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Document-ID: 149554

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Pages: 8 Printed: 02-11-03 09:21:54

Sender: Ariel/Windows

6th

Journal Title: American Journal of Psychology

Volume: 98
Issue:
Month/Year:
Pages: 591-603

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Article Title: Background music and context-dependent memory

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Background music and context-dependent memory

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Two experiments demonstrated the use of background sound for inducing context-dependent memory. If a list of words was presented with sound in the background (instrumental music or white noise), then recall tested 48 hr later was better and forgetting was less if the acoustic background was reinstated rather than changed or removed. If learning occurred with quiet background conditions, recall performance was the same whether testing took place with quiet, music, or white noise in the background. The results imply that context-dependent memory caused by background sound is the beneficial result of contextual cuing rather than a deleterious effect caused by the distractions of a new background sound during testing.

The present study is concerned with the use of background music to induce context-dependent memory (CDM). Variation of the background contexts in which events occur has been shown to affect event memory in a variety of ways such that memory often depends upon the relation between learning and test contexts (e.g., Smith, 1979, 1982; Smith, Glenberg, & Bjork, 1978). One of the most common findings of CDM has been that recall of learned material is better if testing occurs in the original learning context rather than in a different context (e.g., Smith et al., 1978).

A number of dimensions of the background context have proven effective for inducing CDM, including the general physical environment (Godden & Baddeley, 1975; Smith et al., 1978), posture (Rand & Wapner, 1967), meaningful verbal material (Light & Carter-Sobell, 1970), drug states (Eich, 1980), mood states (Bartlett & Santrock, 1979), background colors (Dulsky, 1935), speaker's voice (Geiselman & Bjork, 1980), and audience (Burri, 1931). The present set of experiments examined whether memory is likewise affected by

AMERICAN JOURNAL OF PSYCHOLOGY
Winter 1985, Vol. 98, No. 4, pp. 591-603

variations of acoustic backgrounds, operationally defined as instrumental music, white noise, and quiet conditions.

Background sound is a ubiquitous characteristic of our everyday living environments, ranging from industrial noise to public noise to relative quiet. Background music, for example, can be heard in stores, restaurants, office buildings, homes, and automobiles, even by those who do not use the type of portable music-playing devices that can be taken virtually anywhere. Such background music often plays a part in our everyday memories; for example, people are often reminded of long-past events when an old song is heard on the radio. It may be that these putative cuing effects of background sounds could have a number of applied implications, particularly in the areas of education and memory improvement.

The present research also provides a vehicle for studying the basic explanation for the finding that memory tested in the same context (SC) where learning occurred is better than memory tested in a different context (DC). The question is whether the effect is a facilitative one, resulting from the benefits of contextual reinstatement, or whether the new context has an inhibitory or interfering effect, distracting or misleading the subject's retrieval scheme. This question has been difficult to answer in studies of environmental context (EC) because it does not seem possible simply to remove the original EC without introducing another context. To assess the benefits of contextual reinstatement alone, it would be helpful to compare the SC (or reinstated) condition with a condition where the experimentally presented learning context has been removed, but not replaced with a similar type of context. Distractions of a new context, which may cause a recall decrement, should be revealed by comparing results of test conditions where the originally presented context has been removed with results when it has been replaced by a new context of the same type. Such distraction should also be noted if learning occurs in the absence of a type of context, and a new context is introduced during the final memory test. Just such manipulations are possible using background music as context. In the present study, learning occurred with music or quiet background conditions, and recall took place with either the same music, changed (replaced) music, or removed music (quiet) conditions.

EXPERIMENT 1

In Experiment 1 subjects were given one presentation of a list of words and an immediate free recall test with either a Mozart piano concerto (M), a jazz selection (J), or quiet conditions (Q) as the

acoustic background. Two days later, subjects returned and took a final free recall test with either M, J, or Q conditions, thus creating nine groups. Three groups (MM, JJ, and QQ)[1] were tested with the same context (SC) that was present during Session 1, and the other six groups were tested under different context (DC) conditions. Two groups (MQ and JQ) were tested with the original music absent, but with no new music present during the test, and two (MJ and JM) were tested without the original music *and* with new music playing during the test. Comparing the music-absent conditions (MQ and JQ) with changed music conditions (MJ and JM) should shed light upon the question of whether CDM results from removal of the originally presented context cues or from the addition of a distracting new context. Comparison of QM and QJ groups with the QQ group should also show whether adding a new context has a deleterious effect upon recall.

