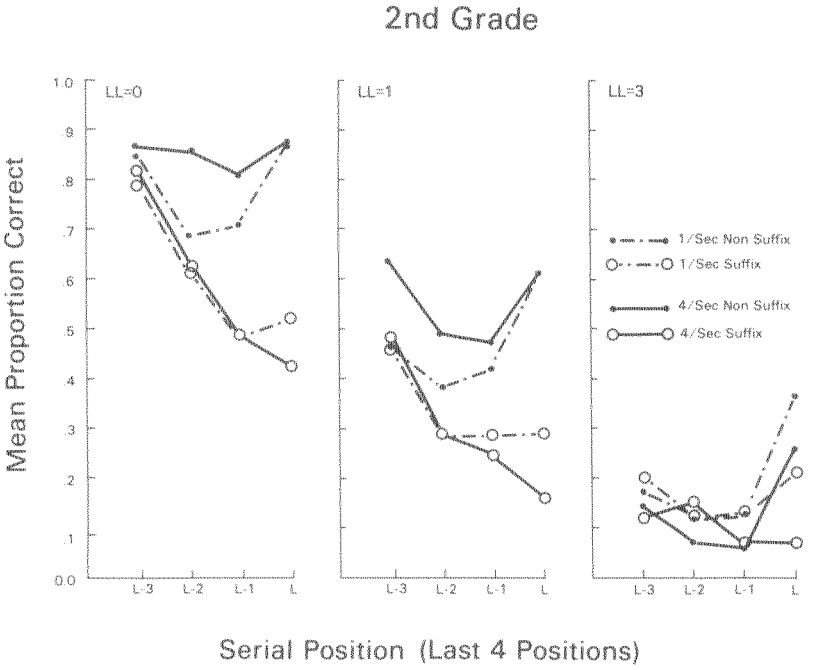

FIG. 1. Mean proportion correct for each of the last four serial positions for second-grade subjects.

was a large decrement in performance caused by the suffix for both groups of subjects on the shortest lists ($LL = 0$) but that the magnitude of the suffix effect decreases as list length increases. In fact, this decrease in suffix effect as list length increased was sharper for the second graders (from a 22% absolute difference between suffix and nonsuffix conditions at $LL = 0$ to 3% at $LL = 3$) than for the sixth graders (from 17% at $LL = 0$ to 11% at $LL = 3$). This was reflected by a Grade $\times$ S/SN $\times$ LL interaction, $F(2, 208) = 5.45$, $p < .01$.

The rate variable made several interesting contributions to these data. For example, if we look at just the lists that were presented at one item per second we see that the second graders showed a much larger suffix effect on the shortest list than did the sixth graders (17 to 6%) but that on the lists one item longer than the span there was little difference and on the longest lists the second graders showed a smaller suffix effect (3 to 11%). This pattern of results is very similar to the results of our earlier study (Engle, 1977) which also used a one item per second rate of presentation.

Inspection of the 4/second data shows a very different pattern of results. There was a slight difference in the magnitude of the suffix effect for the longest lists, but the suffix effect on the two shorter list lengths

