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Articulatory organization in the prefix effect*

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Neisser, Hoenig, and Goldstein (1969) reduced the "stimulus prefix effect" (diminished recall of seven digits preceded by a redundant prefix) when the redundant prefix and the recall digits were produced by different speakers. In the present studies, similar results were obtained using one speaker only, but with the prefix and recall digits spoken separately in different utterances and combined by tape splicing. The results support a hypothesis concerning the perception of intact, wholistically organized articulatory units. A second hypothesis, also based on the idea of intact articulatory units, was tested.

When the stimulus is a string of seven recall digits preceded by a redundant prefix ("zero") and the required response is only the digits, recall is suppressed compared to when the stimulus is only the string of seven digits (Dallett, 1964). This phenomenon is commonly referred to as the "stimulus prefix effect."

Neisser, Hoenig, and Goldstein (1969) reduced the stimulus prefix effect by constructing their stimuli in a different manner than in previous stimulus prefix experiments. The standard way of constructing the stimuli is by having a speaker produce, in a single utterance and in a monotone voice, the redundant prefix followed by seven digits. This standard condition is usually referred to as the 07:7 condition (prefix plus seven digits as stimulus: seven digits as response). In a new experimental condition in the Neisser et al study, the "zero" was spoken by a male speaker whereas a female speaker spoke the seven recall digits (0′7:7 condition). It was found that the recall in their new experimental condition (0′7:7) was better than in the standard condition (07:7).

Neisser et al interpreted their data in terms of the listener's perceptual organization. To the present authors, however, there seem to be two factors which could have caused the prefix and the recall digits to be perceived as two distinct units, both of which tend to focus on production rather than perception. One is the dissimilarity in voice quality between the prefix and the recall digits in the 0′7:7 condition. The second factor is that when a single speaker pronounced both the prefix and the seven recall digits (07:7 condition), the result is one wholistically organized articulatory unit—an eight-digit string. In the 0′7:7 condition, however, the "zero" prefix and the recall digits necessarily are spoken as different articulatory units. Thus, based on either factor, it should be more difficult for the listener to separate the prefix from the recall digits in the 07:7 condition, and hence lower recall scores would be expected.

It is obvious that the effect of either voice quality or articulatory organization, or both, could explain the Neisser et al results. In the present paper, the effect of articulatory organization will be tested.

According to the present view of articulatory organization, the acoustic speech signal is divided into wholistic, integrated units by pauses and/or terminal intonation contours. Each of these units normally consists of seven syllables or so in continuous speech and has been called a rhythmic pattern (Martin, 1972), breath group (Lieberman, 1967), or phonemic clause (Trager & Smith, 1951). While the units of interest in this paper are acoustic and perceptual, they are coextensive with, and will be referred to as, *articulatory units*, to emphasize the point that they are produced by integrated, organized movements. These units are assumed to be organized in such a way that one part of an articulatory unit potentially contains cues or information concerning the preceding and following parts of the unit. Then, for example, when the first elements of sound in an articulatory unit are heard they could convey information concerning aspects of speech yet to come, such as the temporal pattern of the remainder of the unit and its intonation contour.

Articulatory units of speech are decoded by the listener by using the organization of the speech signal. The listener uses the cues from the initial portion of the unit to anticipate the temporal structure of the unit, the intonation contour, and other aspects of the

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unit. Important features of the temporal structure which can be and are anticipated by the listener are the accented syllables, which tend to be equidistant in time (Martin, 1972). In the case of the intonation contour, cues occur which allow the listener to anticipate the time at which the unit will end. According to the present theory, the listener uses cues and information in the initial portion of an articulatory unit to match his listening activities to those of the speaker, so that in some sense he "generates" a percept of the unit in synchrony with, and simultaneously with, the speaker's production of it. That is, the listener actively constructs a representation of the acoustic signal as the speaker produces it.

