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The Effect of Auditory Background on Cognitive Performance

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ABSTRACT

The purpose of this study was to examine the effect of a novel music stimulus on cognitive performance. Measures of cognitive performance included reading comprehension, recall of digits, and a spatial task. Experiment 1 compared performance on the spatial task and the comprehension task in silence to performance while listening to background instrumental music and to vocal music. Results of Experiment 1 showed that performance was not significantly different in the background conditions. Experiment 2 examined the musical stimuli used in Experiment 1 to see if they would generate an irrelevant speech effect in a digit recall task using simultaneous presentation. Results of Experiment 2 showed no significant differences in performance between background conditions. Experiment 3 was conducted again with the simultaneous presentation of digits, in order to compare performance in non-musical speech and quiet. This experiment resulted in an irrelevant speech effect, meaning that the failure to obtain an effect in Experiments 1 and 2 was likely due to the nature of the musical stimuli that were used.

THE EFFECT OF AUDITORY BACKGROUND ON COGNITIVE PERFORMANCE

The past research on the effect of background music covers a wide variety of approaches and a wide variety of variables. One important manipulation is whether the type of task is a reading comprehension task, an arithmetic task, a spatial task, or an immediate recall task. It is also important whether the background music is vocal or instrumental.

Immediate recall tasks

In the literature, serial recall of digits is the most common task used to examine the irrelevant speech effect. The irrelevant speech effect was researched in detail by Salamé and Baddeley (1982). They found that subjects' performance on serial recall of digits was impaired by the presence of speech that they were instructed to ignore. In an interesting mix of results, Salamé and Baddeley (1989)conducted three experiments to examine the effects of background music on a serial recall task. Experiment 1 indicated that classical instrumental music impaired performance as compared to both quiet and popular vocal music in a foreign language. In Experiment 2 they compared classical operatic arias in a foreign language to popular, instrumental music. The vocal music condition led to the highest error rate; however, instrumental music did not

significantly impair performance, compared to the silent control, as it did in Experiment 1. In Experiment 3, the comparisons were between quiet, instrumental music, noise, and speech. The irrelevant speech background was found to impair performance more than the instrumental music background. Overall they concluded that background music can disrupt immediate verbal memory, especially vocal music.

Supporting the above findings, Morris, Jones, and Quayle (1987) conducted a study that examined the effects of irrelevant speech, hummed music, and vocal music on memory performance for a serial recall task. They found that the speech and singing disrupted performance, but not the humming. They suggested that this may be explained by the differences in the segmentation of the sounds, because both sounds were created by the human voice.

In addition, there is some ambiguity in the literature over whether the irrelevant speech effect is limited to serial recall. In a study by Salamé and Baddeley (1990), free recall of visually presented lists was examined in speech and in quiet. Speech did not significantly impair performance in the verbal free recall task. Similar findings led Jones and Macken (1995) to maintain the position that "the disruption by irrelevant speech is minimal in tasks not requiring serial recall" (p. 198). However, LeCompte (1994) showed that irrelevant speech had a significantly different effect from both quiet and white

noise in a free recall task. He suggested the differences in the studies were a result of "list length, type of to-be-remembered words, and continuity of background speech" (LeCompte, 1994, p. 1400).

With the above findings in the immediate recall literature that music and speech disrupt performance, the effect of music seems consistent. However, this consistency is not seen with other types of tasks that do not involve immediate recall.

Tasks not involving immediate recall

It has been shown that music can facilitate performance on certain tasks. For example, a study was conducted by Freeburne and Fleischer (1952) to examine the effect of music on reading comprehension. They used five background conditions: silence, classical, semi-classical, popular, and jazz. All musical conditions were instrumental, and it was found that there were no significant differences in the groups' performance except that the jazz group read significantly faster than the control.

In addition, Mulliken and Henk (1985) showed that subjects listening to instrumental classical music outperformed subjects listening to no music or to rock music on their test of reading comprehension. Soft, slow, classical music generated the highest level of overall, mean performance.

Facilitation by the presence of music is not limited to

instrumental music. Tucker and Bushman (1991) looked at the differences between verbal, math, and reading performance in the presence of rock and roll music. They found that rock and roll decreased math and verbal performance but not reading comprehension. These results are interesting because the rock and roll music contained lyrics, and other studies have shown that the presence of lyrics can hurt performance on a reading comprehension task (Martin, Wogalter, & Forlano, 1988).

