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An irrelevant speech effect with repeated and continuous background speech

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The irrelevant speech effect is the impairment of task performance by the presentation of to-be-ignored speech stimuli. Typically, the irrelevant speech comprises a variety of sounds, but previous research (e.g., Jones, Madden, & Miles, 1992) has suggested that the deleterious effect of background speech is virtually eliminated if the speech comprises repetitions of a sound (e.g., "be, be, be") or a single continuous sound (e.g., "beeeeeee"). Four experiments are reported that challenge this finding. Experiments 1, 2, and 4 show a substantial impairment in serial recall performance in the presence of a repeated sound, and Experiments 3 and 4 show a similar impairment of serial recall in the presence of a continuous sound. The relevance of these findings to several explanations of the irrelevant speech effect is discussed.

An individual's ability to remember a series of visually presented items is substantially impaired if the recall task is undertaken within earshot of human speech (Jones, 1993; LeCompte, 1994). This impairment is known as the irrelevant speech effect, and it occurs even when the subjects are directed to ignore the speech (cf. Jones, 1993). The irrelevant speech effect bears a resemblance to the somewhat better known phenomenon of the suffix effect, in which recall of a series of auditorily presented items is impaired by the presentation of an additional, irrelevant auditory item (Morton, Crowder, & Prussin, 1971).

The similarity of the irrelevant speech effect and the suffix effect can be seen both in the procedures employed by the two paradigms and in the findings resulting from these paradigms. The procedures that produce these effects are quite similar. In both cases, subjects are told to ignore irrelevant auditory stimuli. Likewise, in both cases, serial recall is typically used as the primary task, but the effects have been shown with free recall as well (Engle, 1974; LeCompte, 1994). Even some of the apparent differences in experimental procedure are not true differences. For example, typically, the to-be-remembered stimuli are auditory in the suffix effect paradigm and visual in the irrelevant speech paradigm; however, a number of experiments have demonstrated an irrelevant speech effect with spoken to-be-remembered lists (e.g., Salamé & Baddeley, 1982).

Along the same lines, although the suffix item typically follows the to-be-remembered list and the irrelevant speech typically accompanies the to-be-remembered list, these practices have been violated in several experiments. Thus, a number of experiments have been reported in which a "suffix" occurs within (e.g., Greene 1989) the to-be-remembered list, and other experiments have been reported in which the irrelevant speech is presented entirely after the to-be-remembered list (e.g., LeCompte, 1994). Perhaps the most striking demonstration of the blurry line between the two effects is a study by Watkins and Sechler (1989). They discuss their results in terms of the suffix effect, but several of their experiments include a "suffix" item that is intermixed throughout the to-be-remembered list (although the to-be-ignored and the to-be-remembered items never occurred at the same time) in what could easily be seen as a demonstration of the irrelevant speech effect.

The similarity of the irrelevant speech effect and the suffix effect is also illustrated by a number of parallel findings. Specifically, both effects are strongly influenced by changes in the physical characteristics of the irrelevant stimuli such as spatial location and presentation "rhythm" (Jones, 1993; Morton et al., 1971); both effects occur even when the irrelevant stimuli are devoid of semantic content (e.g., LeCompte, 1994; Morton et al., 1971); and both effects have been demonstrated with nonspeech sounds (Jones & Macken, 1993; Roberts, 1986). Finally, although discussions of the suffix effect typically focus on impaired recall of the end of the list, the impact of the suffix effect, like that of the irrelevant speech effect, can usually be detected throughout most of the list (Penney, 1982).

