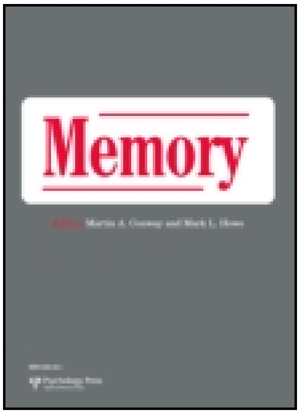


Memory
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pmem20

The dual effect of context on memory of related and unrelated themes: Discrimination at encoding and cue at retrieval

Einat Levy-Gigi [a] & Eli Vakil [a b]

[a] Department of Psychology, Bar-Ilan University, Ramat-Gan, Israel

[b] Leslie and Susan Gonda (Goldschmied) Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel

Published online: 18 Jul 2012.

MEMORY, 2012, 20 (7), 728–741

Psychology Press
Taylor & Francis Group

The dual effect of context on memory of related and unrelated themes: Discrimination at encoding and cue at retrieval

Einat Levy-Gigi[1] and Eli Vakil[1,2]

[1]Department of Psychology, Bar-Ilan University, Ramat-Gan, Israel
[2]Leslie and Susan Gonda (Goldschmied) Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat-Gan, Israel

The influence of contextual factors on encoding and retrieval in recognition memory was investigated using a retroactive interference paradigm. Participants were randomly assigned to four context conditions constructed by manipulating types of presentation modality (pictures vs words) for study, interference, and test stages, respectively (ABA, ABB, AAA, & AAB). In Experiment 1 we presented unrelated items in the study and interference stages, while in Experiment 2 each stage contained items from the same semantic category. The results demonstrate a dual role for context in memory processes—at encoding as well as at retrieval. In Experiment 1 there is a hierarchical order between the four context conditions, depending on both target–test and target–interference contextual similarity. Adding a categorical context in Experiment 2 helped to specify each list and therefore better distinguish between target and interferer information, and in some conditions compensated for their perceptual similarity.

Keywords: Context effect; Retroactive interference; Encoding; Retrieval.

Context plays an apparent role in many domains of psychology, including attention (Shalev & Algom, 2000), perception (Diehl, Lotto, & Holt, 2004), language (Miller, 1999), and decision making (Shafir, Simonson, & Tversky, 1993). Context also affects memory; however, this effect is not unitary and can be demonstrated in different manners (Levy-Gigi, Kelemen, Gluck, & Kéri, 2011; Levy-Gigi & Vakil, 2010; Vakil, Hornik, & Levy, 2008; Vakil, Raz, & Levy, 2007, 2010).

An episodic definition of context suggests that contextual information provides enough details to uniquely specify an event and distinguish it from other similar events stored in memory (Murnane, Phelps, & Malmberg, 1999). As such, context can not only improve retrieval (Murnane & Phelps, 1994; Rutherford, 2000; Smith, 1979, 1986) but also reduce interference by specifying different sources of information (Abeles & Morton, 1996; Dallett & Wilcox, 1968; Pezdek & Greene, 1993). For example, Dallett and Wilcox (1968) have shown that learning different material in two different contexts conferred a memory advantage (i.e., less proactive and retroactive interference) over learning all of the material in the same context.

The aim of the present study is to systematically dissociate between context effects at encoding and at retrieval and investigate their reciprocal relations. We do so by utilising retroactive interference paradigm, that includes three distinct stages: target information (that will be

Address correspondence to: Einat Levy-Gigi, Department of Psychology, Bar-Ilan University, Ramat-Gan 52900 Israel. E-mail: levygigie@gmail.com

This study was conducted as part of a PhD dissertation by Einat Levy-Gigi at Bar Ilan University, Ramat Gan, Israel.

http://www.psypress.com/memory http://dx.doi.org/10.1080/09658211.2012.701632

tested later), interferer information, and a memory test. These stages may take place in different contexts. We claim that manipulating the contextual similarities between the stages can either impair or improve memory performance.

The effect of context at retrieval is driven from the contextual similarity between the target information and the test. When both are presented in the same context the probability of remembering the target information is higher (Tulving & Thompson, 1973; see also Smith, 2007). This idea was illustrated both in a field setting using an environmental context (for example see famous study by Godden & Baddeley, 1975; for review see Smith & Vela, 2001) as well as in laboratory settings using various kinds of context manipulations such as perceptual features (e.g., location and background: Macken, 2002; Sakai, Isarida, & Isarida, 2010; presentation modality: e.g., Cook, Marsh, & Hicks, 2006), mood or emotional state (e.g., Eich & Macaulay 2000; Robinson & Rollings, 2011), physiological state (e.g., Eich, 1980), cognitive processing (e.g., transfer-appropriate processing: Goldstein, 2008; Morris, Bransford, & Franks, 1977; operation match: Dewhurst & Knott, 2010; Mulligan & Lozito, 2006), temporal context (e.g., Kessels, Hobbel, & Postma, 2007), and others (e.g., Hockley, 2008; Hollingworth, 2006; Vakil et al., 2007).

The effect of context at encoding depends on the contextual similarity between the target information and any subsequent interferer information. In the retroactive interference paradigm this condition is explicitly manipulated by presenting two lists of stimuli one after the other and later testing the memory of the first, target list. This condition better reflects our everyday experience than the simple encoding–retrieval paradigm, since retrieval of information does not usually follow its encoding.

Although a large body of studies have investigated the effects of similarity between two sources of information (that can be viewed as target and interferer information), such research does not usually take into account the theoretical perspective of context effect (e.g., Bayen & Murnane, 1996; Ferguson, Hashtroudi, & Johnson, 1992; Geiselman & Crawley, 1983; Lindsay & Johnson, 1991). The aim of those studies was primarily to maximise the differences between the target and interfering information. Accordingly, while context studies typically apply controlled exploration of context effects by using one contextual manipulation at a time, these studies have used multiple contextual dimensions, for example, simultaneous perceptual, temporal, and spatial cues. Under such conditions it is hardly possible to isolate the critical factor that affects target–interference discrimination. Therefore it is not surprising that the findings of these studies are inconsistent, and have led to conflicting conclusions (Hunt & McDaniel, 1993; Reyna & Lloyd, 1997). Several studies have found that memory performance decreases when target and interfering lists are presented in the same format (e.g., by manipulating presentation modality) (Garry, Manning, Loftus, & Sherman, 1996; Hyman & Pentland, 1996; Lane & Zaragoza, 1995; Sahakyan, Delaney, & Goodmon, 2008; Sahakyan & Kelley, 2002), while other studies have failed to find a similar effect (Eckert, Kanak, & Stevens, 1984; Kanak & Stevens, 1992). In summary, it seems the encoding process and its components, as well as the reciprocal relation between encoding and retrieval processes, have not yet been investigated from a context effect perspective.

