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Jade-Isis A. Lefebvre
Bishop's University

Jordan S. Lefebvre
Bishop's University

Lionel G. Standing

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Does Environmental Enrichment While Studying Improve Recall?

Jade-Isis A. Lefebvre, Jordan S. Lefebvre, and Lionel G. Standing

Bishop's University

Previous research suggests that studying audio and visual stimuli in two different rooms increases verbal recall, as compared to studying twice in only one room (Smith, Glenberg, & Bjork, 1978). The present study utilized this paradigm, and also separated the room and modality factors as sources of environmental enrichment. In Experiment 1, subjects learned a list of 40 common English words twice, in either one or two different rooms, and were tested in a third room (N = 60). In Experiment 2, subjects learned the same word lists, using either one or two modalities (audition and vision), and again were tested in a third environment (N = 59). As predicted from the theory of Smith and Vela (2001), the usual improvement in memory from either room or modality enrichment did not occur when short time intervals were used between learning and recall, and the mean recall scores were essentially identical. The enrichment effect is interpreted as involving the development of categorized memory information over time, thus enabling retrieval strategies to operate, rather than an increase in the strength of initial learning. Keywords: verbal learning, recall, two rooms, auditory vs. visual modality, environmental enrichment, context, gender

A familiar finding in studies of verbal memory is that recall performance is better when subjects are tested in the same environment in which they previously learned the material, rather than a new setting. This beneficial effect of reinstating contextual retrieval cues has been reported many times (e.g., Godden & Baddeley, 1975; Sahakyan, 2010; Smith, 1979). Less attention has been paid to a related phenomenon that has been termed environmental enrichment: when subjects learn verbal material in two different rooms rather than twice in the same one, and are tested in a third room, recall performance typically is raised considerably (Smith, Glenberg, & Bjork, 1978: Experiment 1; Smith, 1982; Smith & Rothkopf, 1984).

Lately, however, a recent surge of popular interest in environmental enrichment, or the two--room technique raised recall performance by approximately 50% in the study of Smith, Glenberg, & Bjork, 1978.

The experiment of Smith, Glenberg, & Bjork (1978) involved enrichment of the environment that was achieved by using two rooms, each with a different modality for presentation of the learning stimuli (visual for the first room, and auditory for the second). Thus the independent variables of the number of rooms employed and the number of modalities involved were confounded in the experimental design. In the present study these variables were separated. Also, the retention interval was shortened from 3hr to 17 min (from the first presentation of the list), or 7 min (from the second). The study thus tests the hypothesis of Smith and Vela (2001, p.212), generated on the basis of a meta-

analysis, that the effects of environmental enrichment are reduced when the delay between learning and its retrieval is shortened.

Experiment 1

In the present study, subjects learned the same word list twice, either in a single room (room A, or room B), or else in these two rooms successively. They were then immediately tested in a new setting (room C), whereas in Smith, Glenberg, and Bjork's (1978) experiment there was a three-hour time period between the study sessions.

Method

Participants. The sixty volunteer subjects in this study were students attending Bishop's University, including 21 males and 39 females, taken randomly from across all divisions of the university (social sciences, natural sciences, business, humanities and education). Their ages ranged from 18 to 47 (M = 21.3, SD = 3.78). Twenty participants were randomly selected to study in room A, and 20 to study in room B. The other 20 participants were randomly assigned to study in room A and then room B.Both males and females were included in each group.

Materials. Each participant received a consent form which informed them of their rights, and a debriefing form after testing. A list of 40 one-syllable English nouns was used, selected randomly from the dictionary (see Appendix A). All participants studied this list twice. A filler task was used, employing perceptual four puzzle images, given after each 3-minute study session. The images, taken from the Internet, were printed in black and white and included at least five to nine 'hidden' animals in each picture. A demographic information form was used to record subjects' age, gender, first language, and major program.

All contexts, or rooms, were in the Bishop's University Library. Room A, the "Couch Room", is a spacious room filled with couches, many different sized tables, book cases and journals, as well as large windows. There are many colours, and in the day natural light floods the room. There were many students who used this room both as a study place and a place to chat with friends. In Room B, known as the "Group Study Room," the environment was quite different. The space is confined and only a small table, four chairs, and a whiteboard fill the windowless, ice blue coloured, soundproof room. Only the participants and the author of the study were allowed in this room. There was also a third room (C) used as the neutral testing area, known as the "Silent Study Room." This room differed from both rooms as it is large with small windows and less lighting than Room 1 but more than Room 2. It also has bookshelves, and students studying, though here they are completely silent.

