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Context effects in recognition memory: The role of familiarity and recollection☆

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Abstract

A variant of the process dissociation procedure was coupled with a manipulation of response signal lag to assess whether manipulations of context affect one or both of the familiarity and search processes described by the dual process model of recognition. Participants studied a list of word pairs (context + target) followed by a recognition test with target words presented in the same or different context, and in the same or different form as study (singular/plural). Participants were asked to recognize any target word regardless of changes to form (inclusion), or to only recognise words that were presented in the same form (exclusion). The standard context reinstatement effect was evident even at the short response lags. Analyses of the estimates of the contributions of familiarity and search processes suggest that the context effect demonstrated here can be attributed in part to the influence of familiarity on recognition, whereas the effect on recollection was less clear.
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1. Introduction

In general, reinstating the context in which an item or event was first encountered facilitates memory for that previous experience. Context effects on recognition memory have been reliably demonstrated by manipulating the relationship between pairs of words at study and test (e.g., Humphreys, 1976; Light & Carter-Sobell, 1970; Thomson, 1972; Tulving & Thomson, 1971). However, changes in environmental context have produced less consistent results (Fernandez & Glenberg, 1985; Murnane & Phelps, 1994; see also Smith & Vela, 2001 for a recent review). Variations in reports of context effects may reflect differences in the nature of the type of 'context' defined by the experimental situation. Hewitt (1977, cited in Godden & Baddeley, 1980) made the distinction between intrinsic context as the attributes of a stimulus that are necessarily processed during encoding (e.g., word meaning, grammatical attributes of a word) and extrinsic context as that which is not an essential part of the processing of the stimulus. Baddeley (1982) later introduced a similar distinction between interactive context and independent context. Interactive context determines the way information is encoded by the participant and independent context refers to the environment surrounding the presentation of an item (external such as physical surrounds, or internal such as participant's mood cognitive state). More recently, Smith and Vela (2001) distinguish between non-incidental (intrinsic) contexts and incidental (or environmental) context effects. The type of context effect of interest here is more in keeping with the idea of interactive/intrinsic context, empirically demonstrated by a recognition advantage for test items presented in the same verbal context at study and test over test items paired with a different word. The aim of the experiments was to investigate the nature of the memory processes underlying the effects of verbal context reinstatement on recognition performance.

Tulving and Thomson (1973) interpret context effects on recognition memory in terms of the 'encoding specificity principle.' That is, reinstating the encoding context affects the accessibility of the target word so that in recognition, like recall, retrievability of an item improves if the cues present at test match the encoding environment. Anderson and Bower (1972) have also described context reinstatement effects in retrieval terms, by postulating the use of contextual markers to enhance discrimination between old and new items.

In contrast, theorists who view recognition memory as involving a single, matching process account for context effects in the assessment of the familiarity of an item. For example, Gillund and Shiffrin (1984) proposed that by incorporating information about context into the test 'probe' used to access memory, reinstating the study context will contribute to the assessment of the strength of the match between study and test, or its familiarity value. Clark and Gronlund (1996) provide a detailed comparison of how different global matching models account for verbal context reinstatement effects. Many of these models are capable of demonstrating how context effects can occur because "associative information contributes to the match of the test probe only when *B* is tested with *A*, but not when *B* is tested alone or with different context items" (Clark & Gronlund, 1996, p. 44).

According to dual process theories of recognition memory (e.g., Jacoby, 1991; Mandler, 1980) two memory processes contribute to the recognition decision: A fast, automatic process that is based on an assessment of the familiarity of an item and described in terms of signal detection theory (Yonelinas, 1994); and a slower recollection or search process that retrieves information about the occurrence of the item during the study episode and is consciously controlled (Jacoby, 1991). Mandler (1980) suggested that a sense of familiarity relates to knowing only that an item has been encountered before, and is context free. However, identification of an item, in the sense of knowing where and when this encounter occurred, requires retrieval of contextual information. Therefore, as pointed out by Jacoby (1996a), context effects described by the encoding specificity principle are usually attributed to the influence of a consciously controlled search process. In one test of this premise, Tibergien, Cauzinille, and Mathieu (1979) reanalysed Tulving and Thomson's (1971) data to examine the predictive capability of a conditional search version of the dual process model. These authors concluded that the recognition parameter equivalent to the probability of retrieving information about the encoding episode was sensitive to changes in verbal context. In contrast, the pre-decision process that involves evaluating the familiarity strength of an item was not affected by contextual variation.

A dual role for contextual information in affecting recognition via influences on the evaluation of familiarity and the retrievability of an item has since been proposed (Tiberghien, 1986). That is, both the familiarity of the context and the item may contribute to the familiarity estimate, and contextual cues can also be used to guide the search process. Jacoby (1996b; Jacoby & Hay, 1998) expressed a similar view that variations in context may affect memory for an event via both automatic and consciously controlled influences. Using the process dissociation methodology, Jacoby has demonstrated support for this proposal in relation to associative context effects on cued recall (Jacoby, 1994, 1996a) and recognition (Jacoby, 1996b; Jacoby & Hay, 1998).

In the recognition study (Jacoby, 1996b; Jacoby & Hay, 1998) a typical process dissociation task was used, with participants first studying a visually presented list of words followed by the auditory presentation of a second list of words. The two study phases were followed by an exclusion recognition task in which participants were asked to recognize only those words that were presented in the second study list. Context was manipulated for words seen in the first study phase by presenting associatively related word pairs during study, and then presenting a test word either in the same (related) context as study, or with a different word (unrelated context). During the recognition test, a between-subjects manipulation of how much time was available for responding was also included. According to the logic of opposition, incorrect acceptance of an item from the first list reflects a decision based on familiarity in the absence of retrieval of information about list membership. When a response was required immediately, reinstating the associative context increased the probability of making a false recognition. When more time was available for responding however, the reinstatement of context increased the likelihood of making a correct rejection, and hence fewer false recognitions were made in the same context condition compared to words tested in a new context. These findings were interpreted as evidence for contextual information affecting both the familiarity and recollection processes, depending on the time available for responding. This explanation is based on the assumption that the effects of response signal lag (time between presentation of the stimulus and the request for a response) reflect differences in the temporal dynamics of the two recognition processes where the influence of familiarity is relatively faster than the contribution of the search process (e.g., Hintzman & Curran, 1994; Mulligan & Hirshman, 1995). This assumption has been implied, more or less strongly, in most variations of the dual process model, and has support from studies that combine process dissociation and speed–accuracy–tradeoff (SAT) methods to investigate recognition memory (e.g., see McElree, Dolan, & Jacoby, 1999).