The retroactive interference paradigm enables simultaneous investigation of context effect both at encoding and at retrieval. Therefore it allows a more comprehensive approach that takes the possible reciprocal relations between these effects into account, and helps to determine whether their effect is cumulative or independent. This approach is especially valuable in the light of recent findings showing that context effects on memory are much more complicated than previously thought (Levy-Gigi & Vakil, 2010; Vakil et al., 2007, 2008, 2010).

As mentioned above, there are many ways to manipulate context. In the present study we chose a well-studied context manipulation in which items are presented in different modalities (pictures versus words) (e.g., Kellogg, 2001; Levy-Gigi & Vakil, 2010; Pezdek & Greene, 1993; Vakil, Melamed, & Even, 1996). Using the two modalities (illustrated by the letters A and B), we constructed four contextual conditions of the presentation of target, interference, and test stimuli (ABA, ABB, AAA, & AAB). Different modalities help to specify information and require different cognitive processing that may interfere with each other (e.g., Dhooge & Hartsuiker, 2011; MacLeod, 1991). Therefore we anticipate that similarities between the modalities across the stages will result in context advantage/disadvantage at encoding/retrieval (see Table 1).

TABLE 1
The roles of context at encoding and at retrieval in the four experimental conditions

	Context effect at encoding	*Context effect at retrieval*
	Contextual similarity between target and interfering information	*Contextual similarity between target information and test*
ABA	Different (+)	Same (+)
ABB	Different (+)	Different (−)
AAA	Same (−)	Same (+)
AAB	Same (−)	Different (−)

+/− represent advantage/disadvantage of contextual similarity. Presenting the target and interfering information in different modalities (ABA and ABB conditions) helps to uniquely specify each one of them and therefore serves as advantage compared to presenting it in the same modality (AAA and AAB conditions). Presenting the target information and test in the same modality (ABA and AAA conditions) helps to better retrieve it and therefore serves as an advantage compare to presenting it in different modalities (ABB and AAB conditions).

We predicted that context advantage (marked as "+") both at encoding and at retrieval will improve memory performance compared to context disadvantage (marked as "−"). In addition, we hypothesise that the effect of context is cumulative; hence the performance in the ABA (++) will be significantly better than in the ABB (+−), AAA (−+) and AAB (−−) conditions, whereas the performance in the AAB condition will be the worst. Finally although, both ABB (+−) and AAA (−+) conditions have one contextual advantage and one contextual disadvantage, we predict performance superiority in the ABB (advantage at encoding) condition compared to the AAA condition (disadvantage at encoding). We assert that contextual similarity between the target and interfering information in the AAA condition may prevent an appropriate encoding of the target information. Proper encoding processes are needed in order to enable context advantage at retrieval and improve overall performance (Brown & Craik, 2000; Corrêa et al., 2012). Therefore, when the encoding process is disrupted, the overall performance will decrease.

We used a forced choice recognition test with three proposed options (target item, and two different distractors: one from the interfering list and one novel item). In this way participants need to decide not only whether the presented items are new or old, but also if the old items were presented as part of the first (target) or the second (interfering) lists. Since all three alternatives are presented at the same time, and as part of one question it results in three different measures: hits (choosing the item from the target list), old/interferer false alarms (choosing an old item that was presented in the interfering list), and new false alarms (choosing a new item that was never presented before). Our main interest is in the relations between the old/interfere and the new false alarms. By comparing the response rates in these two measures we can decide whether the participants' errors were due to general memory problem (new false alarms = interferer/old false alarms) or due to interference (interferer/old false alarms > new false alarms) (see Levy-Gigi & Vakil, 2010, for a similar paradigm). Although using this testing method minimises bias effects, we also added a d-prime measure to eliminate any possible bias effect of context reinstatement during retrieval (e.g., Hockley, 2008; Murnane & Phelps, 1995).

In Experiment 1 we investigate the effects of context at encoding and retrieval when the target and interfering lists contain unrelated items. In Experiment 2 we explore how thematic similarity between the items in each list alters these effects. Finally we provide a direct comparison between the two experiments.

EXPERIMENT 1

Method

Participants and design. There were 157 participants in Experiment 1. Two of these were excluded due to erroneous use of the keyboard during the test. The remaining 155 (78 women and 77 men) were undergraduate students at Bar-Ilan University (*M* age = 23.2 years, range 18–31 years), who volunteered to participate in the experiment without payment. Participants were randomly assigned to one of four contextual conditions (ABA, ABB, AAA, & AAB) that served as a between-participants factor. In each group half of the participants learned the target information as pictures (PWP, PWW, PPP, & PPW) and the remainder learned it as words (WPW, WPP, WWW, & WWP). The letters represent the modality that was used in each of the experiment stages. For example in the PWP condition the target list was presented as pictures (**P**WP), the interfering list was presented as words (P**W**P), and the test was presented as pictures (PW**P**). The target and interfering lists were counterbalanced. This resulted in a 2 (Contextual Similarity at Encoding) × 2 (Contextual Similarity at Retrieval) × 2 (Learning Modality) factorial design.

Materials. A list of 85 common object pictures (for examples see Appendix 1) which were consistently named identically by a separate group of 25 participants, and their corresponding word names, served as the experimental stimuli. The items were randomly assigned to the following three lists: the target list, the interfering list, and the test list. The target and the interfering lists contained 35 items presented either as a single picture or as a single word depending on experimental condition. The items were presented in a 7 × 6.5 cm box on a white computer screen background. The test list contained 15 unstudied foil items that were first presented during the test.