It is important to note the temporal implications of this view, and to contrast them with other viewpoints which have previously been proposed. According to the present view, the listener does not wait until the end of the articulatory unit (or breath group) before he "generates" or "processes" or "perceives" it. Neither does he generate, or process, or perceive each phoneme or syllable in sequence. Instead, he begins processing at the onset of an articulatory unit and in some sense generates an integrated, wholistic percept of the unit in synchrony with the speaker's production of it. The view presented here is that speech units are perceived wholistically. Note, however, that this does not imply that listeners cannot perceive, and report, parts or fragments of an articulatory unit. It does imply that perception of an articulatory unit is most "natural" and most "effortless" when the unit is intact.

According to this view of articulatory organization, the organization a speaker gives speech is the same, in a sense, as the organization the listener uses to perceive it. In other words, if speech is produced as one intact articulatory unit, it should be perceived as one unit, and if speech is produced in separate articulatory units, it should be perceived in those same units. This should be true even if the articulatory units are composed only of strings of digits. From this view, if a string of digits is spoken as one integrated, organized articulatory unit, then it is most easily perceived and recalled by the listener as one unit. However, if a string of digits is spoken as one articulatory unit and the listener is asked to recall only part of the string, he would have to somehow suppress part of the string before responding. In doing so, the listener would reduce his recall of the remainder of the string. If, however, the "zero" and the recall digits are produced separately, i.e., in two different articulatory units, the S would not have to separate the "zero" from the recall digits. Hence, the stimulus prefix effect would be eliminated. Although the results of the Neisser et al experiment can be interpreted in terms of this view of articulatory organization, they do not offer conclusive evidence for it, since they can also be interpreted in terms of the dissimilarity in voice quality.

The present experiments were designed to separate the effects of articulatory organization from those of differing voice quality. In these experiments, the same speaker produced the complete stimulus sequence, but with different articulatory units produced by tape splicing. Besides the standard stimulus prefix condition (07:7), another prefix condition was produced by splicing a "zero" onto the beginning of a string of seven digits spoken by the same speaker (0/7:7 condition).

A second experimental hypothesis was tested which would seem to follow from the same theoretical rationale. Suppose that a number of digits are spoken in one articulatory unit, but that one or more initial digits are subsequently spliced out. The remaining string of digits then is no longer an intact articulatory unit and hence it should be more difficult to perceive and recall than an intact string of the same length. To test this idea, two no-prefix conditions were included in the experiments. In one, seven-digit strings were spoken in the standard way (7:7 condition). In the other, eight- and nine-digit strings were produced in the standard way, after which the first one or two digits were spliced out. The result was seven-digit strings, which were, however, no longer intact articulatory units. These four experimental conditions were hence a 2 by 2 design with intactness of the recall string (spoken as a unit vs not spoken as a unit) and prefix (present vs absent) as factors. The expected results were superior recall of the intact recall strings within each prefix condition, i.e., the 0/7:7 and 7:7 strings.

Two experiments were conducted to test the hypotheses. The second experiment incorporated several additional experimental controls and was an attempt to replicate the findings of the first. In order to make these experiments comparable to previous prefix experiments, each string was spoken in the standard way, i.e., in a single utterance in a monotone voice. Some of the intonation contour cues of articulatory organization were obviously eliminated by having the speaker produce the strings in this way. However, it was believed that enough of the cues about articulatory organization would be present, even using monotone speech, to produce the hypothesized effects. If the effects of articulatory organization can be demonstrated when part of the articulatory cues are eliminated, as they are in monotone speech, this would be a very stringent test of the hypotheses.

EXPERIMENT I

Method

Experimental Conditions. Strings of seven digits were produced in two different ways, with prefix and no-prefix conditions produced each way. The two methods of producing the strings were (a) by recording strings spoken in the standard way, and (b) by splicing digits onto or out of strings after they were recorded. The two conditions spoken in the standard way were the 07:7 condition, in which a speaker pronounced a "zero" followed by seven digits, and

the 7:7 condition, in which a speaker pronounced seven digits. The two conditions which had digits spliced in or out were the 0/7:7 and /7:7 conditions. In the 0/7:7 condition, seven-digit strings were produced in the standard way, but with a "zero" from another string spliced in at the beginning. In the /7:7 condition, the seven-digit strings were the remainder of eight- and nine-digit strings from which the first one or two digits had been spliced out.