Facilitation was again found when it was hypothesized that the effects of music would systematically change, depending upon the nature of the task. Miller and Schyb (1989) measured performance on four tasks: a spatial task, a numerical task, a verbal task, and a reading task. They found facilitation for the non-verbal tasks; surprisingly, it was restricted to females who heard popular instrumental music (disco), and popular songs with lyrics. For the verbal analogies and reading, background music had little effect.

In a similar study, Wolf and Weiner (1972) measured performance on arithmetic problems with conditions of quiet, speech, "hard rock" music and noise. Results showed that subjects achieved highest performance in the music condition over all other conditions. It is not clear if the music condition contained lyrics or not.

With the above evidence that music facilitates

performance, it is intriguing to note that the opposite has been found in several studies. For example, Fogelson (1973) showed that popular instrumental music caused a decrement in performance on a reading test of 80 questions.

In the same manner, an earlier study also examined the effect of background music (Henderson, Crews, and Barlow, 1945). The music was chosen based on subjects' reports of what they listened to most often. Classical and popular music were the genres of choice. Subjects were given two tasks, vocabulary and paragraph comprehension. Regardless of study habits, the scores of all groups were similar. The only significant decrement in scores occurred in the popular music, paragraph comprehension condition. Overall, music did not hurt performance as they expected, and it was not possible to assess the role that lyrics played in the disruption.

Other findings provide strong evidence that vocal music can disrupt performance. For example, Crawford and Strapp (1994) performed a study on the differences in performance due to the presence of vocal versus instrumental music. They manipulated different task types that measured spatial scanning, logical reasoning, and long-term memory. Long-term memory was tested with the Object-Number Test (Ekstrom et al., 1976). They found that vocal music disrupted spatial scanning more than instrumental music; however, neither music condition had a significantly greater effect

than silence. Both vocal music and instrumental music disturbed associative learning and recall from long-term memory as compared to silence. Overall, meaningful, vocal music was found to have a greater disruptive effect than instrumental music on cognitive performance.

The hypothesis that vocal music disrupts performance has gained additional support from research using the task of reading comprehension. Martin, Wogalter, and Forlano (1988, Experiment 1) measured the effect of continuous speech, random speech, instrumental music, random tones, white noise, and quiet on a reading comprehension task. They found a significant effect of auditory conditions, with random speech and continuous speech significantly different from quiet. In addition, they reported no interfering effect for instrumental music as compared to speech, tones, and noise, and no significant difference was found between the conditions of music, tones, and noise. This set of experiments contained another design with an instrumentation factor and a verbal factor (sung lyrics versus spoken lyrics versus no lyrics). Results were mixed in that the instrumental background alone did not cause a decrement; only the verbal aspect of the background had any disruptive effect.

The research using the reading comprehension and spatial tasks shows that the effect of background music is inconsistent. A single statement that summarizes all the

findings is difficult to make; however, most of the reading comprehension work has shown that the verbal aspect of the music caused more decrements in performance than the instrumental music. When the task was arithmetic, or a non-verbal task, the results were not as clear.

EXPERIMENT 1

Due to the ambiguous nature of the results in the literature, this study examined the effect of background noise on cognitive performance. The background noise was either vocal or instrumental music. The type of test was varied in Experiment 1; because of the mixed results of the existing literature, we used reading comprehension and a non-verbal, spatial task.

Method

Participants

One hundred and forty-four Louisiana State University undergraduates enrolled in psychology courses participated in exchange for extra course credit. Seventy-two participants participated in the reading comprehension condition, and 72 participated in the spatial condition. Participants were tested in groups of up to six individuals.

Materials and Design

The design was a 2x3 mixed design. The within-subjects independent variable, auditory background, was examined with three conditions: silence, vocal music, and instrumental music. There were two types of tests administered as the

between subjects variable: reading comprehension followed by a multiple choice questionnaire with five questions, and a test of spatial ability.

The tests of reading comprehension were taken from Cliffs Verbal Review for Standardized Tests (Covino & Orton, 1986). The questions used were taken from the book, and additional questions were written by the authors as supplements. The spatial task was a maze tracing speed test taken from the Revised Kit of Reference Tests for Cognitive Factors (Ekstrom, et al, 1976). The test allowed participants three minutes to trace through as many maze boxes as possible (see Appendix A for maze packet).