METHOD

Subjects

The 54 volunteer participants from introductory psychology classes at the University of Oklahoma fulfilled part of a course requirement by participating in Experiment 1.

Design and procedure

All subjects attended two experimental sessions spaced approximately 48 hr apart. During the first session, subjects saw a list of words one time, with each word printed on an index card that was changed by the experimenter approximately every 5 s. Immediately following Session 1, subjects were given 5 min for free recall of the word list. This initial free recall test was given both for closure, so that subjects would not practice the words between sessions, and for a measure of the degree of original learning. Two days later subjects returned to the original laboratory and were given 5 min for a final free recall test.

The acoustic background of Sessions 1 and 2 was manipulated between subjects. One-third of the subjects heard a Mozart piano concerto (M) in the background during list learning and the initial test in Session 1, one-third heard a jazz selection (J), and one-third had quiet (Q) background conditions. Music selections were played on an audiocassette player placed next to the experimenter.

In the background of the free recall test given during Session 2, one-third of each of the M, J, and Q groups had either M, J, or Q conditions, thus creating nine groups. Three of the nine conditions were SC groups (MM, JJ, and QQ), and the other six were DC groups (MJ, MQ, JM, JQ, QM, and QJ).

In addition to the nine major conditions, half of the subjects learned List A and half learned List B.

Materials

Eighty four- and five-letter one-syllable common English nouns were randomly selected from the Kučera and Francis (1967) frequency norms and randomly assigned to Lists A and B. The 40 words on each list were printed on white index cards with one word centered on each card.

Music selections

The background music selections were chosen to meet several criteria. They were (a) exclusively instrumental (no voices or words were heard), (b) not currently popular pieces, and (c) quite different from each other. One piece was Mozart's Concerto No. 24 in C Minor for Piano and Orchestra, and the other piece was "People Make the World Go Around," a jazz selection on Milt Jackson's *Sunflower* record album.

RESULTS

Initial recall

A 3 × 2 (Session 1 Context × Test Context) analysis of variance (ANOVA) was computed for number correct on the initial recall test given during Session 1. Session 1 context was either Mozart (M), jazz (J), or quiet (Q), and test context was either SC (MM, JJ, and QQ) or DC (MJ, MQ, JM, JQ, QM, QJ). Initial recall scores did not significantly differ as a function of either Session 1 context, $F(2, 38) = 1.48$, $p = .24$, $MS_e = 25.56$, or test context, $F(1, 48) = 1.67$, $p = .20$. The average number of words recalled on the initial recall test for those learning with the Mozart piece was 17.28, for the jazz selection it was 18.50, and for the quiet condition, 17.61.

Final recall

Analyses of final recall scores indicated the same results whether the dependent measure was number recalled or number forgotten (initial recall–final recall). Analyses using number forgotten are reported.

Four separate analyses were computed on the forgetting scores; one for all subjects, a second for those who had Session 1 with background music, a third for subjects who had Session 1 with a quiet background, and a fourth comparing MJ and JM groups with the MQ and JQ groups (to assess effects of music change vs. music removal).

The ANOVA computed for forgetting scores of all subjects used a 3 × 2 (Session 1 Context × Test Context) design. A significant effect was found only for test context, $F(1, 48) = 6.64$, $p < .05$, $MS_e = 8.06$. The average DC amount of forgetting between initial and final recall was 4.28 words, as compared with 2.17 words for the SC condition. On the final recall test, subjects in the DC groups recalled an average of 13.46 words, as compared with an SC mean of 15.75 words, an improvement of 17% over the DC mean.

Table 1. Experiment 1 mean initial recall scores, final recall scores, and forgetting scores[a] as a function of Session 1 context and test context

Session 1 context	Test condition: Mozart	Jazz	Quiet
Mozart			
Initial recall	18.67[b]	16.17	17.00
Final recall	18.17[b]	12.67	13.33
Forgetting	.50[b]	3.50	3.67
Jazz			
Initial recall	16.48	23.83[b]	14.66
Final recall	11.15	20.83[b]	8.50
Forgetting	5.33	3.00[b]	6.16
Quiet			
Initial recall	19.98	18.16	14.67[b]
Final recall	16.33	15.33	11.67[b]
Forgetting	3.65	2.83	3.00[b]

Note. There were 40 words possible on the initial and final recall tests.
[a]Forgetting score equals initial recall score minus final recall score.
[b]Denotes SC conditions.