Materials. Thirty-six strings of seven digits, 6 strings of eight digits, and 6 strings of nine digits were chosen from a table of random numbers from 1 to 9, with the provisions that within each string a particular digit not be included more than twice in a row and that no more than two consecutive digits in either ascending or descending order be included. There were 12 strings in each of the four conditions, with the 07:7, 7:7, and 0/7:7 strings coming from the seven-digit strings and with the /7:7 strings coming from the eight- and nine-digit strings.

In all strings, the word "ready" preceded either the "zero" prefix or the first recall digits by 1 sec. The digits were read into a tape recorder at the rate of 1 digit/0.5 sec in a monotone in time with a metronome by a female college student. The metronome was not audible on the tape. For each of the conditions, the timing of the words "ready" and "zero" relative to the recall digits was accomplished by different methods.

The 12 07:7 strings were spoken and recorded in the standard way, with the word "ready" preceding the "zero" by 1 sec and the "zero" preceding the first recall digit by 0.5 sec.

The 12 7:7 strings were also spoken and recorded in the standard way, with the word "ready" preceding the first recall digit by 1 sec.

The 12 0/7:7 strings were constructed by splicing a prefix onto a standard 7:7 string. A "zero" taken from a series of "zeros" (prerecorded at the rate of 1 digit/0.5 sec) was spliced between the word "ready" and the first recall digit of each string. An attempt was made to make the time between the onset of the first vowel in "ready" and the onset of the first vowel in "zero" equal to 1 sec, and to make the time between the onset of the first vowel in "zero" and the onset of the first vowel in the first recall digit equal to 0.5 sec. For this experiment, the digit strings were spoken to metronome beats, and it was assumed that the speaker aligned the onset of the first vowel of a word with the beat. Allen (1972) showed that, in English, the syllable beat location is closely associated with the onsets of vowels. The onsets of vowels were located by sliding the magnetic tape back and forth across the playback head of the tape recorder.

The 12 /7:7 strings were constructed from strings of eight and nine digits which were spoken and recorded with the word "ready" preceding each string by 1 sec. The first digit was spliced out of the eight-digit strings and the first two digits were spliced out of the nine-digit strings, making seven-digit strings. An attempt was made to make the time between the onset of the first vowel in "ready" and the onset of the first vowel of the first recall digit equal to 1 sec. Vowel onsets were located in the same manner as for the 0/7:7 strings.

After recording and preparing the strings for each of the four conditions, they were combined into two tapes, with the 07:7 and the 0/7:7 strings on the prefix tape and the 7:7 and /7:7 strings on the no-prefix tape. Both of these tapes were constructed so that never more than two strings of the same condition were heard successively and so that successive strings were separated by approximately 20 sec. The /7:7 strings made from eight- and nine-digit strings were distributed systematically throughout the no-prefix tape.

Twelve practice strings, each eight digits long, were constructed in a manner similar to that used for the 7:7 strings.

Procedure. First, the eight-digit practice strings were presented auditorially to individual Ss by tape recorder through headphones. The S was instructed to listen to each string of digits and to recall the string orally in any order immediately after hearing it. He was given a grid of eight boxes and was asked to point to the corresponding boxes in the grid, indicating the serial position of the digits as he recalled them. The S was told to say "blank" if he could not remember a particular digit.

For the experimental strings, the S was given a grid of seven boxes and was instructed to point to the boxes as he recalled the digits in the same way as before. The Ss heard both experimental tapes, with half of the Ss hearing the prefix tape first and the other half hearing the no-prefix tape first. Prior to listening to the prefix tape, the S was told to ignore the "zero" prefix and to just recall the following seven digits. Prior to listening to the no-prefix tape, the S was instructed to recall the seven digits that he had heard in each string. The S's responses were tape-recorded.

Subjects. The Ss were 19 female and 13 male students in introductory psychology at the University of Maryland. They volunteered to participate in the experiment in order to gain extra course credit. One additional S was not included in the analysis because of a failure to record her responses.