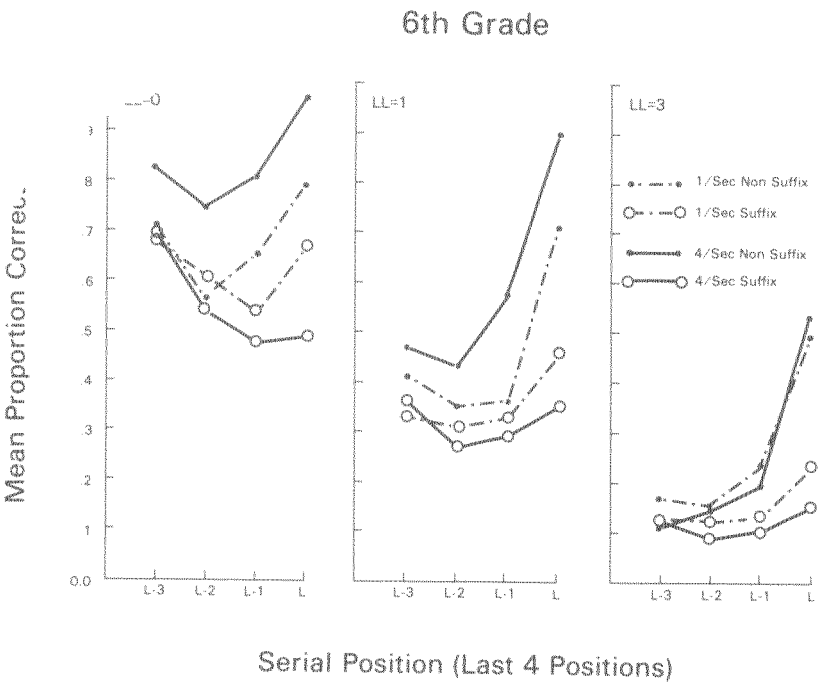

FIG. 2. Mean proportion correct for each of the last four serial positions for sixth-grad subjects.

was virtually identical for the second and sixth graders (26 to 29% fo $LL = 0$ and 25 to 28% for $LL = 1$). While the Grade × Rate × S/SN × LL interaction was not significant, the Grade × Rate × S/NS inter action was, $F(1, 104) = 4.6$, $p < .05$, and separate analyses for the 1 sec and 4/sec data supported the above conclusions with the Grade × S/NS × LL interaction significant for the 1/sec data, $F(2, 104) = 5.0$ $p < .01$, but not for the 4/sec data, $F(2, 104) = 1.2$, $p < .20$.

TABLE 1
PERCENTAGE OF SUFFIX EFFECT FOR THE LAST FOUR POSITIONS

		List length		
	Rate	0	1	3
Grade 2	1	17	13	3
	4	26	25	3
Grade 6	1	6	10	11
	4	29	28	13
Adults	1	8	6	10
	4	23	16	13

Another obvious feature of the data in Figs. 1 and 2 is that, for the two shortest lists lengths, the performance on the nonsuffix lists was much better at the 4/sec rate than at the 1/sec rate. Since performance on the suffix lists was about the same for the two rates this means that the suffix effect was larger for the lists presented at four items per second than for those presented a one item per second. Again, this larger suffix effect for the faster rate only occurred for the $LL = 0$ and $LL = 1$ conditions; there was little or no effect of rate on the longer lists. The interactions that correspond to the above described effects were the Rate $\times$ S/NS $\times$ LL interaction, $F(2, 208) = 7.9$, $p < .001$, the Rate $\times$ S/NS interaction $F(2, 208) = 3.41$, $p < .001$, and the Rate $\times$ LL interaction, $F(2, 208) = 4.2$, $p > .01$.

An additional analysis was performed involving the proportion correct for just the first two positions for each list, the primacy positions. This analysis might allow us to make some inferences about rehearsal as a factor in the effects described above since it is generally assumed that rehearsal is one factor underlying the superior recall of primacy items. These data, summed over the two initial serial positions are shown in Table 2 for all subjects. While both groups showed better performance at the 4/sec rate as reflected by the main effect of Rate, $F(1, 104) = 15.3$, $p < .001$, the interaction of Rate with Grade closely approached significance, $F(1, 104) = 2.8$, $.05 < p < .10$. This latter reflects the higher primacy performance of the sixth graders at the 1/sec rate but the higher performance of second graders at the 4/sec rate.

To summarize the relevant findings of this study, the magnitude of the suffix effects is about the same for the second and sixth graders at the 4/sec presentation rate and for the second graders at the 1/sec rate. The slow rate for the sixth graders, however, gave rise to a much smaller suffix effect. The 4/sec rate led to a larger suffix effect but primarily because of better recall in the nonsuffix condition at the faster rate than at the slower rate while the recall in the suffix condition was about the same for the two rates or slightly worse in the 4/sec condition. The analysis of primacy positions reflected better performance for both grades

TABLE 2
PERCENTAGE OF CORRECT RECALL OVER THE TWO PRIMACY POSITIONS

	Rate		
	1	4	$\bar{X}$
Grade 2	75	90	82.5
Grade 6	79	84	81.5
Adult	87	86	86.5
$\bar{X}$	80	87	

at the faster rate but with the second graders having higher primacy at the 4/sec rate and the sixth graders having higher primacy at the 1/sec rate.