Despite their similarities, the irrelevant speech effect and the suffix effect are typically treated as separate phenomena by most researchers, and theoretical discussions of one do not address the other (e.g., Crowder, 1978; Jones, 1993; Salamé & Baddeley, 1982). If these phenomena can ultimately be shown to be different manifestations of the same underlying cause, the separate theories that exist for each phenomenon would have to be expanded to include the other phenomenon or abandoned entirely

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(e.g., Baddeley, 1986). The purpose of the present work was not to flesh out the theoretical ramifications of relating these two phenomena, but rather to address an empirical issue that is a logically prior step. Specifically, there are a few discrepancies between the empirical findings for the irrelevant speech effect and the empirical findings for the suffix effect. One such difference between the two effects is the degree of disruption caused by a repeated stimulus.

In the suffix effect paradigm, a single auditory item is presented at the end of the list and greatly disrupts memory for the list (e.g., Morton et al., 1971). Somewhat paradoxically, presenting the suffix item several times (usually two or three) does not increase the magnitude of the suffix effect (e.g., LeCompte & Watkins, 1995), and, in fact, it has sometimes been shown to reduce the effect's magnitude (e.g., Crowder, 1978). Nevertheless, the effect of a repeated suffix still causes considerable disruption to subjects' recall relative to a no-suffix control condition.

In contrast, research within the irrelevant speech effect paradigm has led some to conclude that there is virtually no effect of a repeated item. For instance, Jones, Madden, and Miles (1992) concluded that "the effect only occurs if there is variation in the phonology of the speech stream" (p. 665). Likewise, Jones (1993), in a review of the irrelevant speech effect, states that "if the irrelevant stream is made up of a repeated syllable, or of a continuous vowel-sound ... then no disruption of serial recall occurs" (p. 93).

These conclusions are based on a number of experiments reported by Jones and his colleagues (Jones, 1994; Jones et al., 1992; Jones & Macken, 1993). In all of these experiments, the subjects had to recall visually presented consonants or digits (Jones, 1994, also included digits that were lip-read rather than presented graphically) while hearing various kinds of background speech, all of which were irrelevant to the serial recall task. All of the experiments included a quiet control condition and other background conditions, including (1) repetitions of a single syllable, (2) continuous presentation of a syllable, (3) various syllables occurring randomly, (4) repetitions of a single pure tone, and (5) various pure tones occurring randomly. Relative to quiet, varied syllables and varied tones always produced a statistically significant irrelevant speech effect; however, only one of the eight experiments comparing quiet to a repeated syllable or tone produced a statistically significant difference (using an alpha-level of .05). Furthermore, none of the experiments yielded a statistically significant difference between quiet and continuous presentation of a syllable. Finally, in all of these experiments, recall with a repeated background was superior to recall with a varied background. These data seem to suggest that, unlike the suffix effect, a repeated stimulus does not impair performance.

If the suffix effect and irrelevant speech effect are two manifestations of the same phenomenon, how can these seemingly disparate effects of a repeated item be explained? A study by Morris and Jones (1990) on the irrelevant speech effect may provide a clue. Morris and Jones exposed subjects to Italian speech sounds for 20 min and then immediately used these speech sounds as background speech while subjects tried to recall visually presented digits. They failed to find a significant irrelevant speech effect and interpreted this finding as showing that the subjects had habituated to the Italian speech.

If Morris and Jones are correct in interpreting their study as an example of habituation to irrelevant speech, then one possible explanation for the discrepant effect of a repeated suffix item and repeated background speech item is that people have a greater chance to habituate in the irrelevant speech paradigm because the repeated stimulus occurs much more often. Watkins and Sechler (1989) showed that there is little habituation to a standard end-of-list suffix within an experimental session, presumably because it occurs too infrequently.

If habituation is, in fact, responsible for the lack of an irrelevant speech effect with repeated stimuli, then prevention or reduction of such habituation to a repeated stimulus should bring about a substantial irrelevant speech effect.