While previous research has examined the effects of associative context on recognition memory (Jacoby, 1996b; Jacoby & Hay, 1998), the interest of the current study is to further investigate the contribution of context to familiarity and retrieval processes by manipulating context in a different manner. In the experiments to follow, context was operationally defined as the first member of a pair of unrelated words, with the second member being defined as the target, allowing for the effect of context to be assessed when there is no systematic pre-experimental relationship between the context and item members of a word pair. Previous research has shown that this type of context manipulation produces robust effects on recognition performance when the context is altered between study and test (e.g., Tulving & Thomson, 1971).

To examine the effects of reinstating non-associative context on separate components of the recognition decision, familiarity and retrieval processes, a type of process dissociation method was combined with a SAT procedure. In particular, the experimental approach is based on Hintzman and Curran's (1994) third experiment. In that experiment, participants were presented with a list of singular and plural nouns during the encoding phase. The recognition test contained old and new items, with the old items presented either as identical or extremely similar items (i.e., singular if plural at study, and vice versa). The frequency of presentation during study was varied, and seven response signal lags ranging from 100 to 2000 ms were used. Two types of recognition test instructions were given: Either respond YES to any previously presented words regardless of whether they were identical or similar (inclusion), or respond YES only to words that were presented in their identical form (exclusion). At the very short lags in the exclusion condition there was an increase in the number of false recognitions to similar items that declined and levelled out after about lag 1000 ms. To explain these results Hintzman and Curran (1994) discussed the role of search mechanisms in the correct rejection of distractor items. With little time available responses based on familiarity lead to false recognition due to the increased similarity, however with more time available for responding there is opportunity for the search process to contribute and it is likely that the "tendency for familiarity to induce false recognitions is suppressed" (p.16). Differences in the estimated contribution of recollection as a function of response lag, together with no effect on familiarity estimates have also been demonstrated with variants of the process dissociation methodology (Toth, 1996; Yonelinas & Jacoby, 1996a).

The current experiments are based on the general method of Hintzman and Curran (1994) described above, but with two exceptions. First, only two response signal lags (short and long) were used.[1] Second, a manipulation of verbal context was added using non-related word pairs. To include a process dissociation manipulation Hintzman and Curran's (1994) exclusion task was chosen rather than a list discrimination procedure (Jacoby, 1991). Using the singular/plural manipulation overcomes the need to present two lists of words in different modalities, and the decision for rejecting responses is based on retrieval of information about the target per se, rather than list membership. This distinction may be important considering suggestions that different

[1] With only two response signal lags it should still be possible to compare performance under conditions where the influence of recollection is maximal or substantially reduced (Toth, 1996), although the potential cost of losing sensitivity is acknowledged (McElree et al., 1999; Mulligan & Hirshman, 1995).

types of contextual features of an event may involve different memory processes (Clark & Gronlund, 1996; Dennis and Humphreys, 1998, cited in McElree et al., 1999).

Combining the process dissociation method with a manipulation of response lag provides two means of examining the effects of context on the separate contributions of familiarity (F) and search/recollection processes (R) to recognition performance. The first involves examining the pattern of responses to similar items (plurality changes) in the exclusion condition, as a function of context and response lag. If reinstating context at test contributes to familiarity, a higher level of acceptance of similar distractors would be expected in the same context condition compared to items tested in a new context, and this effect would be evident regardless of time available to respond. When there is more time available for responding, search processes supporting retrieval of information about the study episode would increase the probability of rejecting a similar distractor. When test items are presented in the same context as study, therefore, recollection may improve the chances of a correct rejection, but this effect could be offset by a corresponding increase in familiarity.

One way to disambiguate the effects of context on the two recognition components is to apply the process dissociation logic and calculate the quantitative estimates of familiarity and recollection according to the method outlined by Jacoby (1991). If context plays a dual role in affecting recognition, it was expected that reinstating verbal context would affect estimates of F, and that context effects would also show up in the R estimates under long lag conditions when there is greater opportunity for a search process to contribute.

The estimates were derived according to the assumption that familiarity and recollection contribute independently to recognition (see Curran & Hintzman, 1995; Jacoby & Hay, 1998; Jacoby, Begg, & Toth, 1997; Jacoby, Toth, & Yonelinas, 1993; Joordens & Merikle, 1993 for debate on the validity of this assumption). While the estimate of the contribution of recollection is unaffected by assumptions about the relationship between familiarity and recollection, conclusions about experimental influences on the familiarity estimate can be affected by violations of the independence assumption. In the current experiments the inclusion/exclusion test variable was manipulated within-subjects allowing separate estimates of F and R to be derived for each participant posing less of a problem in this regard (Jacoby, 1996a). Critics of the process dissociation approach also point out the potential problems of different response biases operating under the inclusion and exclusion test conditions (e.g., Graf & Komatsu, 1994). Where the error rate to new items is equivalent in inclusion and exclusion conditions, Jacoby et al. (1993) state that no such correction need be undertaken. Yonelinas and Jacoby (1996b) suggest that manipulating type of test within subjects minimizes the likelihood of a difference in base rate responding to new items. If there is a difference in base rate, a number of methods have been proposed which claim to control for differences in response bias (e.g., Buchner, Erdfelder, & Vaterrodt-Plünnecke, 1995; Yonelinas, Regeher, & Jacoby, 1995). This issue will be taken up in the report of the analyses and in Section 6.