The musical selections were taken from a collection of show tunes containing vocal and instrumental versions of the same songs. The selections were "Some Enchanted Evening" from South Pacific and "The Last Night of the World" from Miss Saigon. Show tunes were chosen because subjects were expected to be relatively unfamiliar with them. The order of auditory conditions was counterbalanced with a Latin square, as was the order of passages. In addition, the vocal and instrumental versions of each song played were alternated for each group.

Procedure

Participants were randomly assigned to groups for testing in either the reading comprehension or the spatial task condition. Participants were tested under three auditory

conditions: silence, instrumental version of a song, and the vocal version of a different song. Each participant was tested in all three auditory conditions. Participants were told to complete whatever task to which they were assigned without paying attention to the background music.

In the reading comprehension condition, subjects were told to read and comprehend as much as possible, since they would be asked to answer questions about each passage. The music was played only during the time allowed for reading, and subjects answered the multiple choice questions in silence. This was done to prevent context-dependent memory effects (Balch, Bowman, & Mohler, 1992). The volume of the music was held constant for all auditory conditions in all tasks.

In the spatial task condition, subjects were also told to ignore the background music and concentrate on their task. Subjects were allowed three minutes to complete each maze. The music played during the entire time that they were tested.

Immediately following the testing period in both tasks, subjects were asked to fill out a questionnaire with information on their age, gender, GPA, and major. In addition, the questionnaire assessed how often subjects studied with music, what type of music they listened to while studying, and if the music contained lyrics or not.

Results

A one-way repeated measures analysis of variance yielded a non-significant effect of the auditory conditions for the reading comprehension condition, $F(2,142) = 1.16$, $MSe = 1.35$, $p > .30$. A closer look at the data revealed a significant effect of the order in which the passages were administered, $F(2,69) = 4.07$, $MSe = 23.93$, $p < .05$; however, the non-effect of the auditory conditions remained constant regardless of the order of the passages, as reflected in a non-significant interaction between order and auditory condition, $F(4,138) = 0.96$, $MSe = 1.30$, $p > .40$. Following Martin et al. (1988), raw test scores were transformed into z-scores for each passage in order to reduce the variance of the scores. A one-way repeated measures ANOVA again yielded a non-significant result, $F(2,142) = 1.45$, $MSe = 1.12$, $p > .20$.

For the spatial task condition, a one-way repeated measures ANOVA was also non-significant, $F(2,142)= 0.54$, $MSe = 5.15$, $p = 0.583$.

Discussion

There are many possible explanations for the results obtained in this experiment. This experiment was a conceptual replication of the study completed by Martin, et al. (1988); however, the results from this study did not support their results. One possibility is that the stimuli used in this experiment were not considered a high-

information load stimulus, as defined by Kiger (1989). High-information load music is defined as dissonant and rhythmically varied, while low-information load music is exemplified by a highly repetitive synthesizer piece. Results of Kiger's study showed that subjects in the low-information load condition had higher scores on a reading comprehension task than subjects in both the silent condition and the high-information load condition. This finding suggests that the current stimuli were perhaps not rhythmically varied enough to disrupt reading comprehension or maze tracing tasks; if so, then the stimuli need to be tested with a different task. To examine the stimuli used in the present experiment in more detail, a second experiment was conducted.

EXPERIMENT 2

The focus of this experiment was to examine the effects of background music on an immediate recall task. If the stimuli used in Experiment 1 are capable of producing an irrelevant speech effect on an immediate recall task, then the problems with Experiment 1 would probably not be the result of non-disruptive stimuli. Because the existing irrelevant speech literature uses serial presentation of digits, simultaneous presentation of digits was used.

Method

<u>Participants</u>

Twenty-six male and female undergraduates from Louisiana

State University's subject pool participated for extra course credit. Participants were tested in groups of up to seven individuals.

Materials and Design

The stimuli were 60 lists, each comprised of 8 digits. The digits were chosen randomly from the digits 0 through 9. The digits were presented in the center of a slide which was projected onto a screen.

Three additional lists were created in the same fashion as those above. These three lists were used for practice before the task began, and they were not included in the data analysis. All practice lists were run in quiet. All subjects saw the lists in the same randomly constructed order; however, the order of auditory conditions was counterbalanced, using all possible orders. Thus, each list of digits was presented with a quiet background, a vocal music background, or an instrumental background across all subjects. The design was blocked, with 20 lists in each of the auditory conditions.

