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Structural and Strategic Factors in the Stimulus Suffix Effect

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The stimulus suffix effect has been typically viewed as reflecting the displacement of the current information residing in a limited-capacity sensory store by the presentation of a subsequent speech sound. The present research was primarily concerned with determining if strategic factors will also influence the stimulus suffix effect. An experiment was conducted, based on the research by Aaronson (*Journal of Experimental Psychology*, 1968, 76, 129–140; *Cognitive Psychology*, 1974, 6, 133–158), in which both presentation rate (6, 3, 1.5 digits/second) and practice with suffix or no-suffix lists were factorially crossed between-subjects factors. The serial recall results of 7-item lists of digits indicated that both presentation rate and practice with suffix lists modulated the preterminal suffix effect for serial positions 3–6, whereas, the terminal suffix effect for serial position 7 was relatively unaffected by these variables. These results were viewed as indicating that the suffix effect reflects two distinct processes: 1) a more strategic mechanism which primarily underlies the preterminal suffix effect and 2) a more structural mechanism which primarily underlies the terminal suffix effect. It was therefore argued that only the terminal suffix effect should be viewed as a relatively pure index of the contribution of echoic information to short-term memory performance.

Within the past decade, one of the more pervasive areas of research has been concerned with the investigation and delineation of the auditory sensory store, hereafter referred to as echoic memory. Although there has been considerable diversity in the methodological paradigms used to investigate this store, by far the greatest part of this research has utilized the stimulus suffix technique. In a standard suffix experiment subjects are auditorily presented a list of verbal items for serial recall. In the control condition there is either silence at the end of the list or a nonverbal cue, such as a tone, which prompts the subject to begin serial recall. In the experimental condition the cue to begin recall is a redundant non-recalled speech suffix appended to the end of the list in rhythm with the other list items. Since the suffix item is the same over a substantial number of trials one would expect that subjects should be quite able to learn to ignore it. However, when the suffix condition is compared to the control condition, there is a dramatic increase in errors in the suffix condition primarily for the last list items presented, that is, the recency portion of the serial position curve.

Crowder and Morton (1969) and Crowder (1972, 1976, 1978) argue that the suffix effect reflects a form of echoic memory they refer to as precategorical acoustic storage (PAS). In the control condition a subject has the extra PAS information about the last few list items which can be used to facilitate memory performance on those items, and consequently, leads to the robust recency effect commonly found for auditorily presented materials. However, when the stimulus suffix is presented at the end of the list it displaces any information in PAS, thereby attenuating that recency effect. Although there has been some dis-

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agreement on certain aspects of echoic memory (Kahneman, 1973; Massaro, 1972), this sensory store has typically been viewed as a structural aspect of the human memory system, similar to its visual counterpart, iconic memory, in being affected primarily by the physical parameters of the stimulus materials (Morton, Crowder, & Prussin, 1971).

In the present research an attempt was made to determine whether strategic variables might also influence the stimulus suffix effect. The theoretical framework developed by Aaronson (1968, 1974b) provided an orienting base for this research. Aaronson suggests that there are basically two processes involved in the recall of auditorily presented lists. First, there is a low-level, more passive sensing process which is based largely on the physical features of the stimulus items. The output from this sensing process is then held in an acoustic sensory store similar to Crowder and Morton's PAS. Second, there is a higher-level, more active identification process in which the auditory representation is actually given a label or categorized. The output from this latter process is presumably held in a short-term memory buffer. Aaronson further argues that, depending upon the prevailing presentation rate, subjects may differentially emphasize the sensing or identification process. Specifically, at slow presentation rates subjects may emphasize an active strategy in which each item is both sensed and identified as it is presented, whereas, at fast presentation rates subjects may emphasize a passive strategy in which each item is only sensed during list presentation and then is identified after the complete list is presented.

Given these assumptions, it seemed reasonable that one should be able to modulate the suffix effect by inducing in subjects either the more passive sensing process or the more active identification process. More specifically, if at very fast presentation rates, subjects are more likely to hold the list items in a sensory buffer, as Aaronson suggests, and if the effect of the suffix is to displace the current contents of that sensory buffer, as Crowder suggests, then one should expect to find a relatively larger suffix effect at the fastest presentation rates. On the other hand, with the slower presentation rates, since subjects should presumably be able to identify the list items as they are presented, the suffix effect should be relatively smaller, since the suffix should only minimally interfere with categorical short-term memory information.