Procedure.

The participants were recruited and tested on weekdays in the Bishop's University Library. Upon arrival at the library, the participants were randomly assigned to one of the three conditions: 1-Room A, 1-Room B, or 2-Room, and were asked to read and sign the consent form. Next they were given the list of 40 words to learn for a time period of three minutes. Then, the participants were given Picture 1 and Picture 2. They were told they had seven minutes to find as many animals as possible and record those animals on the separate page. After the seven minutes, participants were told to take a break and walk through the lobby. Following the break, participants returned to the first room, or changed rooms, depending on their assigned group. The participants were again given the word list and told they had three minutes to learn the words. The participants were then again told they had seven minutes to find all of the animals in Pictures 3 and 4, and to record the animals found on the same sheet as Pictures 1 and 2. Lastly, the participants were escorted to the test room (C), where they were given two forms, one asking for personal information, followed by the testing sheet for written recall of the word list, recall thus occurring five minutes after learning. No time limit was imposed. After the recall test, the participants were debriefed and thanked for their participation.

Design. The design of this study was a 3 × 2 (number of rooms × gender) independent groups ANOVA. The manipulated variable, the number of rooms in which the participant studied, had three levels:

1-Room A (subjects studied twice in room A); 1-Room B (subjects studied twice in room B); and 2-Room AB (subjects studied in room A and then room B). The dependent variable was the number of words correctly recalled.

Results

Descriptive Statistics. The main trend noted was that, pooled over genders, participants correctly recalled slightly more words in room B ($M = 15.48$, $SD = 9.76$), in comparison to room A ($M = 14.57$, $SD = 8.98$). Scores in the two-room condition were intermediate ($M = 14.82$, $SD = 9.76$). The mean numbers of words recalled under the one-room and two-room conditions are shown in Table 1, together with confidence intervals.

Effect of Number of Rooms. There was no main effect for the number of rooms used during learning, $F(2, 59) = .049$, $p = .953$, $\eta^2 = .002$. Tukey HSD post hoc tests between all three means supported this finding, all $p > .80$. However, it was noted that female participants correctly recalled more words than male participants, $F(2, 59) = 4.63$, $p = .036$, $\eta^2 = .079$. There was no gender × rooms interaction, $F(2, 59) = .017$, $p = .036$, $\eta^2 = .079$. The size of the gender difference was quite large in absolute terms (17.60 versus 12.32 words correct), although the effect size was small.

Correlations. The only significant demographic correlation noted was that the number of words recalled was positively associated with female gender, $r(58) = .29$, $p = .025$.

Discussion

Although the environment in Room B was quieter than Room A, with many fewer distractions and no students besides participants in the room, their mean scores were almost identical, falling 1.7% below, and 4.4% above, the mean for the two room condition, respectively. These differences are well within the 95% confidence intervals.

Though previous research suggested that participants would correctly recall more words in two rooms, this study indicates the opposite. Participants actually recalled the most words when studying only in Room B, rather than studying in Room A and B, although this difference was not significant.

A significant result of interest was that females correctly recalled more words than males. This may be because females generally perform better in verbal skills while men usually perform better on visual-spatial memory tasks and with motor skills (Halpern, 1997). Another possible explanation could be that the males did not apply themselves in the study as much as the females.

This study used a substantial number of participants (60), as compared to Smith, Glenberg, and Bjork's (1968) experiment employed only 16 subjects. Furthermore, students from various different programs participated in this study. This study isolated the two-room effect while keeping the modality of learning constant. Therefore, if differences other than gender were found, they would have been due to only the modality factor.

In the study of Smith, Glenberg, and Bjork (1968) enrichment via room change was accompanied by enrichment via the successive use of two modalities. It therefore seemed of interest to conduct another experiment with another type of learning modality, again using short retention intervals, to see whether an enrichment effect occurs when two modalities (visual and auditory) are used for learning rather than one, while keeping the room factor constant. Possible gender differences in recall were also of interest.