Procedure

The instructions stated that participants were to remember lists of digits and that although they would sometimes hear music played, they should ignore these sounds. The experimenter explained that for each list, the digit list would appear with 8 digits on the screen simultaneously, and that the list would remain for 5

seconds. Ten seconds were allowed for participants to record the digits on their answer sheets. Participants were instructed that the digits had to be recorded in the position where they appeared on the screen to be considered correct, but that they could recall them in any way that they chose.

Results

The results are depicted in Figure 1. A three-way mixed analysis of variance was used to examine the within-subject factor of auditory background (quiet, vocal, or instrumental) and serial position. The between-subject factor was the order of auditory backgrounds. This analysis yielded a non-significant effect of auditory background $F(2,40) = 0.79$, $MSe = 9.29$, $p > .40$, but a significant effect of serial position was found $F(7,140) = 39.62$, $MSe = 372.08$, $p < .0001$. No interaction was found between serial position and auditory background, $F(14,280) = 0.84$, $MSe = 1.873$, $p > .62$. There were no significant order effects from the between subjects variable of order of auditory background, $F(5,20) = 1.46$, $MSe = 133.50$, $p > .20$. There was no significant interaction between auditory background and the order of the auditory backgrounds, $F = 1.158$, $MSe = 10.76$, $p > .30$; however, a significant interaction was found between serial position and the order of auditory backgrounds, $F = 1.62$, $MSe = 15.25$, $p < .05$. Lastly, the interaction between auditory background, serial position,

and order of auditory backgrounds did not reach significance, *F* = 1.23, *MSe* = 2.75, $p > .10$.

Discussion

These results imply that something is amiss with our stimuli. If the stimuli did not create an irrelevant speech effect in an immediate recall task, it would logically follow that they would not disrupt the tasks tested in Experiment 1. However, since Experiment 2 explored a short-term memory paradigm with a variation on the typical task (i.e., simultaneous rather that serial presentation), it must be taken into consideration that the task itself could account for the results. To examine this possibility further, Experiment 3 was conducted.

EXPERIMENT 3

The purpose of this experiment was to examine the simultaneous presentation of digits during conditions of speech and quiet. The existing literature on the irrelevant speech effect uses serial presentation of digits for either serial or free recall. This experiment examined the irrelevant speech effect using a new variation on the presentation of stimuli.

Method

Participants

Eighteen Louisiana State University undergraduates enrolled in psychology courses participated in exchange for extra course credit. Participants were tested in groups of

two to seven. Two participants had to be deleted due to performance at ceiling.

Materials and Design

The same lists of digits used in Experiment 2 were used in this experiment. Each list of digits was presented with a quiet background or a speech background, comprised of the non-words *chun, drike, foon, gluk, jerf, lape, nost, plew, stap, tarf, vux,* and *yob* (LeCompte, 1994, Experiment 3). The duration of each non-word was approximately 500 ms. The design was blocked, with thirty lists in each of the two auditory conditions. The order of the auditory backgrounds was counterbalanced.

Procedure

The procedure was identical to that of Experiment 2.

Results

The results are depicted in Figure 2. A three-way mixed analysis of variance was used to examine the within-subject factors of auditory background (speech or quiet) and serial position. The between-subject factor was the counterbalancing variable (speech first or quiet first). This analysis yielded significant results of auditory background, $F\ (1,16) = 13.06$, $MSe = 262.59$, $p = .002$, and serial position $F\ (7,112) = 28.22$, $MSe = 324.17$, $p < .0001$. There was also a significant interaction between auditory background and serial position, $F\ (7,112) = 2.43$, $MSe = 8.83$, $p = .02$. The result of the between-subjects

counterbalancing factor was non-significant, $F\ (1,16) = 2.94$, $MSe = 353.34$, $p > .10$. The interaction between auditory background and the counterbalancing variable was non-significant, $F = 1.97$, $MSe = 39.75$, $p > .10$, as was the interaction between serial position and the counterbalancing variable, $F = 1.54$, $MSe = 17.69$, $p > .10$. Lastly, the interaction between auditory background, serial position, and the counterbalncing variable was non-significant, $F = 1.37$, $MSe = 4.98$, $p > .20$.