The test stage comprised 15 three-alternative forced choice questions. Each question presented three items: an item from the target list, an item from the interfering list, and an unstudied foil. All three test items were presented in the same form (pictures or words), according to the different context conditions. For example in the PWP condition the test items were presented as pictures (PW**P**) (see Appendix 2).

Procedure. Participants were tested individually in the presence of an experimenter. Participants were given the following written instructions onscreen (in Hebrew): "In this study, memory for words and pictures is compared. You will be presented with two different item lists. Please pay close attention to these lists." List titles (number 1 or number 2) were presented on a separate screen for 6 seconds. The items in both lists were presented serially for 3 seconds each using Superlab (Cedrus, San Pedro, CA). After viewing the target and the interference lists, the participants were given a 3-minute filler task in which they had to count down from 100 by threes. This was followed by the memory test. The following instructions were given: "Now you are going to be tested on the **first** list **only**. You will be presented with three items each time. Only **one** of them was presented as part of the first list. You have to indicate whether the item shown in the first list now appears on the left-hand side, the middle or the right-hand side of the screen, by using the keys indicated on the keyboard." The experimenter ascertained that participants understood the instructions before they started the test. After completing the test, participants were debriefed.

Results

Learning modality. Based on the picture superiority effect it was predicted that, overall, pictures would be better remembered than words (Nelson, Reed, & Waling, 1976; Paivio, 1971, 1986). Preliminary analysis revealed a significant main effect of Learning Modality, $F(1, 147) = 11.93$, $p < .005$, indicating that, as predicted, the mean percentage of hits when the target list was viewed as pictures ($M = 78.04\%$, $SE = 1.8\%$) was significantly higher than for words ($M = 69.3\%$, $SE = 1.78\%$). However, none of the interactions with Learning Modality reached significance (all Fs < 1). In order to simplify the reporting of results in subsequent analyses the two learning conditions (pictures vs words) were collapsed.

Hit rates. The percentage of hits (Figure 1) was analysed in a 2 Encoding Similarity (same modality, different modalities) × 2 Retrieval Similarity (same modality, different modalities) analysis of variance (ANOVA). A significant main effect of Encoding Similarity was found, $F(1, 151) = 47.5$, $p < .001$, indicating as predicted that the percentage of hits was significantly higher when target and interfering information were presented in different modalities ($M = 82.67$, $SE = 1.83$) than in the same modality ($M = 64.66$, $SE = 1.87$). In addition a significant main effect of Retrieval Similarity was found, $F(1, 151) = 10.12$, $p < .005$, indicated that as predicted the percentage of hits was significantly higher when target and test were presented in the same modality ($M = 77.82$, $SE = 1.87$) than in different modalities ($M = 69.51$, $SE = 1.83$). The Encoding × Retrieval interaction did not reach significance, $F(1, 151) = 0.07$, $p > .05$.[1]

False alarm rates. The percentage of false alarms (see Figure 2) was analysed in a mixed-design ANOVA, with the between-participants factors of Encoding Similarity (same modality,

[1]Similar results were obtained when using d' measure [Z(hits) − Z(total false alarms] as the dependent variable, revealing a significant main effects of Encoding Similarity, $F(1, 151) = 49.83$, $p < .001$, and Retrieval Similarity, $F(1, 151) = 9.97$, $p < .005$.

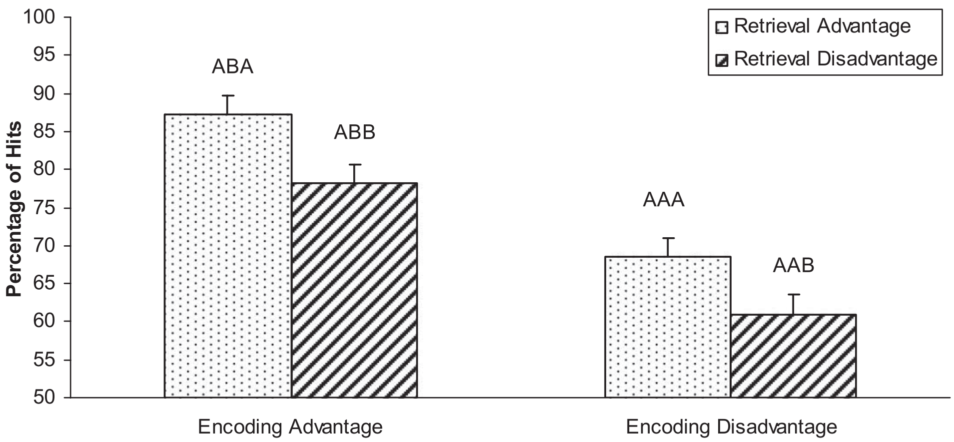


Figure 1. Mean percentage of hits (and standard error) in Experiment 1, as a function of advantages and disadvantages of context at encoding and retrieval processes (for details regarding the different context conditions see Table 1).

different modalities) and Retrieval Similarity (same modality, different modalities) and the within-participants repeated-measure factor of Error Type (interferer/old false alarm vs new foil false alarms). Most of the main effects are redundant and illustrate a mirror picture of the hit rates effects, and therefore are not reported.

There was a significant Encoding Similarity $\times$ Error Type interaction, $F(1, 151) = 10.6$, $p < .005$. Further analyses showed that when the target and interfering information were presented in different modalities (ABA and ABB conditions) there was no significant difference between interferer and new false alarms, $F(1, 78) = 2.96$, $p > .05$. However, when the target and interfering information were presented in the same modality (AAA and AAB conditions), the difference between the two types of error was significant, $F(1, 75) = 36.21$, $p < .001$; in both the AAA and the AAB context conditions the percentage of interfere false alarms was significantly higher than the percentage of new foil false alarms, $F(1, 36) = 15.18$, $p < .001$; $F(1, 38) = 20.76$, $p < .001$, respectively.