Results

Two measures of recall were calculated—(a) the number of completely correct strings, and (b) the number of digits recalled in their correct serial positions. In scoring the first measure, a string was considered completely correct if all and only seven digits were recalled in their appropriate serial positions. In scoring the second measure, only the first seven digits that were recalled by the S were considered and a digit was counted as correct only if it was recalled in the appropriate serial position. The first two strings in each of the four conditions were counted as practice and hence were not scored.

It was predicted that the 0/7:7 strings would be recalled better than the 07:7 strings and that the 7:7 strings would be recalled better than the /7:7 strings.

Strings Correct. The mean number of completely correct strings recalled in the four conditions is shown in Table 1. It can be seen from the table that the number of complete strings correctly recalled is in line with the predictions. A 2 by 2 analysis of variance revealed that the main effect of prefix (4.45 vs 5.97) was significant, $F(1,31) = 34.67$, $p < .001$, and that the main effect of intactness (5.55 vs 4.87) was significant, $F(1,31) = 7.26$, $p < .05$. The interaction was significant, $F(1,31) = 4.18$, $p < .05$. In order to test the hypotheses, a Studentized range statistic was used to compare the differences between prefix conditions (0/7:7 and 07:7) and between no-prefix conditions (7:7 and /7:7). The difference between the two prefix conditions (4.56 vs 4.34) was not significant. The difference between the two no-prefix

Table 1
Mean Strings and Digits Correctly Recalled in Experiment I

	Strings			Digits		
	Prefix 0/7:7	No Prefix 7:7	Combined	Prefix 0/7:7	No Prefix 7:7	Combined
Intact	4.56	6.53	5.55	58.28	62.47	60.38
	07:7	/7:7		07:7	/7:7	
Not Intact	4.34	5.40	4.87	54.97	59.16	57.07
Combined	4.45	5.97		56.63	60.82	

Note—For strings, maximum possible = 10; for digits, maximum possible = 70.

conditions (6.53 vs 5.40) was significant, $q(1,32) = 5.14$, $p < .005$.

Digits Correct. The mean number of correctly recalled digits in their appropriate serial position in the four conditions is also shown in Table 1. A 2 by 2 analysis of variance revealed that the main effect of prefix (56.63 vs 60.82) was significant, $F(1,31) = 24.54$, $p < .001$, and that the main effect of intactness (60.38 vs 57.07) was significant, $F(1,31) = 16.29$, $p < .001$. The interaction was not significant. In order to test the hypotheses, a Studentized range statistic was used to compare the differences between prefix conditions (0/7:7 and 07:7) and between no-prefix conditions (7:7 and /7:7). The difference between the two prefix conditions (58.28 vs 54.97) was significant, $q(1,32) = 5.34$, $p < .001$. The difference between the two no-prefix conditions (62.47 vs 59.16) was significant, $q(1,32) = 4.74$, $p < .005$.

Separate analyses of variance showed no significant differences in recall between the two types of /7:7 strings, those constructed from eight digits and those constructed from nine digits.

In summary, the difference between the prefix conditions was significant for the measure of recall that is probably more sensitive, the number of digits correctly recalled, and the difference between the no-prefix conditions was significant for both measures of recall.

In Experiment I there were some aspects of the experiment that were not controlled: (a) different strings of digits occurred in each of the four conditions; (b) the method of timing the "ready," "zero," and the first recall digit in the spliced conditions (0/7:7 and /7:7) could have resulted in some error in the relative timing; (c) in the 0/7:7 condition, some of the "zeros" sounded lower in intensity than the following digits. A second experiment was designed to incorporate several additional experimental controls and was an attempt to replicate the findings of the first.

EXPERIMENT II

Method

Experimental Conditions. The same four conditions used in Experiment I were employed; however, completely new digit strings were constructed. As described below, the strings were constructed in such a way that not only did the same digits occur in all four string conditions, but the four strings were otherwise nearly identical acoustically in other respects as well. In addition, the strings for the two spliced conditions were constructed in such a way that most of the splices were not even detectable.