Discussion

The results of Experiment 3 show a significant difference in performance due to the presence of irrelevant speech. Because of this difference, simultaneous presentation of digits to test irrelevant speech can be utilized along with serial recall and free recall. The interaction between serial position and auditory condition in this experiment does not have serious implications because of the apparent ceiling effects at the first ordinal position (see Figure 2). Interactions of this type are an inconsistent finding in the irrelevant speech literature (LeCompte, 1994).

GENERAL DISCUSSION

Experiment 1 did not show significant differences in performance on a reading comprehension task or a maze tracing task due to the presence of music that subjects were instructed to ignore. The same music was used in Experiment 2 to test performance on a digit recall task, and again no

significant differences were found. The results of Experiment 3 point to a problem with the stimuli used in Experiments 1 & 2. Since the task used in Experiment 2 is vulnerable to the effects of irrelevant speech (as shown by the results of Exp.3), why was this effect not caused by the musical stimuli used in Experiment 2? The musical stimuli did not cause the decrement in performance that they were hypothesized to cause.

Also, the present study showed no differences in the type of task used in Experiment 1. It was hypothesized that a spatial task would be differentially influenced by the presence of music than a reading comprehension task (Miller & Schyb, 1989). However, since the reading comprehension task was not significantly disrupted in this study, it is not reasonable to draw any conclusions about this aspect of the study. Further research with suitably disruptive stimuli needs to be conducted to address this issue.

In a study by Jones, Macken, and Murray (1993, Experiment 1), the results implied that the decrement in performance caused by music may be from vocal music or from particular types of instrumental music. In addition, they point out that "the effect of music on performance will be rather inconsistent" (Jones, et al., p. 321) unless the segmentation of the stream is controlled. This reasoning could explain the contradictory results of Salamé and Baddeley (1989), who found that instrumental music

significantly impaired performance in one experiment but not in another, in which they used different music. However, in Experiments 1 and 2 of the present study, to control for differences in the instrumental and vocal selections, the instrumental and vocal versions of the same songs were played. This would sufficiently control for the differences in segmentation to which Jones, et al. were referring; however, no effect was shown, in comparing either vocal to instrumental music or both types of music to a quiet control.

Salamé and Baddeley (1989) discussed how music disrupted recall based on the speech-like qualities of the sound. This points to another possible problem with the stimuli. If the subjects did not perceive the words of the songs clearly, semantic or phonological properties of the lyrics would not disrupt their reading (Martin, et al., 1988; Salamé & Baddeley, 1989). To test subjects' perception of the speech-like qualities of the lyrics, an experiment could be conducted in which subjects were only asked to listen to a musical selection and write the words as they heard them. If subjects could correctly understand the lyrics of the song, it would then be judged as an acceptable piece to test for the effect of background music on a reading comprehension task.

Once a piece of music is judged as acceptable, then it could be used to examine the music's effect on the immediate

recall of simultaneously presented digits. One contribution of this study is the use of simultaneous presentation of digits in an immmediate recall task. The existing literature does not discuss this paradigm, and it could be used to assess subjects' strategies for recall when not explicitly instructed to use free recall or serial recall. If subjects were asked to describe the method they used, it could provide insight into the debate over the effect of irrelevant speech on different types of recall tasks (Jones & Macken, 1995; Jones, et al., 1993; LeCompte, 1994; Salamé & Baddeley, 1990).

The major goal of this study was to clarify some of the ambiguity that exists over the effects of background stimuli on cognitive performance. This goal was not attained; however, the absence of an unequivocal answer leaves great potential for future studies in this area.

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Appendix A

Maze Packet

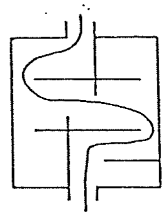
Name: ____________________

MAZE TRACING SPEED TEST — Ss-1

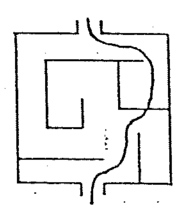
This is a test of your ability to find a path through a maze quickly. You are to draw a pencil line through each maze without having to cross any printed lines.

Look at the two drawings below. In the left square a pencil line has been drawn to show the correct path from top to bottom. The square on the right shows an incorrect path. It is incorrect because the pencil line crosses a printed line.

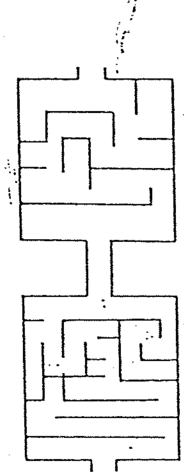
CORRECT



INCORRECT



Practice for speed on the squares below. Remember, you must make a pencil line through each square without having to cross a printed line.