A 2 × 2 (Session 1 Context × Test Context) ANOVA was computed for forgetting scores of subjects who learned with music in the background (i.e., excluding those with quiet learning conditions). There was a significant effect of test context, $F(1, 32) = 8.16$, $p < .01$, $MS_e = 9.08$, caused by decreased forgetting in the SC condition relative to the DC condition. There was also an effect of Session 1 context, $F(1, 32) = 5.33$, $p < .05$, and less forgetting if learning occurred with Mozart rather than with jazz in the background.

The one-way ANOVA computed for the forgetting scores of subjects who learned under quiet conditions compared the reinstated (SC) quiet group (QQ) with the two DC groups that had music on the test (QM and QJ). There was no effect of the testing conditions for these subjects, $F(1, 16) = .04$, $p = .84$, $MS_e = 6.02$.

A 2 × 2 (Session 1 Context × Test Condition) ANOVA was computed for forgetting scores of subjects who learned with music and were tested under altered (DC) conditions (test condition was either quiet or changed music). No significant effects were found; for test condition, $F(1, 20) = .32$, $p = .58$, $MS_e = 10.54$.

DISCUSSION

The results of Experiment 1 confirm the prediction that background music can be used to induce context-dependent memory. When Session 1 occurred with music in the background, recall was better and forgetting was less when the Session 1 music was reinstated rather than removed or replaced. Such was not the case, however, when Session 1 occurred with quiet background conditions; apparently, reinstatement of quiet did not benefit recall. Furthermore, the introduction of a new music selection during testing did not hamper recall for those in the quiet Session 1 condition, implying that the reinstatement effect is the beneficial result of SC cuing rather than a decrement caused by DC distraction. This absence of a distraction effect was further supported by the finding that when Session 1 occurred with a music background, recall was no worse for the changed music condition than for the removed music (quiet) testing condition.

EXPERIMENT 2

The cuing effect caused by the reinstatement of background music in Experiment 1 could be dependent upon re-creating a specific melody, because the effect occurred only in the conditions where music accompanied Session 1, or the effect could extend to other types of experimentally presented background sounds. Experiment 2 replicated the findings of Experiment 1, and extended the phenomenon to another acoustical background, white noise. The presentation mode of learning materials was also manipulated in Experiment 2, including both aural and visual presentations.

METHOD

Subjects

The 90 volunteer participants from introductory psychology classes at Texas A&M University fulfilled part of a course requirement by participating in Experiment 2.

Design and procedure

The design and procedure used in Experiment 2 were identical to those used in Experiment 1, with two exceptions: (a) Only one list of 40 words was used, and (b) words were presented to half of the participants individually with a slide projector (visual presentation mode), and to half with an audiocassette recorder (aural presentation mode).

One-third of the subjects heard a jazz selection (J) in the background during list learning and the initial recall test in Session 1, one-third heard white noise (N), and one-third had quiet (Q) background conditions. As in Experiment 1, three of the conditions were SC groups (JJ, NN, and QQ), and six were DC groups (JN, JQ, NJ, NQ, QJ, and QN). Half of the subjects in each of these nine conditions had a visual presentation of words, and half had an aural presentation. Thus, there were 18 groups, each containing five participants.

Acoustic backgrounds

The jazz selection, as in Experiment 1, was exclusively instrumental. A piece entitled "Destiny's Children" from Freddie Hubbard's record album *Keep Your Soul Together* was used. White noise, recorded at a subjectively similar sound level from a white noise generator, was used for the noise conditions.

RESULTS

Initial recall

Initial recall scores for each subject were submitted to a 3 × 2 × 2 (Session 1 Context × Test Context × Mode) ANOVA. Session 1 context was either jazz (J), noise (N), or quiet (Q); test context was SC or DC; and mode was aural or visual. No significant effects were found. Subjects who had Session 1 with jazz had a mean initial recall of 16.30 words, those with noise during Session 1 recalled 16.40 words, and those with quiet Session 1 conditions recalled a mean of 17.57 words.

Final recall

Final recall scores were subtracted from initial recall scores for each subject to compute forgetting scores. As in Experiment 1, four separate analyses of variance were computed on the forgetting scores: one for all subjects, a second for those who had Session 1 with background sound (either J or N), a third for subjects who had Session 1 with a quiet background, and a fourth comparing JN and NJ groups with JQ and NQ groups.