Discussion

The results of Experiment 1 confirm the effects of contextual similarity between experimental stages both at encoding (between target and interfering stimuli) and at retrieval (between targets and test probes). As expected there is a hierarchical relationship between the four context conditions, suggesting a cumulative context effect: greater correct recognition rates in the ABA condition (+ +) than in the ABB condition (+ −) indicates that encoding and retrieval context effects

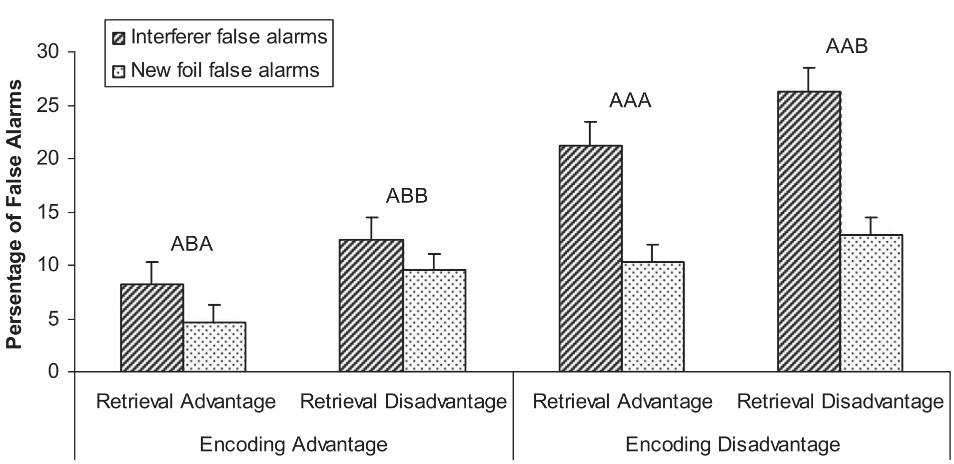


Figure 2. Mean percentage of false alarms (and standard error) in Experiment 1, as a function of advantages and disadvantages of context at encoding and retrieval processes and the type of error (for details regarding the different context conditions see Table 1).

are additive, since performance is significantly better when both effects exist. Greater correct recognition rates in the ABB condition relative to the AAA condition (−+) may suggest that context effect at encoding is more potent compared to its effect at retrieval, in conditions of retroactive interference. Therefore, as predicted, an appropriate encoding is needed in order to enable context advantage at retrieval (Brown & Craik, 2000). Finally, the worst recognition performance in the AAB condition (−−) indicates that in some conditions context effects can be negative, and reduce memory accuracy.

In Experiment 1 the importance of context effect at encoding was demonstrated using perceptual manipulation of context (pictures vs words). The purpose of Experiment 2 was to investigate whether categorical context would compensate for the disadvantage caused by perceptual similarity. As in Experiment 1 we used two lists of items, but rather than using unrelated items, items in each list shared the same theme (items that can be found at home vs items that can be found at the office). In this way each list has its own unique categorical context. Some of the list items represent the theme solely (e.g., bed in the house list and photocopy machine in the office list), while others could be classified equally as part of the target and the interfering lists (e.g., telephone).

We assume that, consistent with prior studies (Hertel, 1985; Lindsay, Allen, Chan, & Dahl, 2004) and in accordance with the definition of context, adding a categorical context would help to uniquely specify each list and may increase the discrimination between them. We predict that this manipulation will mostly affect performance in the AAA and the AAB conditions, in which the lack of perceptual distinction at encoding would be compensated by the conceptual distinctiveness and will allow participants to better discriminate target and interferer items.

EXPERIMENT 2

Method

Participants and design. There were 152 participants in Experiment 2. One of them was excluded due to erroneous use of the keyboard during the test. Two other participants left halfway through without completing the experimental session. The remaining 149 (77 women and 72 men) were students at Bar-Ilan University (M age $= 23.87$ years, range 19–29 years) who volunteered to participate in the experiment without compensation. Assignment to the different conditions was similar to that in Experiment 1. This resulted in a 2 (Contextual Similarity at Encoding) × 2 (Contextual Similarity at Retrieval) × 2 (Learning Modality) factorial design.

Materials. A pre-test was conducted in order to create a list of objects that people expect to be found at home and at the office. An additional 100 participants wrote down "whatever comes to their mind when they think about objects that they can find at home/office". Responses were used to create a bank of 35 household items and 35 office items mentioned by more than 85% of those participants. So 15 studied items from each category together with 15 unstudied foil items were presented during the test. These items were rated as equally expected to be found at home and in office (for example: picture, chair, & computer). Assignment to the various lists and presentation of the items were the same as in Experiment 1.

Procedure. The procedure in the current study was similar to that in the first experiment, except for the fact that we mentioned the theme (home or office) in the list titles as well as in the test.

Results

Learning modality. As in Experiment 1, preliminary analysis yielded a significant main effect of Learning Modality, $F(1, 140) = 43.93$, $p < .001$, indicating as expected that the percentage of hits when the target list was studied as pictures ($M = 87.1\%$, $SE = 1.6\%$) was significantly higher in comparison to words ($M = 71.6\%$, $SE = 1.7\%$). Since neither the Learning Modality × Contextual Condition interaction nor the Learning Modality × Error Type interaction were significant (ps $> .5$), in subsequent analyses the two learning conditions (pictures and words) were collapsed in order to simplify reporting of the results.

Hit rates. The percentage of hits (Figure 3) was analysed in a 2 Encoding Similarity (same modality, different modalities) × 2 Retrieval Similarity (same modality, different modalities) analysis of variance (ANOVA). A significant main effect of

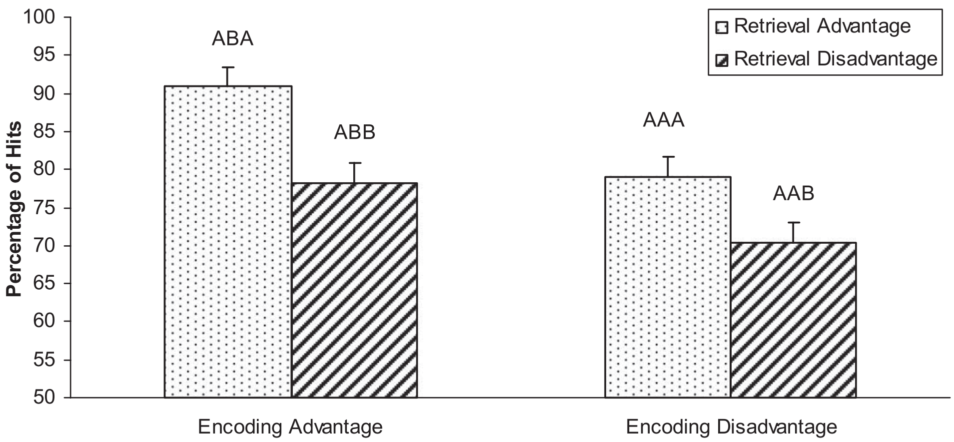


Figure 3. Mean percentage of hits (and standard error) in Experiment 2, as a function of advantages and disadvantages of context at encoding and retrieval processes (for details regarding the different context conditions see Table 1).