2. General method

The following section provides information about the general method common to each of the experiments. Critical departures from this procedure are explained in the introduction to each experiment.

2.1. Participants

Twenty-four people participated in Experiment 1, 36 in Experiment 2a, and 12 in Experiment 2b. All participants were students from the Universite Pierre Mendes-France, Grenoble, France, who spoke French fluently. Each student participated in only one experiment, either as a volunteer or for course credit.

2.2. Materials

A total of 533 French words were chosen from a word pool of over 2000 words selected using the program Brulex (Content, Mousty, & Radeau, 1990). The words were nouns that had one or two syllables, were between 3 and 11 letters long, and occurred with a frequency above 100 per million. The words were divided into two practice blocks and four test blocks (mean word frequency for each block ranged from 277 to 294, *SD* ranged from 67 to 84). Within each block, half of the words were randomly designated the target stimuli, with one restriction that each word could be transformed into its plural by adding the letter 's'. Using the Canvas design program, the target stimuli were prepared for presentation in Geneva 24 point font and underlined, and the context stimuli were prepared for presentation in Geneva 20 point font. The stimuli were presented using the SuperLab program for Macintosh.

Items tested in the same context condition were paired with the same context word at study and test. In the different context condition the test item was paired with a new context word that did not appear on the study list. The following definitions of the test item categories were used: Old items are words that were on the study list and in the same form (singular/plural); Similar items are words that were on the study list but appeared in a different form on the test list (e.g. singular at study and plural at test); New items are words that did not appear on the study list (and were either singular or plural).

Each of the four experimental blocks consisted of a study list (40 context and target pairs, plus four buffer pairs), and a test list (48 pairs, plus four buffer pairs). Thus, there were eight items in each condition representing the factors context (same or different) and item type (old, similar, or new). Half of the target items were presented in their singular form and half in their plural form. The test list was identical for each participant, and the study list was altered so that each target word appeared once in each of the context and item type combinations. Two practice blocks were prepared with three items per condition, one test with inclusion instructions and one with exclusion instructions. The order of presentation was randomised for items in the study and test lists.

2.3. Design and procedure

Experiments 1 and 2 had a $2 \times (2 \times 2 \times 2 \times 3)$ mixed design: (1) response lag (short or long) manipulated between subjects; (2) trial (first or second); (3) test instructions (inclusion or exclusion); (4) context (same or different); and (5) type of test item (old, similar or new). The latter four factors were repeated measures. The final experiment did not include the response lag variable.

Each session commenced with one inclusion and one exclusion practice trial, followed by four experimental trials (two inclusion and two exclusion), with the order of test instructions counterbalanced across participants. Participants were told there would be two types of test, one of which would be indicated after each study episode.

During the study phase each stimulus pair was preceded by the "get ready" signal '+' shown in the center of the screen for 500 ms. Then the context and target words were presented for 4000 ms. The context word replaced the '+' signal, and the target word appeared just below the context. The inter-stimulus interval (ISI) was 750 ms. During the test phase each stimulus was preceded by the '+' signal (500 ms). The '+' was replaced by the presentation of the context word, after which the target word appeared underneath, and both the context and target remained on the screen until the signal to respond was given. In the short lag condition, the response signal (******) was presented immediately after, and slightly below the stimulus. In the long lag condition a delay occurred before the appearance of the response signal (during the delay the screen was blank and no response was accepted). The signal disappeared as soon as the response was made. The ISI was 750 ms. The exact temporal parameters used during the recognition test varied for each experiment and are discussed in more detail later. It should also be noted that SAT studies often confound the time of presentation of the test stimulus with response lag as the stimulus remains on screen until the response signal is presented. In the current experiments, the time of presentation of the test stimulus was kept constant, varying only the delay between presentation of the test stimulus and the signal to respond.

The study instructions informed participants they would see a series of pairs of words on the screen. They were told that all of the words were nouns, and the word underlined could be either singular or plural (the addition of the letter 's'). For each pair, they were instructed to form a short phrase or sentence relating the two words to help them remember the underlined words for a later memory test. They were told it was important to pay attention to whether the word underlined was singular or plural.

Immediately following the study phase participants received either the inclusion or exclusion test instructions. In both cases they were told they would be shown another series of word pairs, where some of the words had occurred in the previous list and some words were new. They were also told that again the underlined words could be singular or plural. The method of presentation was explained and they were instructed to wait for the response signal before responding as quickly as possible. The test instructions always stated that the task was to decide if the underlined word was in the previous list, but to read the first word in each pair as this would help them to make their response. The inclusion test required participants to respond YES if the target word appeared in the previous list regardless of its form (singular or plural), and to respond NO if it had not appeared in the previous list. The exclusion test required participants to respond YES if the underlined word had occurred in the study episode ONLY if the word appeared in the same form as before (singular or plural). They were told to respond NO if the word had not appeared previously or now appeared in a different form.

Participants made their responses by using the index finger of each hand to press either a red key (NO) or a blue key (YES) designated by two keys on the left and right of the keyboard (the left/right position was alternated across participants). The instructions emphasised the importance of responding immediately after the response signal, and no response was accepted until the specified time lag had elapsed. The entire procedure lasted approximately 40 min.

2.4. Data treatment

For the purposes of this paper the analyses were performed on scores averaged over the first and second experimental trials. Although initial analyses included the trial variable, there were few significant variations in the pattern of responses as a function of the first or second test. As these differences were considered to have little implication for the conclusions of the study they will not be discussed further. Therefore, the results presented here are based on data averaged over the first and second experimental trials.

3. Experiment 1

The choice of the temporal parameters for the manipulation of response signal lag was critical in establishing conditions that would support conclusions about recognition responses made when the contribution of recollection was either substantially reduced or fully available. Hintzman and Curran (1994) found changes in the pattern of recognition responses to single words occurred at lags of about 300 ms compared to longer response lags of more than 1500 ms. Using only two response lags, Toth (1996) found differences between 500 and 1500 ms responses. The current experiments, however, involved the presentation of pairs of words at test.[2] The final decision on the appropriate temporal parameters was guided by Jacoby's (1996b) study that also used word pairs. The details of that test procedure were adopted here, with the context word appearing first for 1000 ms followed by the presentation of the context and target together for 750 ms. In the short lag condition a response was required immediately after the test stimulus presentation, and in the long lag condition a 1250 ms delay occurred before the response signal during which no response was accepted (Jacoby, personal communication 1996).