EXPERIMENT 1

The habituation hypothesis was tested in Experiment 1. Subjects tried to recall eight visually presented digits in serial order while hearing one of three background conditions. In the quiet condition, there was no background sound. In the varied-speech condition, subjects heard random permutations of eight different letters. In the repeated-speech condition, subjects heard the same letter repeated eight times within a given list, but, unlike previous experiments (Jones, 1994; Jones et al., 1992; Jones & Macken, 1993), the repeated item varied from list to list in order to minimize the subjects' habituation to the speech sound. If habituation is responsible for the lack of an irrelevant speech effect with repeated stimuli, and if changing the repeated stimulus between lists prevents habituation to the repeated stimulus, then both the varied-speech and the repeated-speech conditions should show an irrelevant speech effect.

Method

Subjects. The subjects were 38 Louisiana State University undergraduates.

Materials and Design. The to-be-remembered stimuli were 60 random permutations of the digits 1–8. Each list of digits was generated separately for each subject. For each subject, the 60 digit-lists were divided into 20 blocks of 3 lists each. Within every block, the 3 lists were assigned randomly to three background conditions. In the silent condition, the subjects saw the digits with no accompanying sound. In the varied-speech condition, the eight digits were always accompanied by a random permutation of the letters B, F, J, K, L, M, Q, and R. These permutations were determined separately for each list and for each subject. In the repeated-speech condition, each of the eight digits in a given list was accompanied by the same sound. For this condition, one of the eight letters used in the varied-speech condition was chosen randomly (with replacement) for each list.

Each of the eight letters used in the two speech conditions was digitally recorded in a male voice. Consequently, for every presentation of a given letter, the computer played the same utterance through the headphones. All of the letters were 485–495 msec in duration. All background speech was presented at 75 dB(A).

Procedure. Each subject was seated in front of an Apple Macintosh Classic II microcomputer. Each subject wore headphones attached to the computer through which the sound was played. Instructions presented on the computer screen informed the subjects that they would see and were to recall lists of digits and that they would sometimes hear sounds in their headphones; however, the instructions emphasized that the subjects should ignore anything they might hear and concentrate on recalling the digits. After reading these instructions, the subjects pressed a key to initiate the experiment.

Each trial of the experiment consisted of eight digits presented in the center of the computer screen in 72-point Courier font at an onset-to-onset rate of 500 msec. There was no pause between digits. Some lists were presented with a quiet background, some were accompanied by a voice saying the names of eight different letters, and some were accompanied by a voice saying the name of one letter eight times. For the speech conditions, the onset of each utterance was synchronized with the presentation of one of the eight digits. Immediately after the presentation of the final digit in each list, a row of eight, equally spaced dots appeared on the screen. The computer's cursor was located immediately beneath the first dot. The subjects tried to recall the list in the serial order in which it had been presented by typing numbers on the computer keyboard. If a subject could not provide a number for a particular serial position, he or she typed a "/." Each time a number or a slash was typed, the cursor advanced to the next position. Striking any other key on the keyboard had no effect on the screen but resulted only in a brief tone. The subjects were therefore unable to backtrack and change their answers once they had been entered. When a response was given for the eighth position, the screen cleared and, after a 2-sec pause, the next list began.

Results

The data are summarized in Table 1. The standard irrelevant speech effect was replicated—probability of recall was reliably lower in the varied-speech condition than in the quiet condition [$t(37) = 6.40, p < .001$]. Also, as found by previous research (Jones, 1994; Jones et al., 1992; Jones & Macken, 1993), probability of recall was reliably lower for the varied-speech condition than for the repeated-speech condition [$t(37) = 2.69$, $p \approx .01$]. However, in contrast to previous experiments, the probability of recall was substantially and reliably lower in the repeated-speech condition than in the quiet condition [$t(37) = 7.14, p < .001$], a finding that is consistent with the hypothesis that previous failures to find an irrelevant speech effect with repeated speech result from subjects' habituating to the extensive repetition of the same item.