The present research was conducted in order to test these possibilities and thus followed the same basic design as the research conducted by Aaronson (1968; 1974a, Experiment I). That is, all subjects participated in two sessions conducted one day apart. Throughout both sessions subjects serially recalled aloud seven-digit sequences. During Session 1 both presentation rate (6, 3, 1.5 digits/second) and the presence or absence of the suffix word "go" were factorially crossed between-subjects factors. Again, based on Aaronson's model, we expected the results of Session 1 to yield a larger suffix effect across more serial positions at the faster presentation rates. During Session 2 all subjects received the same set of 80 lists; 40 with the suffix and 40 without the suffix at a moderate presentation rate of 3 digits/second. Session 2 was conducted in order to determine if any different listening strategies that developed during Session 1 would transfer to a common set of lists received by all subjects.

Method

Subjects

Eighty-four undergraduates participated in this experiment as an option to fulfill a psychology course requirement. Each subject participated in two experimental sessions and for the first of these sessions an equal number of subjects participated in each of six unique between-subjects conditions (three presentation rates: 1.5, 3, and 6 digits/second × suffix vs no-suffix lists).

Stimulus Materials

All stimulus lists were produced by a Votrax speech synthesizer interfaced with a PDP-11 computer and recorded on magnetic tape via a Sony reel-to-reel tape recorder. The digits 1–9 (excluding the two-syllable digit 7) along with the word "go" were originally produced by combining different phonemic patterns and stresses which, as judged by the present authors, most closely approximated the natural language sound of each of the stimuli. The duration of all stimulus items as measured from oscilloscope recordings was approximately 150 milliseconds. Once the acoustic pattern was developed for each of the stimulus items, this pattern was utilized across all conditions, thereby holding the acoustical properties of the stimuli constant throughout the experiment.

Each seven-digit sequence was formed by randomly selecting without replacement seven digits from the total set. The same sequences were used for each between-subjects condition. Rates of 1.5, 3, and 6 digits/second were produced by varying the silent interval between the digits. The suffix word "go" was recorded in rhythm with the prevailing presentation rate for the suffix lists. A tone which cued the subject to begin their recall was recorded 4 seconds after the last digit item for both the suffix and the no-suffix lists. There was a 15-second silent interval between lists for the subjects to make their oral serial recall.

Procedure

During Session 1 subjects received 15 practice trials and 89 test trials. A 5-minute break occurred between the first 44 trials and the second 45 trials. (Hereafter the first 44 trials will refer to the first half of Session 1, and the second 45 trials will refer to the second half of Session 1.) All subjects returned to the lab the following day for Session 2. During this session subjects received 20 practice lists along with 80 test lists (40 with the suffix and 40 without the suffix). Suffix and no-suffix lists were blocked; half the subjects within each between-subjects condition received the suffix block of lists first while the remaining half received the no-suffix block first. In order to reinstate any listening strategies that may have developed the previous day, the 20 practice lists that subjects received during Session 2 were of the same between-subjects condition that they received the previous day.

Throughout the experiment each subject was tested individually in a small room. The lists were presented to the subjects via headphones. Subjects were instructed to wait for the tone to begin their oral serial recall and that the experimenter would record their response. After subjects recalled each list they were given immediate feedback. If the subject recalled the correct list items in their correct order, a green light was flashed, whereas, a red light was flashed when a mistake was made.

Before subjects received suffix lists for the first time they were told that the word "go" would occur at the end of the forthcoming lists and that they should either ignore the word or use it as a signal that the list had ended, but they were not to recall the word "go" along with the other list items. Furthermore, during Session 2, each subject was appropriately informed that there would be a shift in presentation rate and/or the presence of the suffix in the forthcoming lists. In this way, throughout both sessions subjects were aware of the type of list (i.e., with respect to presentation rate and the presence of the suffix) they would be receiving before the lists were actually presented.

At the end of Session 1, each subject was asked to complete a brief strategy questionnaire. This questionnaire included the four strategy statements reported by Aaronson (1967, p. 141) which ranged from "you passively waited for all seven digits to be presented and then actively listened to them" to "you actively listened to each single digit as it was presented." Subjects simply rated each strategy according to

how often they used that strategy with a rating of 5 meaning "I always used this strategy" and 1 meaning "I never used this strategy."