Experiment 2

This study again manipulated environmental enrichment to test its effects on the recall of word lists, but in this case did so by manipulating the use of one versus two modalities during learning, without room change. As with Experiment 1, it also differs in using a short time interval between learning sessions. Instead of 3-hour breaks the participants took a 7-minute break, with a Picture Puzzle as a filler task. This experiment used three different conditions: two visual stimulation sessions, two auditory stimulation sessions, or a visual followed by an auditory session. This experiment tested whether the use of two learning sessions, which employ visual and then auditory stimuli, would increase recall as compared to two sessions using the same modality. The possibility of this type of advantage

for multisensory over unisensory learning has been discussed by Shams and Seitz (2008).

Method

Participants. Fifty-nine fresh participants were used, students taken from Bishop's University and Bishop's College School. The participants' ages varied between 18 and 30 ($M = 20.24$, $SD = 2.39$); 22 men and 37 women were tested. The students were randomly separated into three different learning conditions, with males and females in each group.

Materials. Consent and debriefing forms were used, and a demographic information form. A computer was used to present the learning stimuli in visual and auditory forms; the same set of 40 English nouns was employed as in Experiment 1 (Appendix A). For a filler task subjects received two different forms; both consisted of two different sets of picture puzzles, taken from the Internet, which require the viewer to find the differences between them. Each set of pictures had 12 differences.

Procedure. The participants were tested in a secluded room, either at Bishop's University or Bishop's College School. The participants were first given a consent form. The experimenter then explained to all the participants what they would be doing and then began the experiment. First, the participants in the visual-visual and visual-auditory conditions were shown a list of 40 words at 2-second intervals through a PowerPoint presentation. Those in the auditory-auditory condition heard the same list of 40 words at 3-second intervals by means of an mp3 file (this time interval being chosen to allow for the extra time needed to say a word rather than present it visually). After the first learning period, each participant was given the first 2 sets of picture puzzles as a filler task (this choice of task was made so as to avoid verbal material). They were given 7 minutes to find as many differences as possible. Next, subjects in the visual-visual condition were shown the same list of 40 words at 2-second intervals once again. The participants in the auditory-auditory and visual-auditory conditions heard the same list of 40 words at 3-second intervals. After the second learning period the participants were given two more sets of picture puzzles as a filler task where they were given 7 minutes to find as many differences as possible. Next participants were asked to give their gender, age, first language, and major. Once finished, they were given the memory test, which asked them to write down as many words as they could remember in five minutes. Finally, they were given a debriefing form.

In summary, subjects in the visual-visual condition 1 were shown the word visually in both learning periods, while those in the auditory-auditory condition heard the words spoken in both learning periods. Those in the visual-auditory condition were presented with the words through visual stimulation in the first learning session, then auditory stimulation in the second.

Design. The experimental design was a 3 × 2 (modality type × gender) independent groups ANOVA. The three levels of the modality type variable were visual-visual, auditory-auditory, and visual-auditory, referring to the modalities that the subject used for the first and second learning task. The dependent variable was the number of words recalled correctly.

Results

Descriptive Statistics. Table 2 shows the mean numbers of words recalled for the one-modality and two-modality conditions, together with confidence intervals. Pooled over genders, very slightly higher recall was shown for the auditory-auditory condition ($M = 13.97$, $SD = 4.69$), and the lowest recall for the visual-visual condition ($M = 13.80$, $SD = 5.18$), with the visual-auditory condition intermediate ($M = 13.86$, $SD = 4.92$). The overall mean score for this experiment (13.88 words recalled) was similar to that for Experiment 1 (14.96).

Effect of Number of Modality Types. A 3 × 2 independent groups ANOVA showed no main effect on recall for the number of modalities, $F(2, 53) = .006$, $p = .994$, $\eta^2 = .001$. Recall did not differ between male and female participants, $F(1, 53) = 1.59$, $p = .212$, $\eta^2 = .029$. There was no interaction of gender and number of modalities, $F(2, 53) = .714$, $p = .494$, $\eta^2 = .026$.

Demographic variables. No association of recall with age, major program, or gender was found, all $p (57) > .20$.

Discussion

There was no difference between the mean number of words recalled following visual-visual, auditory-auditory, or visual-visual presentation, so dual-modality learning did not increase memory over that seen using only one modality. These three conditions gave almost identical means. The visual-visual mean was only 0.41% below the visual-auditory mean, while the auditory-auditory mean was 0.97% above it.

A feature of this experiment is that the participants were tested in the same room throughout the experiment, which eliminates the confounding of modality condition with room identity. Also, each condition tested either 19 or 20 participants, which is an adequate sample size.