3.1. Results and discussion

3.1.1. Recognition performance

The data were analysed using a $2 \times (2 \times 2 \times 3)$ ANOVA on the number of YES responses for each condition. The between subjects variable was lag (long or short), and the remaining factors within subject variables, instructions (inclusion or exclusion), context (same or different), and type of test item (old, similar, or new). Analysing YES responses allows for comparison of correct YES responses to old items (hits) and incorrect YES responses to new items (false alarms), for both inclusion and exclusion tests. Note that a YES response to a similar item would be classified as a hit under inclusion instructions and a false alarm under exclusion instructions. A summary of the results is shown in Table 1.

3.1.2. Test instructions

The manipulation of test instruction produced the intended effect indicated by significant main effects of instruction ($F(1,22) = 38.68$, $MSE = 5.79$, $p < .001$) and type of test item ($F(2,$

[2] An initial pilot study revealed two important considerations: It was obvious that the context word needed to appear before the target to ensure attention to both words; and it was clear that with very short presentation times (context = 100 ms, context + target = 300 ms) recognition performance was very poor.

Table 1
Mean number of YES responses in Experiment 1 (with standard deviations in parentheses)

Response lag	Type of test item	Inclusion		Exclusion	
		Same context	Different context	Same context	Different context
Short lag ($N = 12$)	Old	6.50 (.98)	5.58 (1.47)	6.21 (1.03)	5.83 (1.47)
	Similar	5.63 (1.19)	5.13 (1.69)	2.25 (1.50)	2.50 (1.64)
	New	.63 (.61)	.63 (.64)	.79 (.69)	.17 (.25)
Long lag ($N = 12$)	Old	6.54 (.96)	5.79 (1.54)	5.96 (1.01)	5.13 (1.25)
	Similar	6.12 (1.42)	5.88 (1.51)	2.21 (1.12)	2.42 (1.47)
	New	.88 (.86)	.67 (.81)	.83 (.91)	.67 (.83)

Note. The highest possible score in each condition is 8.

44) = 291.90, $MSE = 4.71$, $p < .001$), and a reliable interaction between instruction and type of test item ($F(2,44) = 50.41$, $MSE = 3.14$, $p < .001$). Further analyses compared the number of YES responses given under inclusion and exclusion instructions for each type of item (modified Bonferroni correction applied at $\alpha = .033$). No significant differences were found for old items ($M = 6.10$, $SD = 1.06$ vs. $M = 5.78$, $SD = 1.05$ for inclusion and exclusion tests, respectively, $t(23) = 1.36$, $p > .033$), and new items ($M = .70$, $SD = .60$ vs. $M = .61$, $SD = .61$ for inclusion and exclusion tests, respectively, $t(23) = .79$, $p > .033$). In contrast, significantly more YES responses were made to similar items in the inclusion condition ($M = 5.69, SD = 1.27$) than in the exclusion condition ($M = 2.34$, $SD = 1.34$, $t(23) = 7.83$, $p < .001$). Therefore, participants were able to follow the test instructions to exclude items that had changed in form from study to test.

3.1.3. Context

A significant main effect of context ($F(1,22) = 10.78$, $MSE = 1.61$, $p < .005$) showed that, overall, reinstating the study context increased YES responses, although the pattern of context effects differed as a function of item type ($F(2,44) = 5.96$, $MSE = .90$, $p < .01$). Remember that YES responses to similar items under inclusion instructions are correct responses, whereas YES responses to similar items under exclusion instructions are errors. Subsequent analyses ($\alpha = .033$) showed the context reinstatement effect was reliable for old items ($M = 6.30$, $SD = .80$ vs $M = 5.58$, $SD = 1.12$, same and different context, respectively, $t(23) = 4.27$, $p < .001$) and new items ($M = .78$, $SD = .62$ vs $M = .53$, $SD = .58$, same and different context, respectively, $t(23) = 2.48$ $p < .03$) but not for similar items ($M = 4.05$, $SD = .97$ vs $M = 3.98$, $SD = .78$, for same and different context, respectively, $t(23) < 1$). The negligible effect of context on similar items appears to originate from the exclusion condition where slightly fewer YES responses were made in the same context condition than in the different context condition, despite a standard context effect in the inclusion condition (see Table 1). However, the three-way interaction between instructions $\times$ context $\times$ type of item was not reliable.

3.1.4. Response lag

As shown in Table 1, performance on inclusion and exclusion trials was quite similar over the two response lags. The expected effect of response lag was not significant, nor did this variable interact with either type of test instructions or context.

3.1.5. Analyses of F and R estimates

It was possible to calculate the quantitative estimates of familiarity and recollection for each participant since each person contributed both inclusion and exclusion data. The estimates were calculated using the proportion of YES responses to similar items for each participant according to Jacoby's (1991) procedure,[3] and analyses of variance were then carried out using the individual estimates of F and R as the dependent measures. As indicated above, overall there was no difference in the level of base rate responding to new items in the inclusion and exclusion conditions. However, separate analyses on the new items indicated that significantly more false alarms were made to new items tested in the same context ($M = .78$, $SD = .62$) than in a different context ($M = .53, SD = .58$), ($F(1, 22) = 5.97, p < .05$). As differences in base rates across an experimental manipulation (i.e., context) can affect conclusions about the effect of this variable on the estimates of familiarity, the familiarity measures were also analyzed as d' scores (Fd'),[4] (see Yonelinas et al., 1995). Data were excluded from the analysis if either a negative estimate of R was obtained (due to more YES responses in the exclusion condition than in the inclusion condition[5]) or the exclusion score was perfect (i.e., zero YES responses to similar items). The latter case leads to an underestimation of the contribution of the familiarity component (where $F = 0$, Jacoby et al., 1993). Following these criteria for exclusion, data from 21 participants were retained, and analyses of variance conducted on the R, F and the Fd' estimates.[6] A summary of the results is presented in Table 2.