DISCUSSION

The purpose of this study was to clarify the literature on the development of echoic memory and to further investigate the possible relationship between the magnitude of the suffix effect and list length in younger subjects reported by Engle (1977). The present data indicated that when digits were presented as slowly as one per second the suffix effect was larger for the second graders at the two list lengths where performance was not constrained by floor effects. The sixth graders showed better primacy performance. When the digits were presented as rapidly as four per second, however, there was little or no difference between the second and sixth graders in the decrement in performance caused by the suffix and the ancillary analysis of primacy positions showed better performance for second graders.

We interpret these results to mean that when the digits were presented slowly, the sixth graders were likely to use rehearsal strategies which had the effect of strengthening the short-term memory information for the digits so that, even if the suffix destroyed the echoic trace for the recency items, there was a high probability the item could be recalled based on the short-term memory information. (This would explain why the primacy performance at the slow rate was better for the sixth graders than the second graders.) The second graders, however, were not as likely to rehearse; instead they treated the items rather passively during input and depended on the echoic trace for the items as a basis for recall. Thus, their primacy performance at the slow rate was poor due to the lack of rehearsal.

When the items were presented as quickly as four per second, the sixth graders were unable to effectively rehearse and were forced into a passive treatment of the items at input and were therefore more dependent on the echoic trace for recall. Thus, when the confounding effects of rehearsal are eliminated or reduced by presenting the items at a rapid rate, we observe that second graders and sixth graders appear to have echoic memories, as reflected by the suffix effect, of approximately equal capacity.

We would like to argue further that a strategy of relying on echoic information is adaptive at the faster rate because there is echoic information for more items and the passive strategy would lead to those traces being more salient as a basis for recall than traces resulting from rehearsal (cf. Aaronson, 1974). Both groups of subjects show better recall at the four digits per second rate because they are more likely to rely on available sensory information than they are to rely on the results of rehearsal.

EXPERIMENT 2

Experiment 2 was performed to compare the results obtained in Experiment 1 with children to the results of a similar procedure with adult subjects. Since it made little difference in Experiment 1 whether the suffix conditions were blocked or randomized, this variable was eliminated from the following study. In other respects the experiment was nearly identical to Experiment 1.

Method

Subjects. The subjects were 36 college students participating in the Psychology Department Subject Pool as one means of completing a course requirement. They were pretested to determine digit span in a manner identical to the children in the previous experiment. The results were 5 subjects with a span of 5, 13 with a span of 6, and 18 with a span of 7.

Procedure. The subjects were tested individually with the same lists and apparatus used in Experiment 1. The variables were also the same as the previous experiment except for the obvious manipulation of Grade and the ordering of suffix and nonsuffix lists. The lists used were those from Experiment 1 that randomized the order of suffix and nonsuffix. Otherwise, the procedures and methods of scoring were identical to those used in Experiment 1.

Results

As with the previous experiment, the proportion correct for each of the last four serial positions were entered into an analysis of variance with Rate (one and four items per second), S/NS (presence or absence of suffix), List Length (zero, one or three items beyond the digit span) and Serial Position (1–4) as factors. The results are shown in Fig. 3.

It can be seen that performance was affected by rate of presentation, presence or absence of the suffix, list length, and serial position. Contrary to the performance of the children in Experiment 1, recall was better overall for those subjects receiving the lists at a 1/sec rate. But while both nonsuffix and suffix conditions performed better at the slower rate, the difference was considerably greater for the suffix conditions. Stated differently, the suffix effect was larger at the faster rate, due primarily to the much poorer performance of the suffix conditions at the faster rate even though the nonsuffix conditions resulted in somewhat poorer performance at the faster rate. These conclusions were verified by significant effects of Rate, $F(1, 34) = 5.4$, $p < .05$ and the Rate $\times$ S/NS interaction, $F(1, 34) = 10.0$, $p < .005$.