Summary and Concluding Discussion

The results of the two present experiments are consistent: when a very short retention interval is used, of a few minutes rather than hours, environmental enrichment does not produce the usual increase in the number of words recalled correctly, whether the enrichment was provided by using two rooms rather than one for studying (Experiment 1), or by the use of both visual and auditory modalities rather than a single modality (Experiment 2). The respective group means found here are essentially identical, to within less than two percent in three cases out of four.

This result agrees with the trend noted across various studies in the meta-analysis of Smith and Vela (2001). As they interpret the data of many studies, contextual effects improve or impair memory rather than learning itself, by improving the subsequent retrieval process; a similar point is made by Smith and Rothkopf (1984). This means that the retrieval enhancement process builds up over the time during which material is stored in memory, rather than operating instantaneously. Thus with the very short retention times used here no benefit occurs. But why is this so? Logically there seems no reason why the enhancement effect should require this type of maturation process over time in order to occur.

Our view is that while the initial registration of learning stimuli occurs in a few seconds, subsequent reprocessing and 'refiling' of learned items into more organized schemata will then occur unconsciously during the time they are held in storage. This reprocessing will run, to use a computer analogy, as an automatic background process and not appear in the subject's awareness.

A suggestive parallel may be drawn to the verbatim-to-semantic (or 'syntactic-semantic') shift which occurs progressively in verbal recall after increasing time intervals (Sachs, 1967), or to the reprocessing of remembered items into more organized sequences that is shown over time following learning (Bransford & Franks, 1971). We suggest that only when the learning stimuli have been not only registered, but also 'classified' and 'filed' in this relatively slow way as reprocessing in memory proceeds, can retrieval strategies play a beneficial role. This is because essentially they operate by helping the subject to locate the correct part of his mental data base to examine, rather than by strengthening the memory trace itself.

At the practical level, our results suggest that the benefits of enriching the learning environment will be negligible if a student is attempting to cram just before a test, although they would become progressively greater if he spreads out his studying over a period of time beforehand, even though the total amount of time remains constant. This learning strategy will of course also produce additional benefits due to spaced versus massed practice (Izawa, 1971).

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Correspondence concerning this article should be addressed to Jade-Isis A. Lefebvre, Bishop's University, P.O. Box 463, 2600 College Street, Sherbrooke QC, Canada J1M 1Z7. Electronic mail may be sent to jlefebvre08@ubishops.ca

Table 1

Experiment 1: Mean Words Recalled as a Function of Gender and Number of Rooms Used During Learning, with Standard Errors of the Means and Confidence Intervals

Gender	Rooms Used	*M*	*SEM*	*95% CI*
Female	1-Room A	17.36	2.68	11.96 - 22.77
	1-Room B	18.29	2.39	13.49 - 23.08
	2-Room A & B	17.14	2.39	12.35 - 21.94
Male	1-Room A	11.78	2.98	5.80 - 17.76
	1-Room B	12.67	3.65	5.35 - 19.99
	2-Room A & B	12.50	3.65	5.18 - 19.82

Note: all $n = 20$

Table 2

Experiment 2: Mean Words Recalled as a Function of Modality Used and Gender, with Standard Errors of the Means and Confidence Intervals

Gender	Modalities used	*M*	*SEM*	*95% CI*
Female	Visual-visual	14.20	1.16	11.87 - 16.53
	Auditory-auditory	18.29	2.39	10.93 - 17.30
	Visual-auditory	15.71	1.20	13.30 - 18.13
Male	Visual-visual	13.40	2.01	9.36 - 17.44
	Auditory-auditory	13.82	1.36	11.1 - 16.54
	Visual-auditory	12.00	1.84	8.32 - 15.68

Note: Visual-visual $n = 20$, auditory-auditory $n = 19$, and visual-auditory $n = 20$

Appendix A: Learning Stimuli

1. Noon
2. Crop
3. Rail
4. Rich
5. Wash
6. Tube
7. Mine
8. Suit
9. Sell
10. Swim
11. Wife
12. Nine
13. Gray
14. Nose
15. Coat
16. Band
17. Tool
18. Post
19. Duck
20. Path
21. Ring
22. Bone
23. Frog
24. Wing
25. Bell
26. Thin
27. Send
28. Rose
29. Deal
30. Term
31. Camp
32. Shop
33. Salt
34. Huge
35. Card
36. Feed
37. Seat
38. Glad
39. Deer
40. Neck