The analyses of the estimates of recollection and familiarity did not produce any reliable differences as a function of context, nor response signal lag. However, the pattern of effects shown in Table 2 indicate some support for the proposal that reinstating context affects the recollection process. Here, the estimated recollection contribution was higher for same context (.51) than different context conditions (.46), and this difference was more pronounced at the shorter lag. The estimates of familiarity were largely unchanged by the context manipulation, except for the calculated Fd' estimate for same context being lower than in the different context condition at the short lag.

The results do show that participants were able to select for or against words that appeared in a changed form from study to test, replicating the findings of Hintzman and Curran (1994). Also, robust effects of context on recognition performance demonstrate the typical verbal context reinstatement effect as expected (e.g., Tulving & Thomson, 1971). The results provide some support for Jacoby's (1996b) findings that subjects were more likely to correctly reject an item in the exclusion condition when context was reinstated. Accordingly, a small, but not significant, increase in R estimates was noted in the same context condition. However, these effects were not

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[3] For calculations based on the probability of responding YES to similar items, following Jacoby's (1991) logic of opposition then $R = \text{inclusion} - \text{exclusion}$ and $F = \text{exclusion}/(1 - R)$.

[4] d' cannot be defined when hit rates $= 1.00$ and/or false alarm rates $= 0$. To overcome this problem the correction recommended by Snodgrass and Corwin (1988) was applied, where false alarm rates were corrected by adding .5 and dividing by $N + 1$, where N equals the number of items. An alternative solution is to calculate d' from the group average data, reported by Macmillan and Kaplan (1985) to give estimates close to the true average.

[5] Fixing the R estimate at zero for negative values had a minimal effect and did not alter the overall pattern of results.

[6] For all analyses of the F, R, and Fd' estimates based on individual data, the group estimates for the entire sample were also calculated. Across the experiments, this check showed that the corrections applied in the analysis of individual scores did not distort patterns evident in the group results.

Table 2
Means and standard deviations (in parentheses) for the individual familiarity (F and Fd') and recollection (R) estimates in Experiments 1, 2, and 2b

	F		Fd'		R	
	Same context	Different context	Same context	Different context	Same context	Different context
Experiment 1						
Lag 0 ms ($N = 11$)	.46 (.23)	.45 (.16)	1.06 (.50)	1.35 (.40)	.46 (.19)	.39 (.29)
Lag 1250 ms ($N = 10$)	.56 (.26)	.54 (.13)	1.35 (.77)	1.30 (.54)	.56 (.11)	.53 (.29)
Experiment 2a						
Lag 0 ms ($N = 16$)	.62 (.13)	.54 (.19)	1.17 (.44)	1.22 (.51)	.26 (.21)	.32 (.18)
Lag 1250 ms ($N = 15$)	.62 (.16)	.44 (.15)	1.30 (.44)	.91 (.49)	.40 (.20)	.31 (.25)
Experiment 2b						
Lag 2250 ms ($N = 11$)	.54 (.17)	.38 (.12)	1.30 (.54)	.99 (.35)	.36 (.19)	.38 (.15)

statistically reliable, and further experiments were undertaken to try and replicate these findings and to address the failure to demonstrate an effect of response lag.

4. Experiment 2a

Changes were made to the presentation sequence of test stimuli in an attempt to overcome the absence of a response lag effect in Experiment 1. It was considered important to persist with the method of presenting the context word on its own before the target, but to also limit the duration of the appearance of the context stimulus relative to the target. One possible reason for the lack of an effect of lag in Experiment 1 may have been due to the relatively long presentation of the context word for 1000 ms before the target appeared. After some pilot work, the temporal parameters were set at 250 ms for the context alone, and 500 ms for the context and target presentation. The manipulation of response lag was identical to the previous experiment (0 or 1250 ms). These changes resulted in total presentation times (from stimulus onset to the response signal) of 750 and 2000 ms for the short and long lag conditions, respectively. These times are closer to the response lags shown by Hintzman and Curran (1994) to produce an effect as a function of the test instructions. Apart from these changes, the materials and procedure were the same as Experiment 1, and the same postulates hold.

4.1. Results and discussion

4.1.1. Recognition performance

As for Experiment 1, analyses of raw data were conducted on the number of YES responses, and these results are summarised in Table 3.

4.1.2. Test instructions

As in Experiment 1, the results indicated that participants were able to follow the inclusion and exclusion instructions (see Table 3). The main effect of instructions ($F(1, 34) = 54.22$, $MSE = 4.17$,

Table 3
Mean number of YES responses in Experiments 2a and 2b (with standard deviations in parentheses)

Response lag	Type of test item	Inclusion		Exclusion	
		Same context	Different context	Same context	Different context
Experiment 2a	Old	5.92 (1.15)	5.50 (1.00)	5.19 (1.15)	4.75 (1.06)
Lag 0 ms (short)	Similar	5.42 (1.35)	5.25 (1.35)	3.92 (1.33)	2.94 (1.04)
$N = 18$	New	1.44 (1.08)	.64 (.51)	1.14 (.87)	.92 (1.17)
Experiment 2a	Old	6.19 (1.05)	5.67 (1.43)	5.58 (1.03)	5.19 (1.07)
Lag 1250 ms (long)	Similar	6.33 (.91)	5.11 (1.33)	2.81 (1.25)	2.42 (1.70)
$N = 18$	New	1.03 (.72)	.67 (.87)	.97 (.95)	1.06 (1.21)
Experiment 2b	Old	6.42 (1.14)	5.46 (1.53)	6.00 (1.30)	4.50 (1.28)
Lag 2250 ms	Similar	5.83 (.94)	5.17 (1.35)	2.63 (1.65)	1.92 (.73)
$N = 12$	New	.54 (.62)	.67 (.96)	.63 (.71)	.13 (.31)

Note. The highest possible score in each condition is 8.