Design

During Session 1, two factorially crossed between-subjects factors (presentation rate and suffix condition) and one within-subjects factor (serial position) produced a $3 \times 2 \times 7$ mixed-factor design. During Session 2, three factorially crossed between-subjects factors (presentation rate during Session 1, suffix condition during Session 1, ordering of the suffix and no-suffix blocks during Session 2) and two within-subjects factors (suffix condition during Session 2 and serial position) produced a $3 \times 2 \times 2 \times 2 \times 7$ mixed-factor design.

Results

Throughout the following analyses a strict scoring procedure was utilized. That is, a 1 was given for a correct digit recalled in the correct serial position, whereas a 0 was given in any other case.

Session 1

Figure 1 displays the mean percentage correct recall as a function of presentation rate, suffix condition, and serial position. There are three general observations that should be made about the data displayed in Figure 1: (1) the suffix manipulation had its typical effect, since the difference between suffix and no-suffix groups becomes larger at the later serial positions for all three presentation rates; (2) there is little effect of presentation rate on the obtained suffix effect for serial position 7, where the suffix effect is overall the largest for all three rates; (3) there does appear to be a consistent effect of presentation rate on the obtained suffix effect for the preterminal serial positions 3–6 with the slower presentation rates producing the larger preterminal suffix effects.

In order to test the statistical reliability of these effects a 3 (Presentation Rate) × 2 (Suffix Condition) × 2 (First Half vs Second Half of Session 1) × 7 (Serial Position) analysis of variance was performed on the mean percentage correct recall. The First vs Second Half factor was included in this analysis to determine if there was any evidence of a buildup of a strategic factor across Session 1 lists.

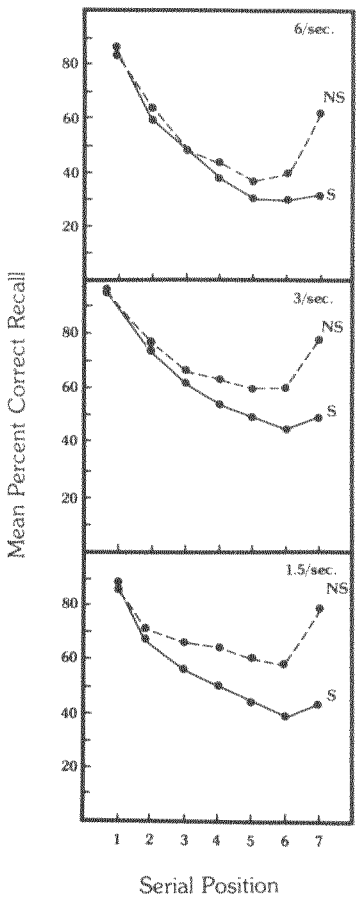

FIG. 1. Mean percentage correct recall as a function of presentation rate, suffix condition, and serial position (NS = no-suffix lists; S = suffix lists).

This analysis yielded a number of noteworthy effects. (Unless otherwise specified, all significant effects have p values less than .05.) First, a significant interaction between presentation rate and serial position was obtained, $F(12,468) = 3.87$, $MS_e = 125.45$, indicating that presentation rate had little effect on performance for the first two serial positions but for the last five serial positions, subjects receiving the fastest presentation rate performed

lower than subjects receiving the slower presentation rates. Second, a significant interaction was also obtained between serial position and the First vs Second Half factor, $F(6,468) = 5.44$, $MS_e = 34.59$, indicating that subjects simply performed better during the second half of Session 1 primarily for the last four serial positions. The most important result of this analysis, however, was a significant interaction among presentation rate, suffix condition, first vs second half of Session 1, and serial position, $F(12,468) = 2.69$, $MS_e = 34.59$. This interaction is shown in Figure 2 which displays the mean percentage correct recall as a function of first vs second half of Session 1, presentation rate, suffix condition, and serial position. There are basically two observations that should be made from the data displayed in Figure 2. First, during the first half of Session 1, there is little, if any, consistent effect of presentation rate for the obtained suffix effect. However, during the second half of Session 1, a consistent pattern does appear to emerge. More specifically, at the preterminal serial positions 3–6 there is a consistent increase in the suffix effect with the slower presentation rates, however, at the terminal serial position, presentation rate does not appear to exert any consistent increase or decrease on the obtained suffix effect.