Your score on this test will be the number of squares through which a line has been correctly drawn. If you should become stuck in any square, you may skip to the following one. You should try to avoid making mistakes, but you will not be penalized for lifting your pencil, for retracing a path that leads to a dead end, or for accidentally crossing lines at the sides of the path being taken. Work as quickly as you can without sacrificing accuracy. On the test, follow the squares around the page the way that they are connected, starting at the top of the left-hand column.

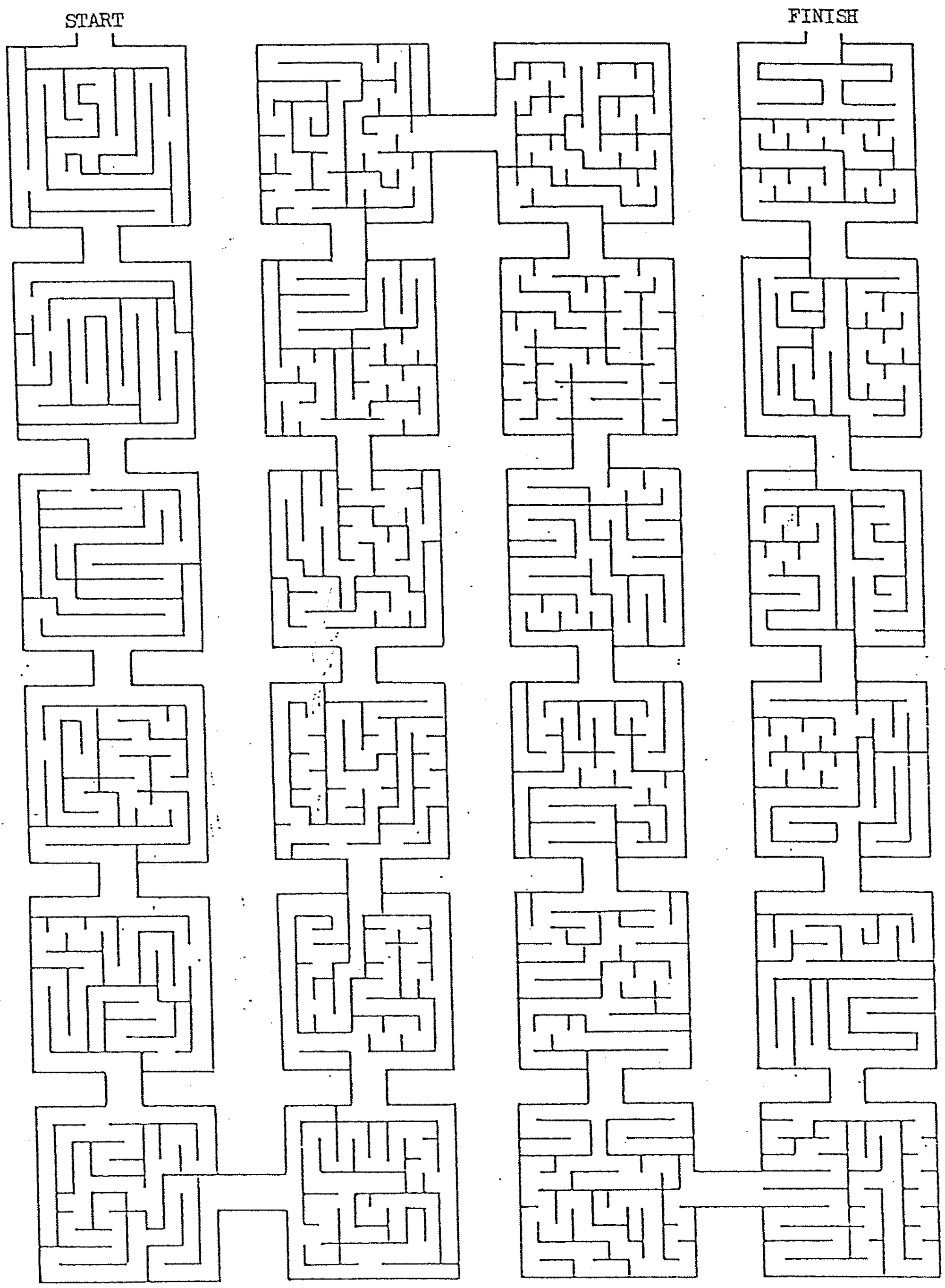
You will have 3 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Appendix continued