Encoding Similarity was found, $F(1, 145) = 14.65$, $p < .001$, indicating as predicted that the percentage of hits was significantly higher when target and interfering information were presented in different modalities ($M = 84.65$, $SE = 1.79$) than in the same modality ($M = 74.67$, $SE = 1.9$). In addition a significant main effect of Retrieval Similarity was found, $F(1, 145) = 19.95$, $p < .001$, indicating as predicted that the percentage of hits was significantly higher when target and test were presented in the same modality ($M = 85.02$, $SE = 1.84$) than in different modalities ($M = 74.3$, $SE = 1.85$). The Encoding × Retrieval interaction did not reach significance, $F(1, 145) = 0.58$, $p > .05$.[2]

False alarm rates. The percentage of false alarms (Figure 4) was analysed in a mixed-design ANOVA, with the between-participants factors of Encoding Similarity (same modality, different modalities) and Retrieval Similarity (same modality, different modality) and the within-participants repeated-measure factor of Error Type (interferer false alarm vs new foil false alarms). As in Experiment 1 most of the main effects are redundant and illustrate a mirror picture of the hit rates effects, and therefore are not reported. There was a significant Encoding Similarity × Error Type interaction, $F(1, 145) = 7.45$, $p < .01$. Further analyses revealed that when the target and interfering information were presented in different modalities (ABA and ABB conditions) there was no significant difference between interferer and new false alarms, $F(1, 78) = 0.69$, $p > .05$. However, when the target and interfering information were presented in the same modality (AAA and AAB conditions), the interaction was significant, $F(1, 69) = 8.63$, $p < .005$. Further analyses indicated that, while in the AAA there was no significant difference between the two error types, $F(1, 34) = 0.32$, $p > .05$, in the AAB condition the percentage of interferer false alarms was significantly higher than the percentage of new false alarms, $F(1, 34) = 12.4$, $p < .005$.

Discussion

The results of Experiment 2 strengthen the claim that the effects of context at encoding and at retrieval are additive and their influence on memory is cumulative. In addition it reveals that categorical context that uniquely specify the target and interferer information helps to distinguish between them, and in some conditions can compensate for their perceptual similarity.

The most significant influence of categorical context was observed when there was no perceptual distinctiveness between the target, interferer and test stages (AAA condition). In this condition we assume that using different categories for each list enabled participants to distinguish between the target and interferer information, and to use the perceptual context advantage at retrieval (both target and test are presented in the same modality) more effectively. However, it seems like such discrimination is not sufficient and does not improve performance in cases of

[2] Similar results were obtained when using d' [Z(hits) – Z(total false alarms)] as the dependent variable, revealing a significant main effects of Encoding Similarity, $F(1, 145) = 18.42$, $p < .001$, and Retrieval Similarity, $F(1, 145) = 21.88$, $p < .001$.

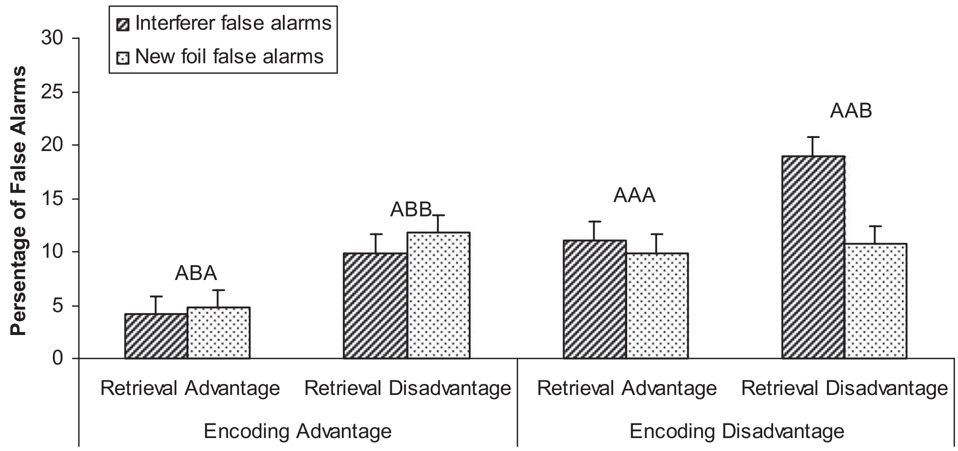


Figure 4. Mean percentage of false alarms (and standard error) in Experiment 2, as a function of advantages and disadvantages of context at encoding and retrieval processes and the type of error (for details regarding the different context conditions see Table 1).

encoding and retrieval disadvantages (AAB condition), nor fully compensate for perceptual similarity between target and interferer information (AAA < ABA). Therefore categorical context that forms thematic discrimination between two lists may help to use the perceptual context advantage at retrieval more effectively (up to a certain level), but without it, its effect in this paradigm is minimal.

In order to further investigate the reciprocal relations between perceptual and categorial contexts, it is essential to compare the performance in each experimental condition (ABA, ABB, AAA, & AAA) as a function of thematic connection within the lists. To that end, in the third part of this article we compared the two experiments directly.