The data were also analyzed as a function of serial position (see Table 1). There was an interaction between background condition and serial position [$F(14, 518) = 4.51$, $MS_e = 0.006$, $p < .001$]. A straightforward description of this interaction would be that the basic irrelevant speech effect is greater at the end of the list than at

Table 1
Probability of Recall for Each of Four Experiments and the Average of the Four Experiments as a Function of Background Speech Condition and Serial Position

Condition	Serial Position 1	2	3	4	5	6	7	8	*M*
				Experiment 1					
Quiet	.91	.86	.80	.76	.64	.56	.43	.48	.68
Varied	.85	.74	.67	.59	.47	.38	.29	.35	.54
Repeated	.89	.80	.74	.66	.52	.40	.28	.36	.58
				Experiment 2					
Quiet	.90	.81	.75	.70	.57	.53	.44	.51	.65
Varied	.82	.70	.58	.51	.39	.31	.26	.37	.49
Repeated	.89	.79	.72	.62	.48	.38	.31	.42	.57
				Experiment 3					
Quiet	.86	.79	.75	.67	.56	.73	.28	.39	.59
Varied	.75	.66	.59	.54	.36	.29	.17	.25	.45
Continuous	.86	.74	.67	.63	.47	.32	.20	.26	.52
				Experiment 4					
Quiet	.89	.83	.79	.74	.60	.52	.44	.53	.67
Varied	.80	.68	.62	.54	.42	.36	.31	.40	.52
Repeated	.88	.81	.77	.71	.56	.48	.37	.43	.63
Continuous	.89	.82	.77	.70	.56	.47	.38	.46	.63
				Average Across All Four Experiments					
Quiet	.89	.82	.77	.72	.59	.59	.40	.48	.65
Varied	.81	.70	.62	.55	.41	.34	.26	.34	.50
Repeated*	.89	.80	.74	.66	.52	.42	.32	.40	.59
Continuous†	.88	.78	.72	.67	.52	.40	.29	.36	.58

Note—For all background speech conditions, the standard error associated with recall averaged across serial position (i.e., the last column in each row) is 0.02. *This condition was not included in Experiment 3. †This condition was not included in Experiments 1 and 2.

the beginning of the list for both varied- and repeated-speech conditions, but that the difference between the varied- and repeated-speech conditions is greater at the beginning of the list than at the end of the list. This pattern was replicated in later experiments, but neither of the existing theories that address this effect offer any insights into interaction effects of this sort (e.g., Jones, 1993; Salamé & Baddeley, 1982).

EXPERIMENT 2

The data from Experiment 1 are consistent with the habituation hypothesis. However, before adopting a habituation explanation, it must be demonstrated that using the same repeated item for every list will, as in previous reports, fail to produce an irrelevant speech effect. Although that failure has been reported several times previously (Jones, 1994; Jones et al., 1992; Jones & Macken, 1993), it is always possible that minor differences in materials or procedure between those experiments and the present experiments would yield an irrelevant speech effect, even when the same item is repeated throughout the experiment.

Method

The method was identical to that of Experiment 1 with the sole exception of the repeated-speech condition. Instead of randomly choosing a different letter for each list, a single letter was chosen randomly (separately for each subject) and used for all 20 of the repeated-speech lists. The subjects were 38 Louisiana State University undergraduates who had not participated in Experiment 1.

Results

The data are summarized in Table 1. Replicating Experiment 1, probability of recall was reliably lower in the varied-speech condition than in the quiet condition [$t(37) = 6.49, p < .001$] and probability of recall was reliably lower for the varied-speech condition than for the repeated-speech condition [$t(37) = 3.92, p < .001$]. Surprisingly, there was a substantial irrelevant speech effect in the repeated-speech condition. Recall in the quiet condition exceeded that in the repeated-speech condition to a reliable extent [$t(37) = 6.14, p < .001$].

To further examine the habituation hypothesis, Experiments 1 and 2 were analyzed as though they constituted a single experiment. There was no evidence that the difference between the quiet background and the repeated background was greater in Experiment 1 than in Experiment 2 [$F(2,148) = 1.18, p \approx .31$]. Moreover, the level of performance in the two repeated-speech conditions did not differ to a statistically significant extent [$t(74) = 0.26, p \approx .80$]. Thus, the evidence does not support the habituation hypothesis.