$p < .001$) and type of test item were significant ($F(2, 68) = 398.25$, $MSE = 3.95$, $p < .001$), as was the instructions × item interaction ($F(2, 68) = 45.17$, $MSE = 2.84$, $p < .001$). Although there were significantly ($\alpha = .033$) more YES responses to old items in the inclusion condition ($M = 5.82$, $SD = 1.08$) than in the exclusion condition ($M = 5.18$, $SD = .92$, $t(35) = 3.74$, $p < .01$), this difference was greater for the similar items ($M = 5.53$, $SD = 1.13$ vs. $M = 3.02$, $SD = 1.15$, for inclusion and exclusion, respectively, $t(35) = 7.83$, $p < .001$). There was no difference in the false alarm rate for new items (Inclusion $M = .94$, $SD = .72$ vs. Exclusion $M = 1.02$, $SD = .88$, $t(35) < 1$).

4.1.3. Response lag

More importantly, the instruction × item interaction changed as a function of response lag ($F(2, 68) = 4.12$, $MSE = 2.84$, $p < .05$). Planned comparisons showed that, as expected, with more time available for responding the number of false alarms to similar items in the exclusion condition decreased from the short lag ($M = 3.43$, $SD = .90$) to the long lag ($M = 2.61$, $SD = 1.24$). This difference just failed to reach significance with a modified Bonferroni correction applied ($\alpha = .025$, $t(34) = 2.27$, $p = .03$). In comparison, there was no difference in the number of correct YES responses to these items under inclusion instructions ($M = 5.33$, $SD = 1.22$ vs. $M = 5.72$, $SD = 1.03$ in the short and long lag conditions, respectively, $t(34) = 1.03$, $p > .05$).

4.1.4. Context effects

The main effect of context was reliable ($F(1, 34) = 26.44$, $MSE = 1.93$, $p < .001$), showing that overall, reinstating the study context increased the number of YES responses ($M = 3.83$, $SD = .48$ and $M = 3.34$, $SD = .60$ for same and different context conditions, respectively). The context manipulation did not produce any lower order interactions with either test instruction or type of test item, although the response lag × instructions × context × item interaction just reached significance ($F(2, 68) = 3.07$, $MSE = 1.33$, $p = .05$). As shown in Table 3, the variation in the effect of context as a function of instructions and response lag was one of degree rather than direction. Further analyses were conducted to specifically examine the effect of context on responses to similar items as a function of test instructions at each response lag ($\alpha = .01$). In the short lag condition, under exclusion instructions, the increase in false alarms to similar items tested in the same context compared to the different context condition, approached significance, ($t(17) = 2.63,\ p = .02$). The same pattern was evident for exclusion at the long lag, but this effect was attenuated and not significant ($t(17) < 1$). Under inclusion instructions there was a context reinstatement effect, but the difference was small at the short lag ($t(17) < 1$) and only reliable at the long response lag ($t(17) = 5.17$, $p < .001$).

4.1.5. Analyses of F and R estimates

Individual estimates of the contributions of the *F* and *R* processes were calculated for each participant using the procedures outlined in the previous experiment, and then subjected to analyses of variance. The results are summarized in Table 2. Again, although there was no difference in the level of base rate responding to new items in the inclusion and exclusion conditions (see above), the main effect of context was reliable ($F(1,34) = 8.43$, $p < .01$). This time, however, there was also a significant context × instructions interaction ($F(1,34) = 4.71$, $MSE = .50$, $p < .05$). A marginally significant difference in inclusion and exclusion base rates was evident in the different context condition, but this effect is in the opposite direction to what would be expected on the basis of more liberal responding in the inclusion test ($M = .65$, $SD = .71$ vs. $M = .99$, $SD = 1.17$, for inclusion and exclusion, respectively $t(35) = 1.92$, $p = .06$). There was no difference in base rates for the same context condition ($M = 1.24$, $SD = .93$ vs. $M = 1.06$, $SD = .90$, for inclusion and exclusion, respectively). Following the same criteria for rejection outlined for Experiment 1, data from 31 participants were retained, and analyses of variance conducted on the *R*, *F* and the *Fd′* estimates.

Although the expected main effect of lag on *R* estimates was not significant, the interaction between context and lag approached significance, ($F(1,29) = 3.74,\ MSE = .02,\ p = .06$). As can be seen in Table 2, there was an increase in the estimated contribution of *R* as response lag increased for items tested in the same context ($t(29) = 1.96,\ p = .06$) but not in the different context condition ($t(29) < 1$). Also shown in Table 2 is a change in the estimate of *F* as a function of context. Verbal context reinstatement produced a significant increase in the influence of familiarity measured by *F* ($F(1,29) = 11.48$, $MSE = .02$, $p < .005$), but this effect failed to reach significance in the analysis of *Fd′* ($F(1,29) = 3.34$, $MSE = .15$, $p = .08$). If the familiarity process is viewed as a fast, automatic process, then the estimated contribution of *F* should not change as a function of response lag. This was not the case in the analysis of *F* based on raw data, although the lag × context interaction was reliable in the analysis of *Fd′* ($F(1,29) = 4.84$, $MSE = .15$, $p < .05$). Further analyses ($\alpha = .025$) showed that this interaction was due to the context reinstatement effect being evident at the longer response signal lag ($t(14) = 2.50$, $p = .025$), but not at the short lag ($t(15) < 1$) (refer to Table 2).

In summary, the results show that participants were able to exclude similar responses but performance on this task improved when more time was available for responding. This improvement indicates an increased contribution of recollection in the long lag condition. There was a general increase in YES responses to items tested in the same context as study. The results suggest that this verbal context reinstatement effect may be attributed to an increase in the contribution of familiarity to the recognition decision. However, at the longer response lag, there was also some evidence that contribution of recollection increased for items tested in the same context, while no such advantage was demonstrated in the different context condition.