COMPARISON BETWEEN THE TWO EXPERIMENTS

A $2 \times 2 \times 2$ ANOVA, with factors of Thematic Connection (same theme, different theme, i.e., Experiments 1 and 2, respectively), Encoding Similarity (same modality, different modalities), and Retrieval Similarity (same modality, different modalities) yielded a significant main effect of Thematic Connection, $F(1, 296) = 10.53$, $p < 0.005$, indicating that the percentage of hits when each list contained items from the same theme ($M = 79.66\%$, $SE = 1.3\%$) is significantly higher compared to conditions in which each list contained unrelated items ($M = 73.67\%$, $SE = 1.3\%$). In addition there was a significant interaction of Thematic Connection and Encoding Similarity, $F(1, 296) = 4.74$, $p < .05$. Further analysis revealed that when the target and interfering information were presented in different modalities (ABA and ABB) the percentage of hits did not differ as a function of thematic connection, $F(1, 156) = 0.71$, $p > .05$; however, when the target and interfering information were presented in the same modality hits percentage was significantly higher in the same- compared to the different-theme condition, $F(1, 144) = 11.9$, $p < .005$, in both the AAA and the AAB context conditions, $F(1, 70) = 7.12$, $p < .01$; $F(1, 72) = 5.19$, $p < .05$ respectively.[3]

A mixed-design $2 \times 2 \times 2 \times 2$ ANOVA, with the between-participants factors of Thematic Connection (same theme, different theme), Encoding Similarity (same modality, different modalities), and Retrieval Similarity (same modality, different modalities), and the within-participants repeated-measure factor of Error Type (interferer false alarms vs new foil false alarms) yielded a significant interaction between Thematic Connection and Error Type, $F(1, 296) = 11.47$, $p < .005$, illustrating the difference between interferer and new foil false alarms as a function of thematic connection (see results of error type main effects in Experiments 1 and 2). No significant interac-

[3] Similar results were obtained when using d' measure [Z(hits) – Z(total false alarms] as the dependent variable, revealing a significant main effects of Thematic Connection, $F(1, 296) = 10.25$, $p < .005$, and significant interaction between Thematic Connection and Encoding Similarity, $F(1, 296) = 4.61$, $p < .05$. Follow up tests showed the same trends revealing significant differences only in the same modality conditions, $F(1, 144) = 9.51$, $p < .005$, but not in the different modalities conditions, $F(1, 156) = 1.14$, $p > .05$.

tions between Thematic Connection and other variables were found. Other effects were redundant to effects presented as part of the results of Experiment 1 and 2. Please note that although we have controlled for some stimulus properties (syllabic length and concreteness) in the two experiments, it is possible that the differences we have found in memory performance are not only due to the thematic connection but also due to other distinctions between the lists we have used. However, since the differences that were found are specific to the AAA and AAB conditions, this possibility is less likely.

GENERAL DISCUSSION

The current study represents an innovative attempt to examine the effects of context at encoding and at retrieval and the reciprocal relations between them. In the first part of the study we used perceptual context (different modalities), and manipulating the similarities between the target, interfering and test stages. In the second part we tested whether adding categorical context (different themes) alters the effects of perceptual context.

Context effects at encoding and at retrieval

The results clearly demonstrate a dual role for context in memory processes—at encoding and at retrieval. These effects obtained whether study lists consisted of unrelated items (Experiment 1) or shared a same theme (Experiment 2). The context effect at retrieval emphasises the important contribution of context in conditions involving exposure to interfering information (see also Levy-Gigi & Vakil, 2010, for similar results in children) and expands it beyond the simple encoding-retrieval design that was previously reported in the literature (e.g., Cook et al., 2006).

The context effect at encoding is consistent with prior studies showing that distinctive processing is important for successful remembering (e.g., Ausubel, 1962; Einstein & Hunt, 1980; Moscovitch & Craik, 1976) as well as for better discrimination between different sources of information (e.g., Bayen & Murnane, 1996; Ferguson et al., 1992; Geiselman & Crawley, 1983; Lindsay & Johnson, 1991). However, it shows that using a single context manipulation, rather than multiple contextual dimensions, is sufficient to affect discrimination in a retroactive interference paradigm.

Greater correct recognition rates in the ABB (+ −) condition relative to the AAA condition (− +) in the first experiment (unrelated items) suggest that encoding and retrieval processes have a differential effect on memory performance. The effect of context at encoding may be more potent compared to its effect at retrieval, particularly since appropriate encoding of information is needed in order to ensure a successful retrieval.

The results are consistent with our prediction (see Table 1), revealing that the influence of context is accumulative and that both effects, at retrieval and at encoding, are beneficial to memory and operate simultaneously. Thus, in order to improve memory of target information in retroactive interference paradigm, both effects should be taken into account. It also supports the recent proposal that context effects should not be treated as a single comprehensive phenomenon but as a complex of factors with different weights (Vakil et al., 2007).

Perceptual and categorical types of context

It was found that adding a categorical context that specify the target and interferer information helps to discriminate between them and leads to a better memory performance. This effect is particularly strong in the AAA condition, when encoding disadvantage (perceptual similarity between the target and interferer information) is accompanied by retrieval advantage (perceptual similarity between target information and test). When the perceptual context distinguished between target and interference lists (ABA and ABB conditions), or when there are perceptual disadvantages both at encoding and at retrieval (AAB condition) the contribution of additional categorical discrimination is not significant. Therefore we concluded that the effect of categorical context is a function of retrieval processes. It may help to use the perceptual context advantage at retrieval more effectively (up to a certain level), but without it, its additive effect in this paradigm is minimal. These results align with theoretical frameworks claiming that appropriate encoding is essential to ensure suitable retrieval (Brown & Craik, 2000).

Practical implications

Our characterisation of the two contributions of context provides a basis for understanding other context-related findings. For example, it has been reported that school-type test performance is not consistently affected by similarity between the learning and test contexts (Fernandez & Alonso, 2001; Metzger, Boschee, Haugen, & Schnobrich, 1979). Based on the dual role of context reported herein, the inconsistency may be due to the fact that possible context effect at encoding was neglected.

Open questions and future directions

The present study was designed to explore the effects of target–interference and target–test similarities. However, it is important to note that similarity between interference and test may affect memory performance as well. This effect can take two opposite forms: contextual similarity between the interferer information and the test may increase the tendency to erroneously endorse interferer items rather than target items. On the other hand, when the target and interference stages are distinct it may help participants to correctly reject the interferer items during the test, and hence to increase the probability of choosing target items (Brainerd, Reyna, & Estrada, 2006). Although a post-hoc interpretation of the current study results supports a recollection rejection process (ABB > AAB), further research is necessary to elucidate this effect and the reciprocal relations between it and the effects of context at encoding and at retrieval.