As in Experiment 1, serial position (see Table 1) interacted with background condition to a significant extent [$F(14, 518) = 3.25, MS_e = 0.011, p < .001$]. Although it was less pronounced, the pattern of data was similar to that observed in Experiment 1. The irrelevant speech effect was larger at the end of the list, but the difference between the repeated- and varied-speech conditions was larger at the beginning of the list.

EXPERIMENT 3

In contrast to previous reports, Experiments 1 and 2 showed a substantial irrelevant speech effect with a repeated background stimulus. Given that the previous finding concerning a repeated sound was, at the very least, of limited generality, Experiment 3 was designed to check on a related finding—that is, that a single, continuously presented stimulus fails to bring about an irrelevant speech effect (Jones et al., 1992). The experiment employed the list-to-list variation used in Experiment 1, although the habituation hypothesis was not at issue in this experiment. Thus, this experiment was similar to Experiment 1, but instead of comparing quiet and varied speech with repeated speech, quiet and varied speech were compared with a speech background consisting of a single continuously uttered syllable.

Method

Subjects. The subjects were 34 Louisiana State University undergraduates.

Materials and Design. The to-be-remembered stimuli were 60 digit-lists generated as in Experiment 1. The 60 lists were divided into 20 blocks of 3 lists each. The 3 lists in each block were assigned to three conditions randomly and separately for each subject. The three conditions were quiet, continuous speech, and varied speech. In the quiet condition, the digits were presented without any accompanying sound. In the continuous-speech condition, the digits were accompanied by a single utterance of one of four different vowel sounds: *ee* as in *wheel*, *ah* as in *father*, *ay* as in *pay*, and *oh* as in *boat*. Each vowel sound was generated by slicing a small segment from a digital recording of a male voice uttering each of the vowels, which was then copied and joined end-to-end to create an unwavering sound lasting 4 sec. For each subject, the choice of vowel was determined randomly for each list of digits. Finally, in the varied-speech condition, the first, third, fifth, and seventh digits were each accompanied by a different sound which continued to the next digit. These sounds consisted of the first 900 msec of one of the four utterances used in the continuous-speech condition. The order of these sounds was determined randomly and separately for each subject. All sounds were presented at 75 dB(A).

Procedure. The procedure was the same as that of Experiment 1.

Results

The data are summarized in Table 1. Probability of recall in the quiet condition exceeded that in the varied-speech condition to a statistically reliable extent [$t(33) = 5.71, p < .001$]. Likewise, probability of recall in the continuous-speech condition exceeded that in the varied-speech condition to a reliable extent [$t(33) = 4.44, p < .001$]. The most important comparison, however, is between the quiet condition and the continuous-speech condition. Previous results would lead one to expect no effect whatsoever (Jones et al., 1992), but probability of recall was reliably lower in the continuous-speech condition than in the quiet condition [$t(33) = 4.17, p < .001$], thereby demonstrating an irrelevant speech effect with continuous-speech stimuli.

The serial position data are summarized in Table 1. As in the first two experiments, there was a significant interaction of background condition and serial position [$F(14, 462) = 3.24$, $MS_e = 0.007$, $p < .001$] and the pattern of data was roughly the same. The irrelevant speech effect was larger at the end of the list, but the difference between the two speech conditions was larger at the beginning of the list.

EXPERIMENT 4

The first three experiments demonstrated an irrelevant speech effect with repeated and continuous speech, findings that run counter to the prevailing wisdom. Because of the surprising nature of these findings, a replication was conducted. Consequently, Experiment 4 included a quiet condition, a varied-speech condition, a repeated-speech condition, and a continuous-speech condition, which allows for a comparison of the repeated- and continuous-speech conditions.