Materials. Forty-eight strings of seven digits were chosen from a table of permutations, with the restriction that no more than two consecutive digits in either ascending or descending order be included. In addition to this restriction, the number "seven" was excluded from all strings because it is a two-syllable digit, "zero" was excluded because it was used as the redundant prefix, and the number "three" did not occur as the initial digit of any string because its long initial consonant cluster would have been difficult to manipulate in the two spliced conditions.

The digit strings were read into a tape recorder at the rate of 1 digit/0.5 sec, in a monotone and in time with a metronome, by a male speaker. All strings were preceded by the word "ready" 1 sec before either the "zero" or the first digit of the recall string.

Each of the 48 strings were spoken and recorded in such a way as to ensure smooth speech flow and precise timing across the splices. The voice quality across splices was controlled in the following manner. A master recording was made of each of the 48 strings of digits spoken twice consecutively—once *with* and once *without* the prefix. The reason the strings were spoken consecutively was to keep the articulation, intensity, etc., as close to identical as possible, so that there would be smooth speech flow across splices when part of one copy of a string was subsequently spliced *out* of that string and spliced *into* another copy of the same string. The timing of the digit strings was done as follows. The metronome beats were fed into one channel of a tape recorder and, as they were being recorded, they were monitored simultaneously through headphones by the speaker who spoke the digit strings in time with the beats. The digit strings were recorded on another channel of the tape recorder so that the metronome was not audible on the channel with the digits. The metronome beats were used at a later time for timing across splices.

Two copies were made from the master recording, resulting in four matched copies of each of the 48 strings—two copies with and two copies without the prefix. Since splicing was to be done on these copies, they were made at one-fourth speed (making the copies four times longer and two octaves lower than the master recording) so that any error in timing as the result of splicing was presumably reduced when the strings were subsequently recorded at the original speed.

A different copy of the strings was used in constructing each of the four conditions, resulting in 48 strings in each condition. One intact copy of each string which was preceded by a prefix provided the 07:7 strings, and another intact copy without the prefix provided the 7:7 strings. The other two copies of each of the 48 strings—one copy with and one copy without the prefix—provided the pairs of strings from which the /7:7 and 0/7:7 strings were constructed. To construct a /7:7 string, the "zero" was simply removed from a prefix string and the ends of the tape were then spliced back together. The "zero" which was removed was spliced into the matched, no-prefix copy of the same digit string between the "ready" and the first digit of the strings to produce the corresponding 0/7:7 string. Precise timing of the "ready," "zero," and the first digit of the recall string in the /7:7 and 0/7:7 conditions was facilitated by the recorded metronome beats. The onsets of the metronome beats were used to measure the time between the "ready" and the first digit of the /7:7 strings and between the "ready" and the "zero" in the 0/7:7 strings to ensure that it was equal to 1 sec. The onsets of the metronome beats were also used to measure the time between the "zero" and the first digit in the 0/7:7 strings to ensure that it was equal to 0.5 sec. The method used in preparing the /7:7 and 0/7:7 strings appeared to result in smooth speech flow across splices. However, to determine the degree of smoothness and the detectability of the splices, three listeners were asked to make judgments of whether each string was spliced or not. Each listener judged each string used in the experiment twice. These splice detectability data will be presented later.

After recording and preparing the 48 strings for each of the four experimental conditions, they were combined into four experimental tapes. For one of these experimental tapes, 12 strings from each of the four experimental conditions were selected in such a way that the same string occurred only once. The tape consisted of four blocks—two prefix and two no-prefix—with 6 strings of each of the two appropriate conditions in each block. A block was arranged so that never more than 2 strings of the same condition occurred successively. After all four blocks of the tape were arranged in this manner, they were rerecorded at four times the normal rate, resulting in the final copy of the experimental tape with a speed that was equal to that of the master recording. The other three counterbalancing experimental tapes were constructed in parallel, so that a particular string appeared in a different condi-

tion on each tape and in the same serial position across corresponding blocks of the tapes. On all four experimental tapes, successive strings were separated by approximately 20 sec.