The above observations were supported by two separate simple effects analyses on

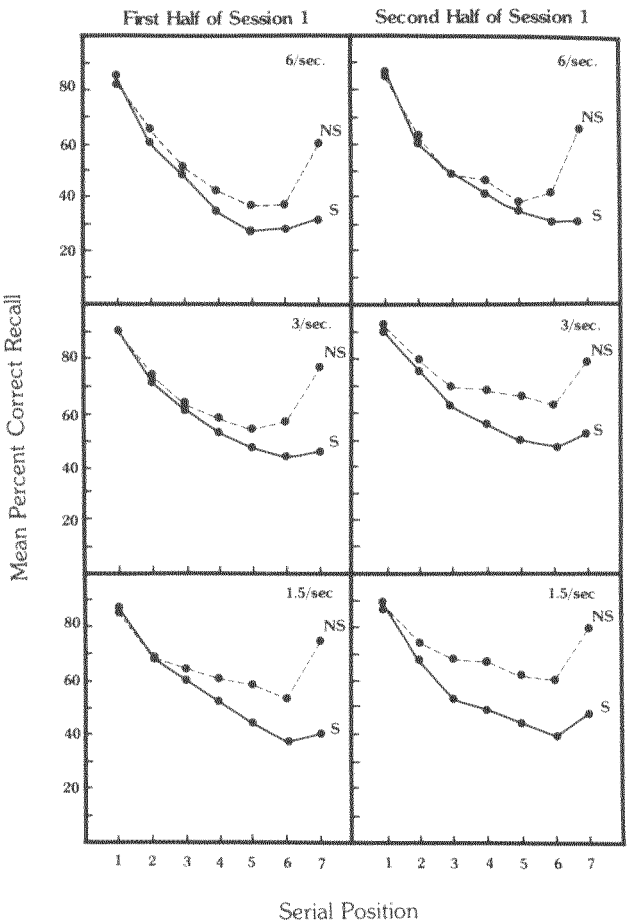

FIG. 2. Mean percentage correct recall as a function of first vs second half of Session 1, presentation rate, suffix condition, and serial position (NS = no-suffix lists; S = suffix lists).

the serial positions 3–7 for the first half and second half of Session 1. (Serial positions 1 and 2 were excluded from these analyses because there was little if any evidence of a suffix effect at these serial positions.) As expected, for the first half of Session 1, the interaction among presentation rate, suffix condition, and serial position did not approach statistical significance, $F(8,312) = .47$, $MS_e = 59.47$. However, for the second half of Session 1, the interaction among presentation rate, suffix condition, and serial position was significant, $F(8,312) = 2.57$, $MS_e = 52.77$. Post hoc t tests which were based on the error term from the interaction obtained in the second half of Session 1 were conducted at serial positions 3–7 to determine if the mean differences were indeed statistically reliable. These t tests confirmed our expectations. That is, for the preterminal serial positions 3–6, the slow presentation rate led to a significantly larger suffix effect than did the medium presentation rate which in turn led to a significantly larger suffix effect than the fastest presentation rate. The only two exceptions to this were: (1) the medium presentation rate did not produce a significantly greater suffix effect than the fast presentation rate for serial position 6, $t(368) = 1.75$, $p < .10$; (2) the slow presentation rate did not produce a significantly greater suffix effect than the medium presentation rate for serial position 5, $t(368) = 1.20$, $p > .10$. However, it is also noteworthy that both of these exceptions still followed the overall pattern of the effect of presentation rate at the preterminal serial positions 3–6. On the other hand, for the terminal serial position 7, the only significant effect of presentation rate on the obtained suffix effect was that the fastest presentation rate led to a significantly larger suffix effect than the medium presentation rate. However, since the fastest and the slowest presentation rates produced comparable terminal suffix effects, with the medium presentation rate producing the smallest terminal suffix effect, we are led to conclude that presentation rate has little, if any, consistent effect on the magnitude of the large terminal suffix effect, but does have a substantial and consistent effect on the magnitude of the smaller preterminal suffix effect.

Session 2

Before presenting the results of Session 2 it is important to remind the reader that during Session 2 all subjects received the same 80 lists—40 with the suffix and 40 without the suffix—presented at a moderate presentation rate of 3 digits/second. Furthermore, since the presence or absence of the suffix was a within-subjects factor during Session 2, the mean relative suffix effect for each serial position for each subject was calculated using the formula

$$\frac{(\%\text{ Correct on No-Suffix Lists} - \%\text{ Correct on Suffix Lists})}{(\%\text{ Correct on No-Suffix Lists})}$$

This measure was utilized to give an estimate of the effect of the suffix on performance relative to the overall level of performance at that serial position on no-suffix lists. Theoretically, this measure should give an estimate of the amount of useful information (possibly echoic) that is displaced or interfered with by the presentation of the suffix item and which could have been used to supplement recall, as indicated by no-suffix list performance.