Method

Subjects. The subjects were 82 Louisiana State University undergraduates.

Materials and Design. The method was generally the same as in Experiment 3. There were 72 digit-lists rather than 60, and the lists were divided into 18 blocks of 4 lists each. The 4 lists in each block were assigned to four conditions randomly and separately for each subject. The four conditions were quiet, continuous speech, repeated speech, and varied speech. In the continuous-speech condition, the list of digits was accompanied by a single utterance of one of eight vowel sounds: *uh* as in *dove*, *oo* as in *boot*, *ee* as in *wheel*, *ah* as in *father*, *ay* as in *pay*, *aw* as in *paw*, *oh* as in *boat*, and *a* as in *cat*. Each vowel sound was 4 sec in duration and was generated in the same fashion as in Experiment 3. The choice of vowel was determined randomly for each digit list. In the repeated-speech condition, each of the eight digits was accompanied by a repetition of the same sound. The repeated sound consisted of the first 490 msec of one of the eight utterances used in the continuous-speech condition. Also, as in the continuous-speech condition and as comparable to Experiment 1, the choice of vowel was determined randomly for each digit list. Finally, in the varied-speech condition, each digit was accompanied by a different sound. The sounds were the same shortened vowels used in the repeated-speech condition. The order of these sounds was determined randomly and separately for each subject.

Procedure. The procedure was the same as that of Experiment 1. The only difference was the inclusion of a continuous-speech condition. In this condition, the long vowel sound began as the first of the eight digits was presented.

Results

The results are summarized in Table 1. As in the previous experiments, probability of recall was lower in the varied-speech condition than in the quiet condition [$t(81) = 10.21$, $p < .001$] and probability of recall in the varied-speech condition exceeded that in both the repeated-speech [$t(81) = 9.30$, $p < .001$] and the continuous-speech conditions [$t(81) = 10.60$, $p < .001$]. Most importantly, this experiment replicated the findings of a substantial irrelevant speech effect with both repeated speech [$t(81) = 3.96$, $p < .001$] and continuous speech [$t(81) = 3.47$, $p < .001$]. The difference between the repeated-speech and continuous-speech conditions was not statistically reliable [$t(81) = 0.80$, $p \approx .43$].

Serial position data are shown in Table 1. Serial position and background condition interacted to a significant extent [$F(21,1701) = 5.11$, $MS_e = 0.008$, $p < .001$]. The pattern of the interaction is similar to that of the previous experiments. The difference between quiet and the three speech conditions is greatest at the end of the list, especially for the repeated- and continuous-speech conditions. On the other hand, the difference between these two conditions and the varied-speech condition was most pronounced at the beginning of the list.

GENERAL DISCUSSION

Because of their procedural similarities, it seems reasonable to entertain the possibility that the suffix effect and the irrelevant speech effect are two manifestations of the same underlying phenomenon. With this view in mind, the purpose of these experiments was to reconcile the fact that within the suffix paradigm, a repeated auditory stimulus causes a substantial impairment to recall of a list of auditory stimuli, whereas within the irrelevant speech paradigm, a repeated auditory stimulus seemed to cause no discernible impairment to recall of a list of visual stimuli. In contrast to previous reports, Experiments 1, 2, and 4 showed substantial impairment as a result of presenting the same speech sound repeatedly. Likewise, Experiments 3 and 4 showed a substantial impairment as a result of a continuously presented speech sound. Experiment 4 showed no difference in the magnitude of the irrelevant speech effect for the repeated- and continuous-speech backgrounds.

Why are the present data at odds with previously reported findings? One response to that question is to attribute the difference in findings to small differences in methodology between the experiments of Jones and his colleagues (e.g., Jones & Macken, 1993; Jones et al., 1992) and the present experiments. Differences such as list length, the length of delay before recall, and the synchronization between the background speech and the to-be-remembered stimuli might account for the failure of Jones and his colleagues to find an irrelevant speech effect with repeated and continuous speech; nevertheless, Jones (1994) employed methodology very similar to the present experiments and still concluded that repeated speech produces no appreciable irrelevant speech effect. Although a search for the critical factor or factors responsible for the different findings is certainly important, it is beyond the scope of this article.