5. Experiment 2b

When considering the results so far, it seemed possible that differences in the way the test stimuli were presented may have affected performance across Experiments 1 and 2a. Although the lag between stimuli and response signal was kept constant at 0 or 1250 ms across experiments, the presentation time for the context and target stimuli differed. In effect, the briefer presentation of the context and target in Experiment 2a meant that the total presentation time in the long lag condition was 2000 ms (context 250 ms + context and target 500 ms + lag 1250 ms). This total time is considerably shorter than the 3000 ms used in the long lag condition in Experiment 1 and by Jacoby (1996b), (context 1000 ms + context and target 750 ms + lag 1250 ms). Therefore, to check whether it is the longer total presentation time that is needed to demonstrate an effect of context on recollection, the conditions of Experiment 2a were tested again, but with a longer response signal lag of 2250 ms (total time = 3000 ms).

5.1. Results and discussion

The results replicate the pattern of findings reported in Experiment 2a, so to be brief only the principal findings are presented here. As can be seen from Table 3, subjects were able to follow the test instructions, with fewer YES responses to similar items in the exclusion condition ($F(2,22) = 33.72$, $MSE = 1.86$, $p < .001$). Again, a robust context reinstatement effect was evident ($F(1,11) = 17.29$, $MSE = 2.05$, $p < .01$), and this time the interactions between context and type of item ($F(1,11) = 6.51$, $MSE = 1.88$, $p < .05$), and context and test instructions were significant ($F(2,22) = 2.92$, $MSE = .61$, $p = .05$). There was a general increase in the number of YES responses to targets tested in the same context as study (see Table 3), although only significant for old items ($\alpha = .033$), ($t(11) = 4.05$, $p < .01$). Overall, the context reinstatement effect was larger in the exclusion condition ($M = 3.08$, $SD = .66$, vs. $M = 2.18$, $SD = .57$, $t(11) = 4.88$, $p < .001$), compared to the inclusion condition ($M = 4.26$, $SD = .56$ vs. $M = 3.76$, $SD = .98$, $t(11) = 2.51$, $p < .05$).

Analysis of the estimates of the contributions of the F and R processes were undertaken following the procedures outlined previously ($N = 11$), and are also presented in Table 2. The calculated estimates of the contribution of F here should be viewed with caution, however, given the very low incidence of false recognitions to new words in the exclusion different context and consequently significantly different base rates as a function of test instruction, $t(11) = 2.60$, $p < .05$. With this in mind, reinstating context produced a significant increase in the estimate of familiarity, $t(10) = 2.67$, $p < .05$. When the Fd' estimates were calculated to account for differences in base rate as a function of context this difference was not reliable ($t(10) = 1.33$, $p > .05$). However, comparing the results from the previous experiment to these, it is interesting to note that the estimates of Fd' are almost identical. The estimated contributions of R were not affected by changes in context $t(10) < 1$.

6. General discussion

The purpose of these experiments was to examine the effect of context on familiarity and search processes in recognition memory by placing these processes in opposition using process dissociation, and at the same time varying the time available for responding. Looking to the effects of manipulating response lag across the experiments, the results demonstrate sensitivity to the choice of temporal parameters for the presentation of stimuli. In the first experiment, where the context word was presented for a relatively long duration before the target, there was no effect of lag. The failure to replicate results of previous research using the same parameters (Jacoby, 1996b; Jacoby & Hay, 1998) may be due to substantial differences between the tasks in other respects (e.g., the nature of the test instructions). When the context duration was shortened considerably there was evidence of a change in performance in keeping with past research (Toth, 1996). These results support the interpretation of a 'recall to reject' purpose for search processes in recognition memory (cf. Clark & Gronlund, 1996; Hintzman & Curran, 1994). In other words, when participants were required to respond immediately to the stimulus, the responses relied more on the assessment of the familiarity of the test item. Under exclusion instructions, a higher level of false recognitions to similar items resulted from the increase in the familiarity of these distractors. When more time was available for responding, an increased contribution of recollection led to a decrease in the level of false recognition to similar items presumably due to retrieval of information about the target memory. Exclusion performance was further improved when the response lag was made even longer in Experiment 2b. It is interesting to note that with a quite different paradigm, the contribution of search processes in recognition to the rejection of similar distractors has been demonstrated by manipulating the lag between successive presentations of related items during the test phase (Brainerd, Reyna, & Kneer, 1995).

Of primary interest was to determine what part the manipulation of non-associative verbal context would play in mediating recognition performance. First, a robust verbal context reinstatement effect was demonstrated in all experiments. In keeping with past research, the number of positive recognition responses increased when a test item was paired with the same context word as in the study phase (Humphreys, 1976; Light & Carter-Sobell, 1970; Thomson, 1972; Tulving & Thomson, 1971). To examine the processes contributing to this context effect, the estimates of F and R derived from the process dissociation procedure were analysed. Overall, there is reason to suggest that context changes affect both familiarity and recollection processes. In the first experiment the F estimates were unaffected by the context manipulation. The subsequent experiments used a shorter stimulus presentation time and demonstrated a reliable increase in F estimates when context was reinstated, regardless of the response signal lag. This effect could be described as an increase in the strength of the match between the test probe and memory (e.g., Gillund & Shiffrin, 1984), or as affecting the assessment of familiarity described by a signal detection process (Yonelinas, 1994). That the effects of context on F show up when the presentation time for the context stimulus alone was relatively short makes sense as the evaluation of familiarity is viewed as a relatively fast process (e.g., Hintzman & Curran, 1994).