A 3 × 2 × 2 (Session 1 Context × Test Context × Mode) ANOVA was computed for forgetting scores of all subjects. There was a significant effect of test context, $F(1, 78) = 7.05$, $p < .01$, $MS_e = 3.97$, due to decreased forgetting in the SC condition (Table 2). Overall, SC subjects recalled an average of 1.27 more words than DC subjects, an improvement equal to 10% of the DC mean recall.

There was also an interaction of test context with Session 1 context, $F(2, 78) = 8.64$, $p < .01$. This interaction indicates that when

Table 2. Experiment 2 mean initial recall, final recall, and forgetting scores[a] as a function of Session 1 context and test context

Session 1 context	Test condition: Jazz	Noise	Quiet
Jazz			
Initial recall	17.40[b]	15.90	15.60
Final recall	14.80[b]	12.40	12.20
Forgetting	2.60[b]	3.50	3.40
Noise			
Initial recall	13.80	16.50[b]	18.90
Final recall	8.50	14.60[b]	13.20
Forgetting	5.30	1.90[b]	5.70
Quiet			
Initial recall	18.40	16.70	17.60[b]
Final recall	13.80	13.70	12.90[b]
Forgetting	4.60	3.00	4.70[b]

Note. There were 40 words possible on the initial and final recall tests.
[a]Forgetting score equals initial recall score minus final recall score.
[b]Denotes SC conditions.

Table 3. Experiment 2 mean forgetting scores[a] as a function of Session 1 context, test context, and mode of presentation

Session 1 context	Test condition: Jazz	Noise	Quiet
Jazz			
Aural	2.0[b]	3.2	4.2
Visual	3.2[b]	3.8	2.6
Noise			
Aural	6.0	1.0[b]	5.8
Visual	4.6	2.8[b]	5.6
Quiet			
Aural	3.6	1.4	5.4[b]
Visual	5.6	4.6	4.0[b]

[a]Forgetting score equals initial recall score minus final recall score.
[b]Denotes SC conditions.

there was sound in the background during Session 1 (J or N), SC forgetting was less than DC forgetting, but when the Session 1 background was quiet, DC forgetting was slightly less than SC forgetting (Table 2). The analysis of all subjects' data also found a three-way interaction of Session 1 Context × Test Context × Mode, $F(2, 78) = 5.38$, $p < .01$. This interaction was due to the fact that when Session 1 occurred with sound in the background (J or N), the decreased SC forgetting was greater for the aural than for the visual presentation mode, but when Session 1 occurred under quiet conditions, the aural mode produced decreased DC forgetting, whereas the visual mode produced decreased SC forgetting (Table 3).

A 2 × 2 × 2 (Session 1 Context × Test Context × Mode) ANOVA using forgetting scores was computed for subjects who had Session 1 with sound in the background (J or N). There was a significant effect of test context, $F(1, 52) = 18.95$, $p < .001$, $MS_e = 3.48$; there was less forgetting in the SC group than in the DC group. The mean SC recall was 2.35 words greater than DC recall, an improvement equal to 19% of the DC mean (Table 3). There was an interaction of Session 1 context with test context, $F(1, 52) = 7.24$, $p = .01$, indicating that the increased DC forgetting was greater for those who had Session 1 with white noise than with a music background (Table 3). There was also an interaction of test context with mode, $F(1, 52) = 4.42$, $p < .05$, indicating that the increased DC forgetting was greater when words were presented in the aural rather than the visual mode (Table 3).

A 2 × 2 (Test Context × Mode) ANOVA of forgetting scores was computed for subjects who had Session 1 under quiet conditions. There was no effect of test context, $F(1, 26) = 1.09$, $p = .31$, $MS_e = 4.95$. There was, however, an interaction of test context with mode, $F(1, 26) = 7.34$, $p < .05$, indicating decreased DC forgetting for the aural presentation mode condition and decreased SC forgetting in the visual presentation mode condition (Table 3).

A 2 × 2 (Test Condition × Mode) ANOVA using forgetting scores was computed for subjects who had sound experimentally presented in the background during Session 1 (J or N). Test condition was either changed sound (JN and NJ) or removed sound (JQ and NQ). No significant effects were found; for test context, $F(1, 36) = .05$, $p = .82$, $MS_e = 4.48$.