With respect to the effect of repeated speech, another possible response to the discrepancy between the present results and those of Jones and his colleagues is to argue that the two sets of data are not really at odds. If the various hypothesis tests reported by Jones and his colleagues (Jones, 1994; Jones & Macken, 1993; Jones et al., 1992) are summarized, it appears that the repeated-speech condition failed to produce an irrelevant speech effect in multiple experiments; however, a closer examination of their data yields a different picture. Specifically, across many of the experiments reported by Jones and his colleagues, there is a small, but consistent, impairment of the repeated-speech condition relative to the quiet condition. In fact, in all but one of the eight experiments comparing a repeated condition with a quiet condition, there is some detrimental effect of the repeated stimulus: the difference in probability of recall ranges from approximately .01 to approximately .05, even though only one of the experiments yielded a statistically significant effect. None of the experiments used more than 24 subjects, so the statistical power of these experiments was more limited than that of the current experiments.

A study by Watkins and Sechler (1989) provides converging evidence that a repeated stimulus can have a substantial effect on serial recall. They presented the word *zero* throughout an experiment in which subjects were required to recall auditory lists in serial order (although the irrelevant *zero* never overlapped with the relevant auditory stimuli). Relative to a quiet control condition, the repeated stimulus had a large detrimental effect on recall performance.

Although an analysis of previous data suggests that the present finding of an irrelevant speech effect with repeated speech might not really be in contradiction to previous reports, the same cannot be said of the present finding of an effect with continuous speech. In the experiments reported by Jones et al. (1992), there was no evidence of an irrelevant speech effect with a continuous stimulus. The resolution of this discrepancy is not obvious. One possible reason is that some continuous stimuli cause an irrelevant speech effect and some do not. As mentioned before, variations in materials or procedures may be able to account for the different results.

Regardless of why the present results differ from those reported previously, these data are important theoretically. First, these data remove one potential obstacle to a theoretical consolidation of the irrelevant speech effect and suffix effect because they align the two effects with respect to the impact of a repeated irrelevant stimulus. It is well established that a repeated suffix has a substantial effect on auditory recall (e.g., LeCompte & Watkins, 1995), and the present results demonstrate a substantial irrelevant speech effect with repeated stimuli. Likewise, as the bottom panel of Table 1 shows, when the serial position data are averaged across the four experiments, it is apparent that the irrelevant speech effect is concentrated at the end of the list, which is consistent with the proposition that the suffix effect and the irrelevant speech effect are related phenomena because the suffix effect also tends to be concentrated at the end of the list (Morton et al., 1971), although this pattern has not been found consistently in experiments on the irrelevant speech effect (e.g., Salamé & Baddeley, 1982). The consistent effects found in these experiments suggest that future research should explore the relationship between irrelevant speech and serial position.

The present data also replicate the finding that varied speech causes greater impairment than repeated speech (e.g., Jones et al., 1992). This finding is also consistent with a single basis for the irrelevant speech and suffix effects. LeCompte and Watkins (1995) showed that although multiple suffix items usually fail to increase the suffix effect, such an increase can be demonstrated if the different suffix items are spoken in different voices. Thus, variation in the suffix items increases the suffix effect. Jones and Macken (1993) showed that the increased impairment found with varied speech can be achieved simply by varying the pitch at which a single item is spoken (e.g., "ah" presented in four different octaves), a manipulation similar to varying voice of presentation. The reduced effect of repeated speech can be explained by invoking the Gestalt principle of similarity (cf. LeCompte & Watkins, 1993, 1995): perceptually similar stimuli are retained in primary memory as a group and can, at least to some extent, be ignored as a group. This idea is related to the concept of perceptual streaming, which has been applied to a number of findings in primary memory (see Jones, 1994, and LeCompte & Watkins, 1993).