Page 2 ____________________

Part 1 (3 minutes)



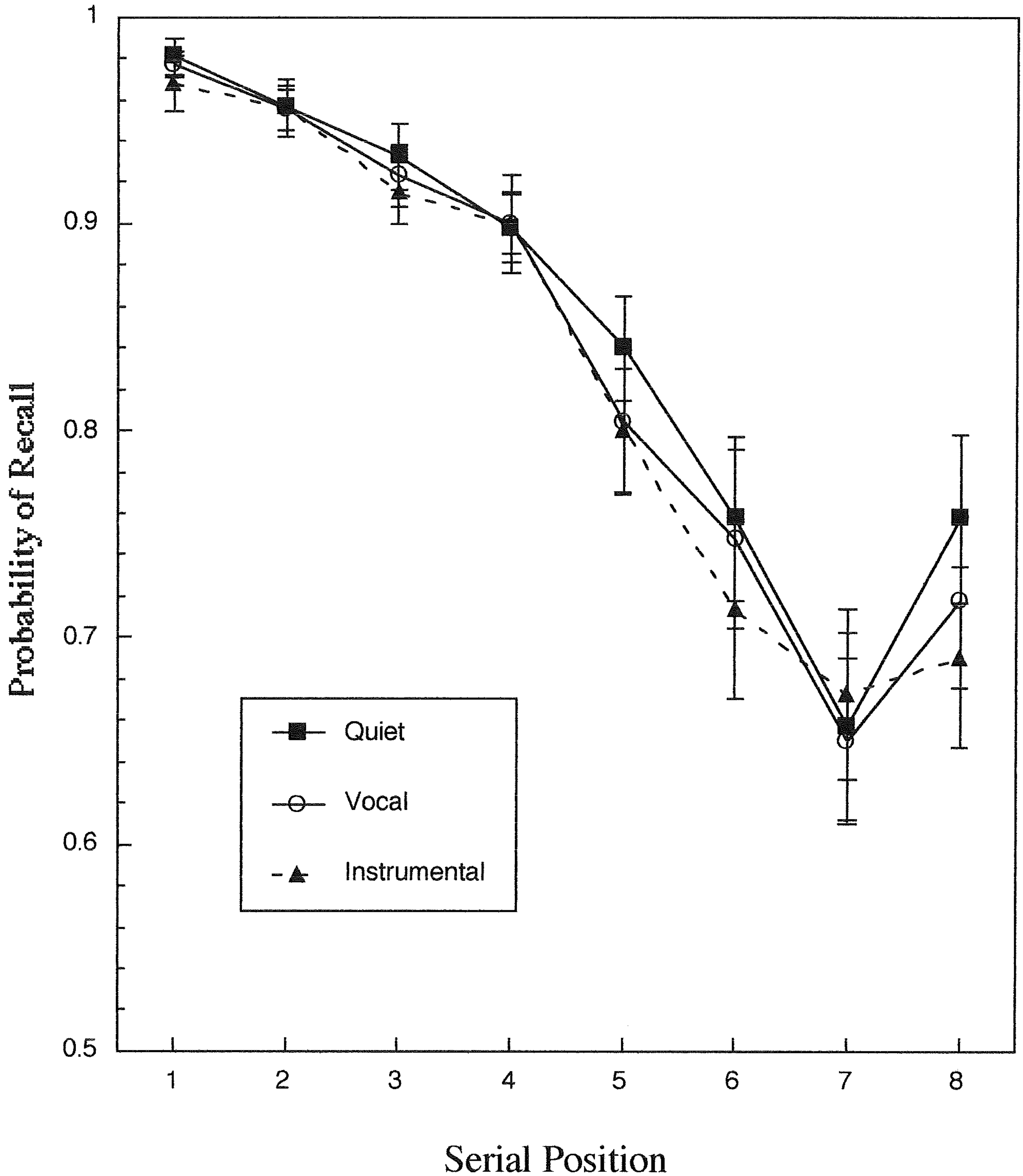
DO NOT GO ON TO THE NEXT PAGE UNTIL ASKED TO DO SO.

STOP.