The results of Session 2 were submitted to a 3 (Presentation Rate during Session 1) × 2 (Suffix Condition during Session 1) × 2 (Order of Suffix Conditions during Session 2) × 7 (Serial Position) analysis of variance on the mean relative suffix effect. In addition to this overall analysis, separate 3 (Presentation Rate during Session 1) × 2 (Suffix Condition during Session 1) × 2 (Order of Suffix Conditions during Session 2) analyses of variance were conducted on the mean relative suffix effect for each of the last 5 serial positions. At this point, it should be noted that since for some individual subject-positions, performance was actually higher

on the suffix lists than on the no-suffix lists, a negative mean relative suffix effect was obtained at these particular subject positions. These negative mean relative suffix-effects, however, were not eliminated from the above-described analyses.

Although the overall analysis indicated that training at different presentation rates during Session 1 did not significantly influence the obtained suffix effect or participate in any significant interactions during Session 2 (all F's < 1.00), an interesting pattern did emerge in the results of Session 2. This pattern is shown in Figure 3 which displays the mean percentage correct recall as a function of suffix condition during Session 1, suffix condition during Session 2, and serial position. Also, in Figure 3 are displayed the mean relative suffix effects obtained in Session 2 for those receiving suffix lists during Session 1 and those receiving no-suffix lists during Session 1. As can be seen in Figure 3, subjects receiving suffix lists the previous day showed less of a suffix effect during Session 2 than those subjects receiving no-suffix lists the previous day, $F(1,72) = 7.52$, $MS_e = .108$. This effect is in itself interesting because the suffix effect has been viewed as being relatively independent of practice effects (cf. Crowder, 1969).

The second observation to be made from the data displayed in Figure 3 is that practice with suffix lists the previous day primarily reduced the suffix effect for the preterminal serial positions 3–6, the same serial positions that were influenced by presentation rate during Session 1. Although the results of the overall analysis indicated that the interaction between suffix vs no-suffix lists and serial position only approached statistical significance, $F(6,432) = 1.72$, $MS_e = .028$, $p = .12$, the results of the separate ANOVAs for each serial position did support our interpretation of the results displayed in Figure 3. More specifically, these analyses yielded an effect of practice with suffix lists the previous day which was significant at serial position 3,

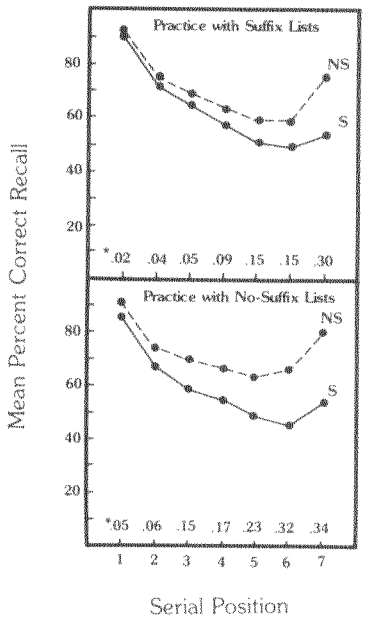

FIG. 3. Mean percentage correct recall as a function of suffix condition during Session 1, suffix condition during Session 2, and serial position (NS = no-suffix lists; S = suffix lists).

* Numbers refer to the mean relative suffix effect at that serial position, see text for details.

$F(1,72) = 4.50$, $MS_e = .046$; approached significance at serial position 4, $F(1,72) = 2.81$, $MS_e = .047$, $p < .10$; was significant at serial position 5, $F(1,72) = 4.67$, $MS_e = .032$; and was significant at serial position 6, $F(1,72) = 8.11$, $MS_e = .067$. Furthermore, a separate post hoc analysis on just the preterminal serial positions 3–6 also yielded a highly significant overall main effect of practice with suffix lists the previous day, $F(1,72) = 9.86$, $MS_e = .096$. On the other hand, for serial position 7, the effect of practice with suffix lists the previous day did not approach statistical significance, $F(1,72) = .77$, $MS_e = .032$.