Twelve practice strings of eight digits each were also constructed, in a manner similar to that used for the 7:7 string.

Procedure. For the practice strings, the instructions and the procedure were the same as for Experiment I. For the experimental strings, the instructions were the same as for Experiment I and the S's responses were again tape-recorded. Each S heard one of the four experimental tapes, with an equal number of Ss hearing each tape. All of the Ss heard blocks of prefix strings alternated with blocks of no-prefix strings. Half of the Ss heard the first block of prefix strings, the first block of no-prefix strings, the second block of prefix strings, and the second block of no-prefix strings, in that order. The other half of the Ss heard the first block of no-prefix strings, the first block of prefix strings, the second block of no-prefix strings, and the second block of prefix strings, in that order.

Subjects. The Ss were 39 female and 33 male students in introductory psychology at the University of Maryland. They volunteered to participate in the experiment in order to gain extra course credit.

Results

The same two measures of recall were calculated in this experiment as in Experiment I. The first string of each condition in a block of strings was counted as practice, and hence was not scored.

Strings Correct. The mean number of completely correct strings recalled in the four conditions is shown in Table 2. It can be seen from the table that the number of strings completely correct is consistent with the hypotheses. A 2 by 2 analysis of variance revealed that the main effect of prefix (5.81 vs 6.90) was significant, $F(1,71) = 38.06$, $p < .001$, and the main effect of intactness (6.53 vs 6.18) was significant, $F(1,71) = 4.96$, $p < .05$. The interaction was not significant. In order to test the hypotheses, a Studentized range statistic was used to compare the differences between prefix conditions (0/7:7 and 07:7) and between no-prefix conditions (7:7 and /7:7). The difference between the two prefix conditions (6.05 vs 5.56) was significant, $q(1,72) = 3.50$, $p < .05$. The difference between the two no-prefix conditions (7.00 vs 6.79) was not significant, although it was in the predicted direction.

Digits Correct. The mean number of correctly recalled digits in their appropriate serial positions in the four conditions is also shown in Table 2. A 2 by 2 analysis of variance revealed that the main effect of prefix (57.91 vs 62.13) was significant, $F(1,71) = 50.36$, $p < .001$, and that the main effect of intactness (60.71 vs 59.33) was significant, $F(1,71) = 7.56$, $p < .01$. The interaction was not significant. In order to test the hypotheses, a Studentized range statistic was used to compare the differences between prefix conditions (0/7:7 and 07:7) and between no-prefix conditions (7:7 and /7:7). The difference between the two prefix conditions (58.95 vs 56.86) was significant, $q(1,72) = 4.20$, $p < .005$. The difference between the two no-prefix conditions (62.47 vs 61.79) was not significant, although it was in the predicted direction.

Table 2
Mean Strings and Digits Correctly Recalled in Experiment II

	Strings			Digits		
	Prefix 0/7:7	No Prefix 7:7	Combined	Prefix 0/7:7	No Prefix 7:7	Combined
Intact	6.05	7.00	6.53	58.95	62.47	60.71
	07:7	/7:7		07:7	/7:7	
Not Intact	5.56	6.79	6.18	56.86	61.79	59.33
Combined	5.81	6.90		57.91	62.13	

Note–For strings, maximum possible = 10; for digits, maximum possible = 70.

Relationship Between Splice Detectability and Digits Correct. Judgments of whether each string was spliced or not were collected so that a comparison could be made between the splice detectability and the number of digits correctly recalled in the spliced conditions. The splice detectability data showed that only 57.9% and 48.3% of the judgments of the 0/7:7 and /7:7 strings, respectively, indicated the strings were spliced, with the percentage of "spliced" judgments varying from 100% to 0% for any particular string. A comparison between the number of spliced judgments made by the three listeners and the number of digits correctly recalled by the 72 experimental Ss showed no relationship between the two measures. Hence, the detectability of the splices cannot account for the number of digits correctly recalled in the spliced conditions.