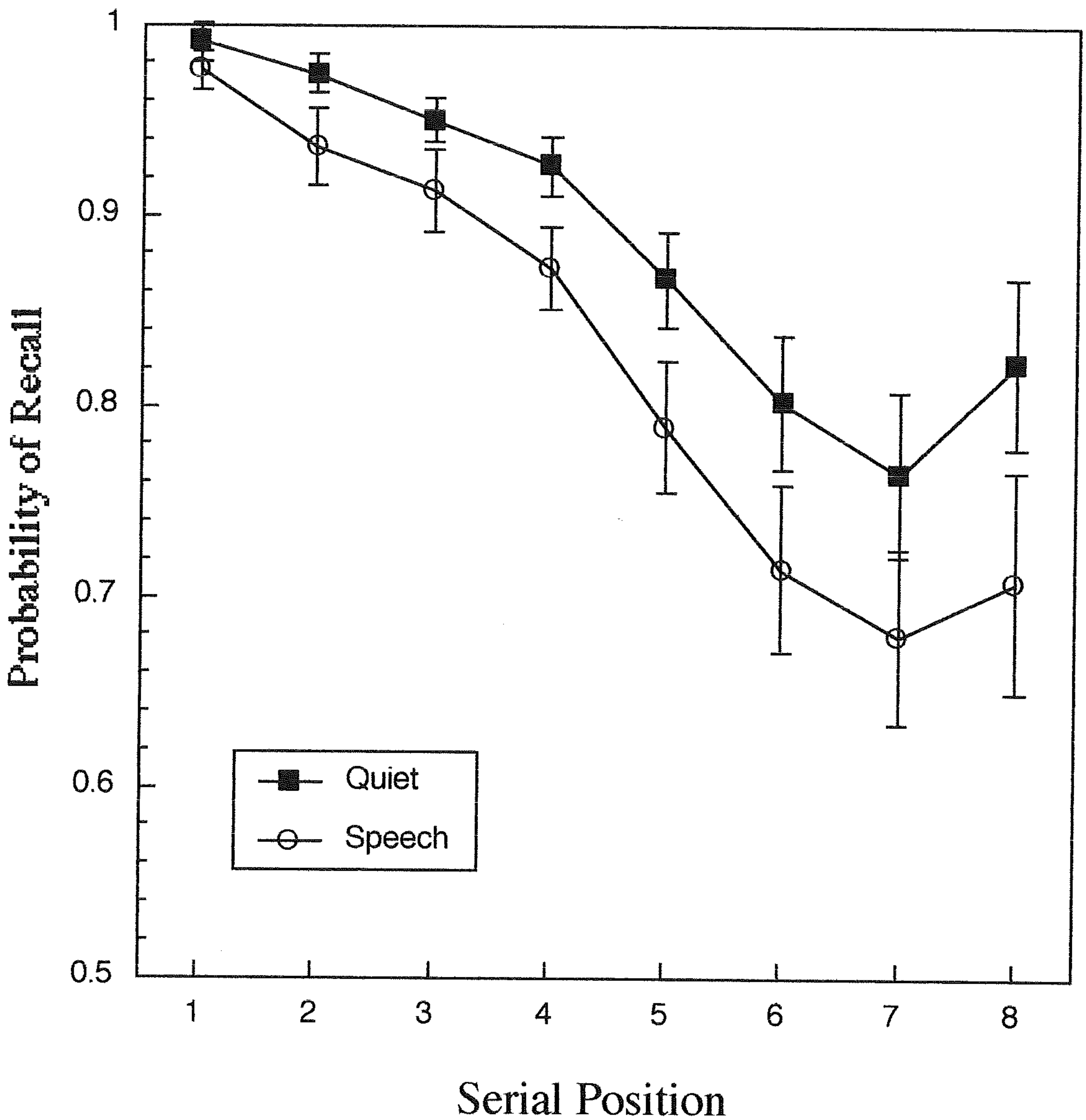
Figure Captions

Figure 1. Mean probability of recall (and standard errors) as a function of background condition and serial position in Experiment 2.

Figure 2. Mean probability of recall (and standard errors) as a function of background condition and serial position in Experiment 3.



Probability of Recall
1
0.9
0.8
0.7
0.6
0.5
1
2
3
4
5
6
7
8
Serial Position
Quiet
Vocal
Instrumental



1
0.9
0.8
0.7
0.6
0.5
Probability of Recall
Quiet
Speech
1
2
3
4
5
6
7
8
Serial Position