The only remaining effect which reached statistical significance was the effect of order of suffix conditions for serial position 5, $F(1,72) = 7.00$, $MS_e = .032$, indicating that subjects receiving the block of 40 suffix lists first during Session 2 exhibited a smaller suffix effect than those who received the block of 40 no-suffix lists first

during Session 2. A similar pattern was also found for the remaining serial positions and indeed when collapsed across the preterminal serial positions 3–6, the mean relative suffix effect for those receiving the suffix block first (.125) was significantly smaller, $F(1,72) = 5.04$, $MS_e = .096$, than those receiving the no-suffix block first (.20). This effect suggests that subjects can quickly develop a strategy during the first 40 lists of Session 2 which is specific to suffix or no-suffix lists and in turn may interfere with performance on the remaining 40 lists during Session 2. The important point to note, however, is that again this interference appears to be localized for the preterminal serial positions 3–6, since the difference between the relative suffix effect for those receiving the suffix block first (.32) compared to those receiving the no-suffix block first (.31) did not approach statistical significance for the terminal serial position, $F(1,72) = .07$, $MS_e = .032$.

General Discussion

The results of the present research are quite clear. Both presentation rate and practice with suffix lists had reliable effects on the suffix effect obtained for the preterminal serial positions 3–6; however, for the last serial position, there was little, if any, effect of these variables. These effects are even more noteworthy when one considers that the terminal suffix effect is considerably larger than the preterminal suffix effect and therefore should have more latitude to be influenced by these variables. However, before we discuss the implications of this pattern of data for current theoretical accounts of the suffix effect, we shall first briefly discuss their relevance for Aaronson's (1968, 1974b) model of auditory memory.

In the introduction, it was predicted that a larger suffix effect should be found at the faster presentation rates. This prediction was based on Aaronson's notion that subjects should be more likely to hold the list items in a sensory store at the faster presentation rates, since there should not be sufficient time to both sense and identify the items at list presentation. Thus, when the suffix is presented, there should be more sensory information—that may be potentially displaced by the suffix—at the faster presentation rates. The results of Session 1, however, clearly did not support this prediction. Instead, the slower presentation rates actually led to an increased suffix effect which was primarily localized at the preterminal serial positions. Thus, the present results appear to demand a finer discrimination than is currently available between the sensory buffer described by Aaronson and that component of memory which is influenced by the stimulus suffix.

Implications for Theoretical Accounts of the Suffix Effect

The issue still at hand is what mechanism(s) led to the pattern of data obtained in the current research? One possible account of this research is based on the notion that the preterminal suffix effect is mediated by a different mechanism than that which mediates the terminal suffix effect. In fact, Crowder (1976, 1978) has argued that only the terminal suffix effect should be viewed as a reflection of echoic memory. Unfortunately, there has been little empirical evidence to date which discriminates terminal from preterminal suffix effects. Furthermore, this failure to discriminate terminal from preterminal suffix effects is theoretically crucial, since it may have propagated the current disarray in theoretical accounts of echoic memory. For example, Penney (1979), on the basis of an obtained suffix effect for the last 5–6 serial positions, argued that PAS information must be available for the last 5–6 items, a greatly disparate estimate from Crowder's one-item capacity. Also, the frequent presence of a suffix effect across numerous serial positions may have led some theorists to attribute the suffix effect to interference in a relatively more permanent auditory short-term memory store instead of the displace-

ment of auditory sensory information (Massaro, 1972; Penney, 1978).

In this light, the present research has considerable theoretical import, since it appears to indicate that only the terminal suffix effect is a reflection of echoic information, whereas the preterminal suffix effect may reflect a different, more strategic, mechanism. This general argument is supported by a number of converging aspects of our data. First, if the preterminal suffix effect is based solely on echoic memory, and, if the echoic store has a temporal decay parameter which has been estimated to be about 2 seconds[1] (Crowder, 1971), then one should expect a suffix effect only for those list items which occurred within 2 seconds of the suffix, that is, only at serial positions 6 and 7 at the slow presentation rate and at all seven serial positions at the fast presentation rate. However, the present research actually yielded a larger preterminal suffix effect at the slow than at the fast presentation rate. Therefore, it seems unlikely that these preterminal suffix effects could simply reflect an echoic trace which decays within 2 seconds of its instantiation. Second, the effect of presentation rate on the preterminal suffix effect developed primarily during the second half of Session 1, that is, after subjects had sufficient practice to develop listening strategies that were specific to the prevailing presentation rates. However, the terminal suffix effect was relatively unaffected by presentation rate in both the first and second half of Session 1, which should be expected if indeed the terminal suffix effect reflects a more mechanical displacement of echoic information. Third, subjects receiving the fast presentation rate reported using the *passive* listening strategy (mean rating = 3.3) *more* often than those receiving either the medium (mean rating = 2.9) or the slow (mean rating = 2.8) presentation rate. On the other hand, subjects receiving the fast presentation rate reported using an *active* listening strategy (mean rating = 2.3) *less* often than those receiving either the medium (mean rating = 2.7) or the slow (mean rating = 2.8) presentation rate. These self-report data suggest that there were indeed strategic differences between subjects receiving different presentation rates (a similar pattern has been reported by Aaronson, 1967). Fourth, the results of Session 2 indicated that those subjects who received suffix lists the previous day exhibited a smaller preterminal suffix effect than those who received no-suffix lists the previous day. This latter finding suggests that with practice subjects may develop a strategy that will attenuate the preterminal suffix effect. On the other hand, the terminal suffix effect appeared to be impervious to such practice effects which again should be expected if the terminal suffix effect is simply the result of a more mechanical displacement of echoic information.