These data are inconsistent, however, with certain other explanations of the irrelevant speech effect. Jones et al. (1992) proposed an explanation of the irrelevant speech effect that makes the prediction that repeated and continuous stimuli will have little or no effect on serial recall of visually presented items. This changing-state hypothesis states that background speech that varies or changes state will disrupt serial recall because the order information inherent in the auditory stimuli will be confused with the order information that subjects effortfully associate with the visual stimuli. When the auditory stimulus is repeated or continuous, it carries no order information; therefore, it cannot create any confusion. Therefore, repeating a speech sound in the background should not cause an irrelevant speech effect.

The present data imply, at the very least, that the changing-state hypothesis cannot serve as a complete explanation of the irrelevant speech effect. Regarding the effect of repeated speech, Jones et al. (1992) state that "for the intermittent 'ah' condition, a weak prediction is made, such that a modest degree of interference will arise simply by virtue of the change in energy of the signal from one utterance to the next" (p. 653). Jones et al. do not provide any standard for evaluating whether an effect is modest; however, using the effect size d (defined as the difference between the two means of interest divided by their common standard deviation), Cohen (1988) suggested that d values of .20, .50, and .80 roughly correspond to small, medium, and large effects. In the present experiments, comparisons of the quiet condition to the repeated-speech condition yielded d values of 1.17, 1.01, and 0.44 for Experiments 1, 2, and 4, respectively. Thus, two of the three would qualify as a large effect, while the other would qualify as a medium effect. Furthermore, these d values are similar to those for the comparison of quiet and varied speech, which were 1.05, 1.07, 0.96, and 1.14 in Experiments 1, 2, 3, and 4, respectively.

Although the repeated-speech data seem to contradict the predictions of the changing-state hypothesis, the continuous-speech data make an even stronger case against the hypothesis. Jones et al. (1992) stated that "the changing state hypothesis makes a strong prediction for the continuous 'ah' condition by anticipating no disruptive effect of the type of speech" (p. 653). Thus, the presence of any effect whatsoever in this condition is inconsistent with the changing-state hypothesis, and the observed d values were 0.73 and 0.39 for Experiments 3 and 4, respectively.

Although the data are damaging to the changing-state hypothesis, they are not problematic for another explanation of the irrelevant speech effect—the phonological store hypothesis. Salamé and Baddeley (1982) proposed that irrelevant speech impairs short-term memory for visually presented materials because the visual stimuli are retained, via rehearsal, in a phonological "store" and speech stimuli automatically enter this same store, which results in displacement of, or confusion with, the visual stimuli. The degree of interference depends on the phonological similarity of the to-be-remembered visual items and the irrelevant background speech.

This theory can account for the fact that the irrelevant speech effect is smaller with a repeated stimulus by claiming that a repeated stimulus contains relatively little phonological information, so opportunities for confusion are limited, but if the repeated speech shares at least some phonological information with the visual stimuli, there should be some interference. Recent data, however, suggest that phonological similarity plays little, if any, role in the irrelevant speech effect, thereby questioning the core assumption of the phonological store theory (Jones & Macken, 1995; LeCompte & Shaibe, 1995).

In conclusion, the experiments reported here demonstrate that although repeated- and continuous-speech backgrounds produce irrelevant speech effects that are smaller than those produced by varied speech, these effects remain substantial. This finding challenges the conclusion drawn by some (e.g., Jones, 1993) that no such effect exists. By no means do the present data imply that repeated and continuous backgrounds always produce irrelevant speech effects, but the demonstration that such effects can occur challenges the theoretical assertion of the changing-state hypothesis that such large effects should not exist (Jones, 1993; Jones et al., 1992) and therefore significantly changes our picture of the irrelevant speech effect.

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