To summarise, the current study simulates everyday life where retrieval of information does not always follow its encoding and may serve as a first step towards developing a wider and more comprehensive theoretical framework regarding the contributions of context effect as demonstrated in retroactive interference paradigm.

Manuscript received 7 April 2010
Manuscript accepted 6 June 2012
First published online 18 July 2012

REFERENCES

Abeles, P., & Morton, J. (1999). Avoiding misinformation: Reinstating target modality. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, *52A*, 581–592.

Ausubel, D. P. (1962). A subsumption theory of meaningful verbal learning and retention. *Journal of General Psychology*, *66*, 213–224.

Bayen, U. J., & Murnane, K. (1996). Aging and the use of perceptual and temporal information in source memory tasks. *Psychology & Aging*, *11*, 293–303.

Brainerd, C. J., Reyna, V. F., & Estrada, S. (2006). Recollection rejection of false narrative statements. *Memory*, *14*, 672–691.

Brown, S. G., & Craik, F. J. M. (2000). Encoding and retrieval of information. In E. Tulving & F. I. M. Craik (Eds.). *The Oxford handbook of memory* (pp. 93–108). Oxford, UK: Oxford University Press.

Cook, G. I., Marsh, R. L., & Hicks, J. L. (2006). The role of recollection and familiarity in the context variability mirror effect. *Memory & Cognition*, *34*, 240–250.

Corrêa, M. S., Balardin, J. B., Caldieraro, M. A., Fleck, M. P., Argimon, I., Luz, C., et al. (2012). Contextual recognition memory deficits in major depression are suppressed by cognitive support at encoding. *Biological Psychology*, *89*, 293–299.

Dallett, K., & Wilcox, G. (1968). Contextual stimuli and proactive inhibition. *Journal of Experimental Psychology*, *78*, 475–480.

Dewhurst, S. A., & Knott, L. M. (2010). Investigating the encoding-retrieval match in recognition memory: Effects of experimental design, specificity, and retention interval. *Memory & Cognition*, *38*, 1101–1109.

Dhooge, E., & Hartsuiker, R. J. (2011). The distractor frequency effect in a delayed picture–word interference task: Further evidence for a late locus of distractor exclusion. *Psychonomic Bulletin Review*, *18*, 116–122.

Diehl, R. L., Lotto, A. J., & Holt, L. L. (2004). Speech perception. *Annual Review of Psychology*, *55*, 149–179.

Eckert, E., Kanak, N. J., & Stevens, R. (1984). Memory for frequency as a function of environmental context. *Bulletin of the Psychonomic Society*, *22*, 507–510.

Eich, E., & Macaulay, D. (2000). Are real moods required to reveal mood-congruent and mood-dependent memory? *Psychological Science*, *11*, 244–248.

Eich, J. E. (1980). The cue-dependent nature of state-dependent retrieval. *Memory & Cognition*, *8*, 157–173.

Einstein, G. O., & Hunt, R. R. (1980). Levels of processing and organization: Additive effects of individualitem and relational processing. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 588–598.

Ferguson, S. A., Hashtroudi, S., & Johnson, M. K. (1992). Age differences in using source-relevant cues. *Psychology & Aging*, *7*, 443–452.

Fernandez, A., & Alonso, M. A. (2001). The relative value of environmental context reinstatement in free recall. *Psicologica*, *22*, 253–266.

Garry, M., Manning, C. G., Loftus, E. F., & Sherman, S. J. (1996). Imagination inflation: Imagining a childhood event inflates confidence that it occurred. *Psychonomic Bulletin and Review*, *3*, 208–214.

Geiselman, R. E., & Crawley, J. M. (1983). Incidental processing of speaker characteristics: Voice as connotative. *Journal of Verbal Learning & Verbal Behavior*, *22*, 15–23.

Godden, D., & Baddeley, A. (1975). Context-dependent memory in two natural environments: On land and underwater. *British Journal of Psychology*, *66*, 325–331.

Goldstein, E. B. (2008). *Cognitive psychology: Connecting mind, research, and everyday experience* (2nd ed.). Belmont, CA: Thomson Wadsworth.

Hertel, P. T. (1985). Isolation and adaptation in passage memory. *Discourse Processes*, *8*, 75–90.

Hockley, W. E. (2008). The effects of environmental context on recognition memory and claims to remembering. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *34*, 1412–1429.

Hunt, R. R., & McDaniel, M. A. (1993). The enigma of organization and distinctiveness. *Journal of Memory & Language*, *32*, 421–445.

Hyman, I. E., & Pentland, J. (1996). The role of mental imagery in the creation of false childhood memories. *Journal of Memory & Language*, *35*, 101–117.

Kanak, N. J., & Stevens, R. (1992). PI and RI in serial learning as a function of environmental context. *Applied Cognitive Psychology*, *6*, 589–606.

Kellogg, R. T. (2001). Presentation modality and mode of recall in verbal false memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *27*, 913–919.

Kessels, R. P., Hobbel, D., & Postma, A. (2007). Aging, context memory and binding: a comparison of "what, where and when" in young and older adults. *International Journal of Neuroscience*, *117*, 795–810.

Lane, S. M., & Zaragoza, M. S. (1995). The recollective experience of cross-modality confusion errors. *Memory & Cognition*, *23*, 607–610.

Levy-Gigi, E., Kelemen, O., Gluck, M. A., & Kéri, S. (2011). Impaired context reversal learning, but not cue reversal learning, in patients with amnestic mild cognitive impairment. *Neuropsychologia*, *49*, 3320–3326.

Levy-Gigi, E., & Vakil, E. (2010). Developmental differences in the impact of contextual factors on susceptibility to retroactive interference. *Journal of Experimental Child Psychology*, *105*, 51–62.

Lindsay, D. S., Allen, B. P., Chan, J. C. K., & Dahl, L. C. (2004). Eyewitness suggestibility and source similarity: Intrusions of details from one event into memory reports of another event. *Journal of Memory & Language*, *50*, 96–111.