[1] Watkins and Todres (1980) have recently presented data which appear to indicate that a suffix effect can be found over a 20-second delay between the presentation of the last list item and the presentation of the suffix item; thereby suggesting that echoic information lasts up to 20 seconds (also, see Watkins & Watkins, 1980a). Although their data are compelling, we still have a few reservations with accepting their conclusion of a 20-second echoic trace at the present time. First, the suffix effects presented in their research were on the average approximately 15% effects at the terminal serial position. This effect is approximately half the suffix effect that is typically reported, thereby suggesting that there was considerable loss of information even at their shortest suffix delay of 2 seconds, which is Crowder's estimate. Second, they did not present suffix delays less than 2 seconds to determine the shape of the decay function during the first 2 seconds after list presentation. Possibly, the majority of usable echoic information is indeed lost in the first 2 seconds. Third, it is not clear whether the suffix effect obtained at such long delays is due to sensory information or to interference in a relatively more permanent memory store. To test this possibility it would be useful to show that the suffix effect at these long delays is (1) dependent upon the physical relationship between the list items and the suffix items and (2) independent of the semantic similarity between the list items and the suffix items. Finally, it is important to note that there are a number of studies which have utilized different methodological approaches to echoic memory that appear to converge on the notion of an echoic trace lasting on the order of 1–4 seconds (cf. Crowder, 1976, Chap. 3, for a review of this literature).

The Nature of the Preterminal Suffix Effect

If the preterminal suffix effect is primarily due to the influence of a strategic mechanism, then an issue that still must be addressed is to more clearly specify the nature of this strategic mechanism. One possibility, which has consistently recurred in the literature, is that the suffix interrupts attentional processes. For example, Kahneman (1973) has argued that the suffix effect simply reflects failures in selective attention and grouping instead of echoic memory. Although there are a number of difficulties with Kahneman's particular attentional account of the suffix effect (see Crowder, 1976), an attentional model may still be useful in accounting for the preterminal suffix effect. More specifically, it may be the case that even though the subject fully expects the suffix to occur over a substantial number of lists he/she is unable to exclude the suffix from attention. In this case the effect of the suffix is to demand attention which could otherwise be directly allocated to the list items or allocated to strategic processes such as rehearsal or response organization.

The results of the present research fit quite nicely into an attentional/strategic account of the preterminal suffix effect. For example, during Session 1, if indeed subjects receiving the fastest presentation rate engaged in a more passive listening strategy (allocated less attention to the list items), then the absolute deleterious effect of allocating attention to the suffix should be attenuated at the fastest presentation rate, as the results indicated. With respect to the Session 2 results, practice with suffix lists may have allowed subjects to become able to allocate more attention to the list items and less attention to the redundant suffix, thereby reducing the deleterious effect of the suffix. Indeed, there are recent studies (e.g., Hirst, Spelke, Reaves, Caharack, & Neisser, 1980) which indicate that with practice there is a reallocation of attentional capacity to maximize task performance. On the other hand, subjects who received suffix lists for the first time during Session 2, had no practice in distinguishing the to-be-recalled list items from the nonrecalled suffix item and therefore the suffix should have demanded considerable attention which could have otherwise been allocated to the preterminal list items.