A more discerning inspection reveals that, particularly for the data from the faster rate, only the last position was involved in a suffix effect

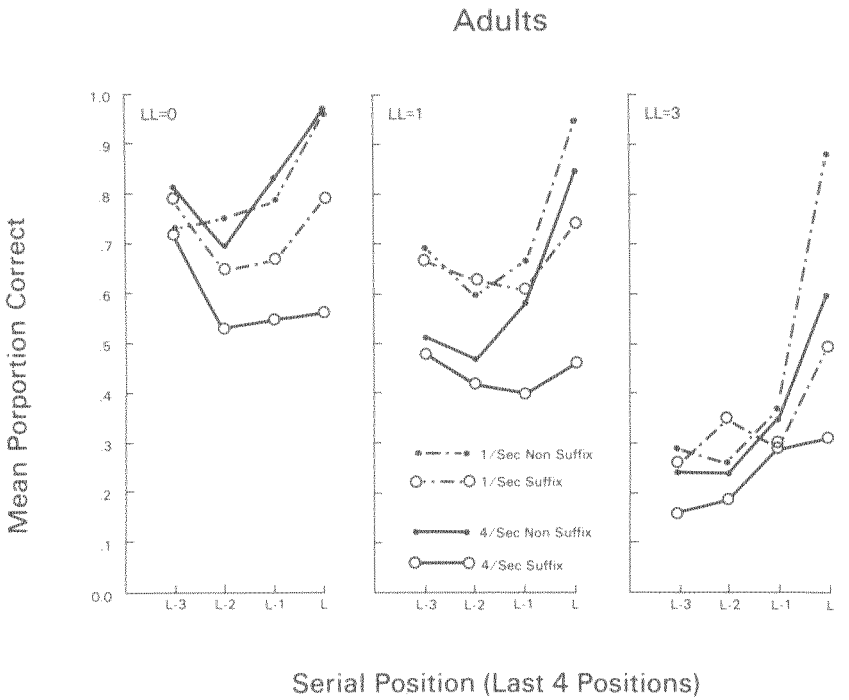

FIG. 3. Mean proportion correct for each of the last four serial positions for adult subjects.

for the longest lists ($LL = 3$). The $LL = 1$ lists showed a suffix effect for the last two positions and the $LL = 0$ lists showed a suffix effect for the last three positions. So, the suffix effect extended over three recency positions when the lists were span length, but only over one position when the lists were three digits longer than span length. These results were reflected in the significant interactions of S/NS $\times$ LL $\times$ SP, $F(6, 204) = 3.1$, $p < .01$, and Rate $\times$ S/NS $\times$ LL $\times$ SP, $F(6, 204) = 2.8$, $p < .05$.

As in Experiment 1, the data from the two primacy positions were analyzed separately. As can be seen from Table 2, there were no differences in the primacy performance for adult subjects receiving fast and slow presentation.

In Table 1 we can compare the magnitude of the suffix effect for the adult subjects with that for the younger subjects in the first experiment. It can be seen that, at least for $LL = 0$ at the fast rate, the magnitude of the suffix effect is about the same for all three groups of subjects.

Another comparison of the adult data with the results of Experiment 1 should be noted. The faster rate led to a larger suffix effect, not because of an improvement in recall for the nonsuffix condition as was the case

with the children, but because, while the performance in both non-suffix and suffix conditions was poorer at the fast rate, there was greater decrement for the suffix than the nonsuffix condition.

Since Crowder (1978) has argued that the suffix effect for only the last position should be considered important in theorizing about echoic memory and because the suffix effect in the present two experiments seems confined to about the last three positions, the data were compared another way in Table 3. This table presents the percentage of suffix effect for the two preterminal positions separately from the suffix effect for the terminal serial position. Again, we can see that, at least for $LL = 0$ at the 4/sec rate, the suffix effect for both preterminal and terminal positions was about the same for all three groups. Even for the $LL = 1$ lists at the 4/sec rate, magnitude of the suffix effect is remarkably similar over the three groups with the outlier being the terminal position for the sixth graders.

These data are also relevant to a recent paper by Penney (1979), who argued that a time-dependent echoic trace, as proposed by Crowder and Morton (1969) and Crowder (1978), should predict that faster presentation of the items and suffix should lead to a larger suffix effect, particularly for the last position since the suffix (i.e., the mask) occurs temporally closer to the last item with faster presentation. She found no such effect of rate using 10-digit lists and, thus, argued against the view of echoic memory proposed by Crowder and Morton (1969). It is obvious from

TABLE 3
PERCENTAGE OF SUFFIX EFFECT FOR THE TWO PRETERMINAL POSITIONS (P) AND THE TERMINAL POSITION (T)