Lindsay, D. S., & Johnson, M. K. (1991). Recognition memory and source monitoring. *Bulletin of the Psychonomic Society*, *29*, 203–205.

Macken, W. J. (2002). Environmental context and recognition: The role of recollection and familiarity. *ournal of Experimental Psychology: Learning, Memory, and Cognition*, *28*, 153–161.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, *109*, 163–203.

Metzger, R. L., Boschee, P. F., Haugen, T., & Schnobrich, B. L. (1979). The classroom as learning context: Changing rooms affects performance. *Journal of Educational Psychology*, *71*, 440–442.

Miller, G. A. (1999). On knowing a word. *Annual Review of Psychology*, *50*, 1–19.

Morris, C. D., Bransford, J. D., & Franks, J. J. (1977). Levels of processing versus transfer appropriate processing. *Journal of Verbal Learning and Verbal Behavior*, *16*, 519–533.

Moscovitch, M., & Craik, F. I. M. (1976). Depth of processing, retrieval cues, and uniqueness of encoding as factors in recall. *Journal of Verbal Learning and Verbal Behavior*, *15*, 447–458.

Mulligan, N. W., & Lozito, J. P. (2006). An asymmetry between memory encoding and retrieval. Revelation, generation, and transfer-appropriate processing. *Psychological Science*, *17*, 7–11.

Murnane, K., & Phelps, M. P. (1994). When does a different environmental context make a difference in recognition? A global activation model. *Memory & Cognition*, *22*, 584–590.

Murnane, K., & Phelps, M. P. (1995). Effects of changes in relative cue strength on context-dependent recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *21*, 158–172.

Murnane, K., Phelps, M., & Malmberg, K. (1999). Context-dependent recognition memory: The ICE theory. *Journal of Experimental Psychology: General*, *128*, 403–415.

Nelson, D. L., Reed, U. S., & Walling, J. R. (1976). Picture superiority effect. *Journal of Experimental Psychology: Human Learning & Memory*, *2*, 523–528.

Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt, Rinehart & Winston.

Paivio, A. (1986). *Mental representations: A dual-coding approach*. New York: Oxford University Press.

Pezdek, K., & Greene, J. (1993). Testing eyewitness memory: Developing a measure that is more resistant to suggestibility. *Law & Human Behavior*, *17*, 361–369.

Reyna, V. F., & Lloyd, F. (1997). Theories of false memory in children and adults. *Learning & Individual Differences*, *9*, 95–123.

Robinson, S. J., & Rollings, L. J. (2011). The effect of mood-context on visual recognition and recall memory. *The Journal of General Psychology*, *138*, 66–79.

Rutherford, A. (2000). The ability of familiarity, disruption, and the relative strength of nonenvironmental context cues to explain unreliable environmental-context-dependent memory effects in free recall. *Memory & Cognition*, *28*, 1419–1428.

Sahakyan, L., Delaney, P. F., & Goodmon, L. B. (2008). Oh, honey, I already forgot that: Strategic control of directed forgetting in older and younger adults. *Psychology and Aging*, *23*, 621–633.

Sahakyan, L., & Kelley, C. M. (2002). A contextual change account of the directed forgetting effect. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*, 1064–1072.

Sakai, T., Isarida, T. K., & Isarida, T. (2010). Context-dependent effects of background colour in free recall with spatially grouped words. *Memory*, *18*, 743–753.

Shafir, E., Simonson, I., & Tversky, A. (1993). Reason-based choice. *Cognition*, *49*, 11–36.

Shalev, L., & Algom, D. (2000). Stroop and Garner effects in and out of Posner's beam: Reconciling two conceptions of selective attention. *ournal of Experimental Psychology: Human Perception and Performance*, *26*, 997–1017.

Smith, S. M. (1979). Remembering in and out of context. *Journal of Experimental Psychology: Human Learning and Memory*, *5*, 460–471.

Smith, S. M. (1986). Environmental context-dependent recognition memory using a short-term memory task for input. *Memory & Cognition*, *14*, 347–354.

Smith, S. M. (2007). Context and human memory. In H. L. Roediger III, Y. Dudai, & S. M. Fitzpatrick (Eds.). *Science of memory: Concepts* (pp. 111–114). Oxford, UK: Oxford University Press.

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin and Review*, *8*, 203–220.

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review*, *80*, 352–373.

Vakil, E., Hornik, C., & Levy, D. A. (2008). Conceptual and perceptual similarity between encoding and retrieval contexts and recognition memory context effects in older and younger adults. *The Journal of Gerontology: Psychological Sciences*, *63*, 171–175.

Vakil, E., Melamed, M., & Even, N. (1996). Direct and indirect measures of contextual information: Older versus young adult subjects. *Aging, Neuropsychology, and Cognition*, *3*, 30–36.

Vakil, E., Raz, T., & Levy, D. A. (2007). Multifactorial context effects on visual recognition memory. *The Quarterly Journal of Experimental Psychology*, *60*, 916–923.

Vakil, E., Raz, T., & Levy, D.A. (2010). Probing the brain substrates of cognitive processes responsible for context effects on recognition memory. *Aging, Neuropsychology and Cognition*, *17*, 519–544.

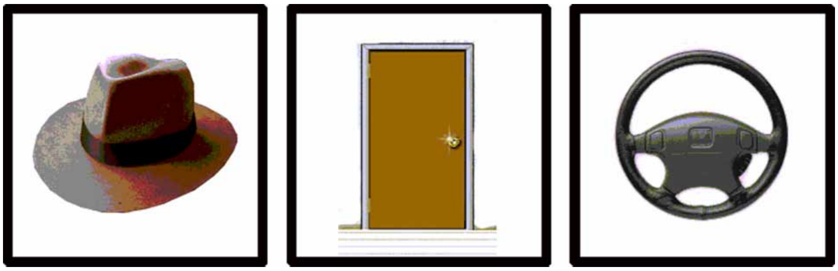
APPENDIX 1

Samples of stimuli presented as pictures (reduced in size)

APPENDIX 2

Samples of the three alternative forced choice questions

Test items are presented as pictures (e.g., in the PWP context condition).



Test items are presented as words- (e.g., in the PWW context condition). The original words were presented in Hebrew.