DISCUSSION

The results of Experiment 2 replicated the results of Experiment 1, extending the finding of "music-dependent memory" to white noise background conditions and an aural presentation of learning materials. As in Experiment 1, context-dependent memory (i.e., SC recall better than DC recall, SC forgetting less than DC forgetting) occurred only when experimentally presented background sound accompanied Session 1. Reinstatement of quiet produced no overall SC recall advantage, again indicating that (a) experimentally presented sound can act as a memory cue, whereas quiet does not cue memory, and (b) introducing a new acoustic background does not decrease recall. In support of the latter conclusion, it was found that when Session 1 occurred with sound in the background, introduction of a new sound produced no worse recall than simple removal of the Session 1 background sound.

The conclusion that sound can serve as a memory cue whereas quiet does not cue memory might be explained in at least two ways. One idea is that white noise and unpopular music selections are far less likely than quiet conditions to be encountered frequently during the 48-hr retention interval, and therefore should serve as more distinctive cues than the more common experience of relative quiet. Another idea is that subjects encode an experimentally presented music or noise selection, but they do not encode the absence of experimentally presented sound any more than they might encode the absence of any type of stimulus, such as pain or food. This assumes, of course, that subjects are not expecting to hear experimentally presented background music or sound. At the time of testing, a replayed background sound could act as a memory cue if its encoded representation is associated with learned material, but the reinstatement of quiet conditions would not cue memory if there were no encoded representation of quiet.

The greater SC recall advantage for the aural presentation mode of Session 1 material is not obviously explainable, although a few hypotheses seem possible. One is that the interaction of text context with mode was a chance occurrence, especially because of the robust context effect in Experiment 1 found with a visual presentation mode. A second possibility is that when stimuli are presented aurally, the subject is not as focused upon the stimuli as when they are presented visually, and therefore more contextual information is encoded. Finally, it may be that context is more likely to be used during encoding and retrieval if context and learning material are both presented in the same mode. Perhaps subjects are most receptive at any given time to information presented in one sensitized sensory mode. Such a possibility, then, would also predict visual context effects to be strongest when learning materials are presented visually.

It was also found in Experiment 2 that the SC advantage was stronger when Session 1 occurred with a white noise background than with a music background. Again, this result is not easily explainable, but one speculative possibility will be offered. Smith (1979) found that DC subjects could mentally reinstate their learning environment and, hence, could overcome the deleterious effects of DC testing. It may be that a musical melody is more possible to implicitly retrieve as a self-generated cue than is white noise. Therefore, some SC subjects (i.e., those with music in their Session 1

backgrounds) could have mentally reinstated their acoustic backgrounds, whereas retrieval of white noise would be considerably more difficult. As stated above, however, the reason for this interaction is not obvious.

SUMMARY AND CONCLUSIONS

Both experiments demonstrated the phenomenon of context-dependent memory using acoustic backgrounds (music and white noise) as context. The results suggest that the effect is a facilitative one caused by the reinstatement of contextual cues, rather than a detrimental effect caused by the distraction of a new context introduced at the time of testing. These conclusions are consistent with those of Smith (1979), who concluded that environmental context effects were caused by contextual cuing rather than the unfamiliarity of a new test environment.

Although contextual cuing was found for both aural and visual presentations of learning material, and for both music and white noise learning backgrounds, Experiment 2 found stronger effects for aural presentations against a white noise background. Caution should be exercised, of course, in the interpretation of these results, given the limitations of the study; these experiments used lists of unrelated words, 48-hr retention intervals, and free recall tests.

The potential application of these results to educational situations may be greater than applications of environmental context effects. Reinstatement of the learning environment may improve examination performance in some situations (Abernethy, 1940; Mellgren, 1984; Metzger, Boschee, Haugen, & Schnobrich, 1979); context manipulations might be used either to optimize examination performance by testing under SC conditions, or to maximize the sensitivity of an examination to context-free learning by testing under DC conditions. Furthermore, variation of learning contexts has been shown to improve recall tested in a new environment, both in studies using word lists (Smith, 1982) and in studies using educationally relevant materials (Smith & Rothkopf, 1984). Manipulation of background sounds should prove easier and less expensive to implement than manipulation of rooms or other types of environmental settings. The applied usefulness of music-induced context-dependent memory, however, remains to be demonstrated.

Notes

The author thanks Kelvin Carrington, who collected the data for Experiment 1, and Steven Blankenship and Cynthia Higgs, who collected the data for Experiment 2. Requests for offprints should be sent to Steven M.

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1. The first letter in this notation indicates the background condition for Session 1, and the second letter indicates the background condition for Session 2. For example, JQ indicates that jazz was played during Session 1 and that testing (Session 2) occurred with quiet conditions.

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