DISCUSSION

The results in the no-prefix conditions in Experiment I support the notion that a string of digits spoken as an intact articulatory unit is easier to perceive and recall than a string of the same length which is not an intact unit. In Experiment II, this hypothesis was not supported. The fact that a significant difference between the no-prefix conditions was not a consistent finding may have resulted for the following reasons: (a) The measure used in the experiments (digit recall) may not have been sensitive enough to detect differences between the no-prefix conditions. (b) Splicing off the initial digits of the articulatory unit in the /7:7 condition may not have disrupted the organization of the unit enough to produce a measurable effect on perception. More research is needed to further test this hypothesis before a conclusion can be made.

The results in the prefix conditions in both Experiment I and Experiment II support the notion that if a string of digits preceded by a "zero" is all spoken in one articulatory unit, it is more difficult to recall the string than if the "zero" has no articulatory continuity with the intact recall string. This supports

the idea that articulatory organization is used in perceiving and recalling the digits.

It is obvious from the comparison of the 0/7:7 and 7:7 conditions that the spliced-on "zero" did have some negative effect on recall. In the Neisser et al experiment, the difference between their 0/7:7 and 7:7 conditions was not as great as between our 0/7:7 and 7:7 conditions. This may suggest that the results in the Neisser et al study reflect the additive effects of both articulatory organization and voice quality. It may be that the effect of voice quality is even greater than that of articulatory organization. However, the results of the present studies appear to show that articulatory organization alone does have an effect, even when the discontinuities between the prefix and the recall digits are not detectable.

Other stimulus prefix results are consistent with the articulatory organization hypothesis. Dallett (1965) tried to eliminate the stimulus prefix effect by instructing Ss to use the initial "zero" as a ready signal, i.e., to treat the "zero" as separate from the recall digits. The stimulus prefix effect persisted nevertheless, as would be expected according to the present theory. Listeners, according to this view, are compelled to perceive intact articulatory units, and instructions to change that natural process should not be effective.

Neisser et al (1969), in another experimental condition, found that the stimulus prefix effect was reduced when the redundant prefix was a triad of "zeros" (0007:7 condition) rather than a single "zero" (07:7 condition). In the 0007:7 condition, they predicted that a triad of similar digits—three "zeros"—would be grouped together to form a perceptual unit distinct from the other digits. Hence, the "zeros" in the 0007:7 condition should be easier to suppress during recall than the "zero" in the 07:7 condition. However, it should be pointed out here that it is unclear why three prefix "zeros" should be perceived as a distinct perceptual unit any more than one prefix "zero," since the "zeros" are set apart from the recall digits in either case. Perhaps a better interpretation of the results in the 0007:7 condition might be based on the present theory. Suppose that the speaker split the 10 digits (13 or 14 syllables) into two articulatory units, one containing the triad of "zeros" and the other containing the 7 recall digits (a natural thing to do). Then the redundant triad of "zeros" is separated from the recall digits, and the recall in the 0007:7 condition should be better than in the 07:7 condition, as in fact it was.

The results of other studies concerning what has been referred to as the "response prefix effect" (Conrad, 1958, 1960; Dallett, 1964) are also consistent with the present view. In a response prefix condition, the stimulus is a string of elements (digits or letters) and the required response is the string to which a S adds either a variable or fixed prefix of the same or different category as the recall string (e.g., a 7:07 condition in present notation). Results have shown that the response prefix effect cannot be explained by the following interpretations: (a) the time delay caused by speaking the prefix (Conrad, 1960); (b) interstring competition caused by the similarity of the prefixes (Crowder & Hoenig, 1969); (c) the similarity between the prefix and the recall string (Crowder, 1967, Experiment II; Smallwood & Tromater, 1971); (d) the extra memory load imposed by the prefix (Crowder, 1967, Experiment III). However, the response prefix effect can be seen as consistent with the present view by the same argument that explained the stimulus prefix effect, namely, recall diminishes when there is a mismatch between the articulatory organization of the stimulus and the response. Thus, in both the stimulus and response prefix experiments which show reduced recall, the S must change the articulatory organization of the stimulus in order to give the appropriate response.

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