	Rate	Serial position	List length 0	1	3
	1	P	14	11	0
		T	36	32	15
Grade 2					
	4	P	28	21	−4
		T	45	45	19
	1	P	4	4	7
		T	12	25	26
Grade 6					
	4	P	28	22	7
		T	47	54	37
	1	P	11	1	0
		T	17	21	38
Adults					
	4	P	22	12	5
		T	40	39	30

Table 3 that the suffix effect, at least for the adult subjects, is not much different for the fast and slow rates if we only look at $LL = 3$ but that rate does have a sizeable effect on the decrement caused by the suffix at the shorter list lengths, particularly for the terminal position. We would argue that our $LL = 3$ condition is probably similar to Penny's experiment since she used 10-digit lists, i.e., three digits beyond the proverbial magic number seven. With shorter list lengths, the effect of presentation rate on the magnitude of the suffix effect is in the direction predicted by Crowder and Morton, that is, a much larger effect of the suffix at the faster rate.

GENERAL DISCUSSION

This research was motivated by the question of whether there are developmental differences in echoic memory. Based on our data, we would argue that there is no observable difference in the capacity of echoic memory as a function of the age of the subject. The evidence suggests that, as with studies of iconic memory (i.e., Morrison *et al.*, 1974), the differences that appear to be present in some conditions are probably due to processes related to but independent of the sensory store itself.

While the magnitude of the suffix effect is larger for the youngest subjets with relatively slow presentation of the list items, with faster presentation of the items there is little or no difference in the magnitude of the suffix effect for second graders, sixth graders, and adults. We would further argue that it is only with the most rapid rate of presentation and those lists that are span length or slightly longer that we see a picture of echoic memory across age groups that is close to being uncontaminated by the differential registration and rehearsal of information in the more central postcategorical short-term memory. That is, the data from lists presented as slowly as one item per second are likely to be clouded by the greater likelihood that older subjects will attempt to rehearse the list items. Thus, recall can be accomplished from the resulting trace in short-term memory even if the echoic trace has decayed or has been eliminated by the suffix mask. This is one of the less-than-desirable characteristics of the suffix procedure. In other words, it is difficult to distinguish between items being recalled as a result of sensory information and items being recalled as a result of some source of information that is more permanent.

One result of the two studies that we find very interesting is that speeded presentation facilitated the recall performance of both groups of children but retarded the performance of adults. This result is not necessarily related to echoic memory because, as Aaronson (1967) argues, presentation rate can have at least two effects in studies of short-term memory: (1) faster presentation of items may allow less time for

decay and therefore result in better recall performance, and (2) faster presentation may give less time for perception, encoding and rehearsal and, therefore, result in lower performance. The first effect is presumably independent of strategic factors while the second is determined by the nature of the strategies used and the degree to which they are used.

It is our contention here that echoic memory does play a role in the reverse effects of presentation rate for children and adults and in the following way. First, it is assumed that there is echoic information about more of the list items with faster presentation rates than with slower rates. While this is probably true regardless of list length, the serial output of longer lists simply means that the subject would not begin to make use of that echoic information until it had considerably decayed and the result would be less difference between the amount of echoic information for the different rates. Thus, it is most obvious at shorter list lengths.

The second graders probably use relatively few encoding and rehearsal strategies, even at the slow rate, relying instead on the echoic trace as their basis for recall. Thus, the rapid rate of presentation facilitates their performance because there is more echoic information available. The sixth graders probably do use encoding and rehearsal strategies, at least at the slow rate and thus the suffix has an attenuated effect because there is a postcategorical source for recall even if some of the echoic trace is destroyed.

At the rapid rate, however, we assume that the sixth graders are unable to encode and rehearse rapidly enough to make use of strategies. Thus, they revert to the passive reliance on echoic information used by the second graders. We have to assume that, at least for the sixth graders, the first factor mentioned above is more adaptive than is the second. That is, the beneficial effect of less decay with faster presentation is more beneficial to recall than is rehearsal with slow presentation.

The adults on the otherhand are assumed to be almost automatic in their use of strategies and do not adopt a passive stance even when the rate of presentation is so rapid as to make rehearsal difficult. That is, they persist in their attempts at rehearsal at the fast rate even though a passive strategy might be more useful. Beyond that we have to assume that the encoding and rehearsal strategies of adult subjects are sufficiently sophisticated that any benefit to be gained by less decay in the rapid presentation condition is offset by the additional time for rehearsal with slower presentation.

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