In a study particularly relevant to the present discussion, Hitch (1975) directly investigated whether there is an attentional component underlying the stimulus suffix effect. In the auditory conditions of his second experiment, subjects were either presented "sandwiched" lists in which a redundant suffix item was interleaved between all items, or standard lists with no interleaved suffix items. Hitch argued that by interleaving the suffix word between list items subjects should become able to selectively attend to only the list items and ignore the irrelevant suffix items, thereby eliminating the suffix effect for the sandwiched conditions. However, results of an analysis conducted on the sandwiched conditions and a *separate* analysis on the standard conditions yielded significant suffix effects for both conditions, therefore suggesting that the auditory suffix effect is not mediated by an attentional mechanism. Interestingly, however, a closer inspection of Hitch's data (Fig. 2, p. 504) reveals that only the terminal suffix effect was uninfluenced by sandwiching the suffix item; the preterminal suffix effect for the sandwiched conditions was indeed reduced when compared to the preterminal suffix effect for the standard nonsandwiched conditions. In fact, there was little, if any, difference between the terminal suffix effect for the standard (.36) and the sandwiched conditions (.38), whereas, for the preterminal serial positions 2–7, the obtained suffix effect was significantly larger for the standard (.20) than for the sandwiched conditions (.08), $F(1,30) = 11.67$, $MS_e = .031$. Thus, if the effect of interleaving the suffix word between list items is to allow subjects to

selectively attend to only the list items and ignore the irrelevant suffix items, it appears that this "extra" attention given to the list items only influences performance at the preterminal serial positions and does not influence performance at the terminal serial position. In this light, we believe the Hitch data lend support to our contention that the preterminal suffix effect is relatively more dependent upon an attentional factor, whereas the terminal suffix effect is more dependent upon the displacement of echoic information.

Recently, Baddeley and Hull (1979) have also argued that the terminal and preterminal suffix effects are being mediated by different mechanisms. They base their argument on the results of two experiments which indicate that as the number of syllables in the suffix item increases, the preterminal suffix effect increases, whereas, the terminal suffix effect decreases. (Actually, the terminal suffix effect appears to be unaffected when it is compared against a no-suffix control condition; however, Baddeley and Hull did not utilize this more standard measure for the terminal suffix effect.) Within the present framework, these preterminal suffix syllable effects may be attributed to the longer suffixes drawing more attention than the shorter suffixes. It does, in fact, seem reasonable that since the longer suffixes were both longer in duration and had more phonemic pattern changes, they may demand a greater amount of attentional capacity. According to the present arguments this increased demand on attentional capacity should have led to an increased preterminal suffix effect, as Baddeley and Hull reported.

Concluding Remarks

In closing, it is important to note that we are not arguing that the preterminal suffix effect is exclusively the result of strategic processes whereas the terminal suffix effect exclusively reflects echoic memory. Rather, we are suggesting that the preterminal serial positions, because of the increased difficulty with which they are recalled (as indicated by serial position functions), are more demanding of strategic memorial processes which in turn are influenced by the presence of a stimulus suffix. On the other hand, since an echoic sensory trace for the last auditorily presented item should be freest from factors such as sensory decay, displacement, and/or interference, the terminal suffix effect should be the *best* reflection of echoic memory. In this light, we feel that when one wishes to make inferences about echoic memory and utilizes the stimulus suffix paradigm, only the suffix effect obtained for the last serial position should be viewed as a relatively "pure" strategy-free estimate of the echoic store.

The notion of two processes underlying the suffix effect is not new to this area of research. There have been numerous theorists (e.g., Morton, 1976; Morton et al., 1971; Routh & Davison, 1978; Routh & Lifschutz, 1975; Watkins & Watkins, 1980b) who have also suggested that the suffix effect not only reflects echoic memory but may also reflect a more central or cognitive (cf. Morton, 1970) mechanism. However, these theorists have made no distinction between the mechanisms underlying the terminal and preterminal suffix effects, that is, both mechanisms are presumably involved at any serial position where a suffix effect is obtained. Since with this approach an obtained suffix effect can often be attributed to either or both mechanisms, it has been difficult for researchers to empirically tease the two mechanisms apart. However, we have suggested, based on the present research, that strategic and structural mechanisms may have a differential influence on preterminal and terminal suffix effects. This view was primarily supported by the finding that strategic variables such as presentation rate and practice with suffix lists influenced the preterminal suffix effect but had little impact on the terminal suffix effect. Thus, the present re-

search not only supports the distinction between two processes underlying the suffix effect but also suggests that the echoic suffix interference occurs primarily at the last serial position, whereas, the more central suffix interference occurs primarily at the preterminal serial positions.

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