The findings with respect to recollection were less clear, with certain aspects of the data suggesting that an effect of context on R estimates cannot be discounted. There was a weak effect of context on R estimates in the first experiment, and in Experiment 2a the estimate of the contribution of recollection increased over response lag when context was reinstated. Again, given proposed differences in the temporal dynamics of the two recognition processes (e.g., Hintzman & Curran, 1994; Mulligan & Hirshman, 1995), one might expect that a longer presentation time would support the use of the recollection process. In these circumstances providing the same verbal context at test would improve the retrievability of the target, and hence recognition memory (Jacoby, 1996b; Jacoby & Hay, 1998; Tiberghien, 1986). However, some anomalies in the results, such as more pronounced effect of context reinstatement at the short lag in Experiment 1, and the absence of an effect in the final experiment, suggest that these effects are quite sensitive to the range of temporal parameters used. It is possible that how long the context cue is made available is more critical in directing the search process than the overall response lag per se. For example, it is interesting to note that the estimates of recollection in the long lag condition in Experiment 1 appear to be higher than the estimates of recollection in the final experiment. In both cases the total time between the onset of the context word and the response signal is the same, three seconds, but the context word appears for one second in the first experiment and only 250 ms in the latter. It may be that the longer presentation of the context word promotes a 'cued recall' type of response strategy. Further work is required to investigate the effects of systematically varying the timing parameters, and in particular to observe any changes in the effects of context that may be evident.

In addition, task differences between these experiments and Jacoby's (1996b) method may be important. The type of task used here emphasized memory for the form of an item (singular or plural), which may be particularly sensitive to changes to the intrinsic/interactive context that affect the evaluation of familiarity (Tiberghien, 1997). A task that relied on information about list context, such as the typical process dissociation method used by Jacoby (1996b), may be more likely to show up context effects on the recollection process. As noted earlier, researchers are beginning to explore how different kinds of context may be mediated by different aspects of memory (e.g., Clark & Gronlund, 1996; Dennis and Humphreys, 1998, cited in McElree et al., 1999). Other procedural differences may also have affected the results.[7] The way in which the different context condition was contrived in our experiments meant that all context stimuli in this condition were new. Jacoby's method used old words that had been paired with an unrelated word at study to make up the different context condition. It may be the case that here, because half of the context stimuli were new, subjects were less likely to engage in recollection using the context word. A further difference that may have affected the sensitivity of the task to changes in recollection was that previous studies manipulated response lag whilst leaving the stimuli on the screen for the lag duration (Hintzman & Curran, 1994; Jacoby & Hay, 1998). In the current experiments the presentation duration was kept constant across variations in response signal lag.

It is also worth noting that conclusions based on calculating F and R estimates can be affected by questions about the process dissociation method. In particular, the effect of response bias and validity of the independence assumption have been identified as problems in the literature (Buchner et al., 1995; Curran & Hintzman, 1995; Jacoby & Hay, 1998; Yonelinas and Jacoby, 1996b). The individual data were reanalyzed using the Buchner et al. (1995) multinomial model which provides an alternative method for correcting for response bias, and also stipulates the conditions for estimating the contributions of familiarity depending on whether independence,

[7] Thank you to two anonymous reviewers for making these points.

exclusivity, or redundancy between F and R processes is assumed.[8] The main difference with the Buchner method is that the effects of context on the estimates of R were less pronounced in Experiment 1 (.55 vs. .52 for same and different context) and there was no lag effect in Experiment 2a (.31 vs. .32 for same and different context, respectively). The analyses supported the findings of Experiment 2a, that F is altered by changes in context, regardless of the assumed relationship between F and R.[9]

Finally, the findings reported here may also be considered in terms of a single process view of recognition memory (e.g., Gillund & Shiffrin, 1984). In this case, context would be seen as part of the trace used in the automatic access of information represented in memory. As noted by Ratcliff, Van Zandt, and McKoon (1995), this view of a single process that incorporates list context can result in different estimates of familiarity in the inclusion and exclusion conditions in a list discrimination paradigm. It is less clear, however, how variations in the pattern of responses under exclusion instructions as a function of response signal lag could be explained. One possible answer has been couched in terms of changing decision rules (Dennis and Humphreys, 1998; cited in McElree et al., 1999; Shiffrin & Steyvers, 1997). For example, Shiffrin and Steyvers (1997) put forward the idea of a 'two phase' approach to recognition, where the type of information contained in the probe cue would vary, perhaps first using features which define a particular memory set and then using word features. According to this view, the nature of the information contained in the probe cue, and hence on which the recognition decision is made, would vary as a function of retrieval time. As more time was available, the probe cue may contain information about list context and support exclusion decisions more accurately than earlier on in the recognition decision. Taken from a dual process perspective, this account describes list context as affecting later recognition decisions, perhaps in the same way that search processes are described as contributing when more time is available for responding. Verbal context, on the other hand, may be part of a probe used early in retrieval and affect the influence of familiarity on recognition.

In summary, the experiments reported here demonstrate robust effects of reinstating non-associative verbal context on word recognition. The suppression of false recognition of similar distractors when more time is available for the recognition decision supports the distinction between two recognition processes. Analyzing the data by quantifying the separate contributions of these processes to the recognition decision suggests that context effects can mediate recognition performance via the assessment of the familiarity of an item. Together with past research, the effects of context changes on the recollection process cannot be discounted. Further research needs to systematically investigate how familiarity and search processes are affected by context

[8] As Buchner et al. (1995) explains, the independence variant of the model leads to an estimate of familiarity in the same way as Jacoby's (1991) method. In the redundancy variant of the model, the estimate of unconscious processes (u or familiarity) is equal to performance in the inclusion condition ($u_R = p_{inclusion}$). Assuming exclusivity leads to an estimate of the unconscious processes (or familiarity) equal to performance in the exclusion condition ($u_E = p_{exclusion}$). Allowances for guessing are made by taking into consideration the probability of incorrectly responding *old* to a distractor item under inclusion and exclusion conditions when calculating the estimates of conscious and unconscious processes. For details of the model's equations refer to Buchner et al. (1995, pp. 143–145).

[9] In Experiment 2a, the mean estimate of F was greater in the same context condition compared to the different context condition when calculated assuming either independence ($M = .59$ ($SD = .17$) vs. $M = .41$ ($SD = .20$), $t(25) = 4.53$, $p < .001$), exclusivity ($M = .39$ ($SD = .13$) vs. $M = .27$ ($SD = .14$), $t(25) = 3.55$, $p < .005$), or redundancy ($M = .71$ ($SD = .17$) vs. $M = .59$ ($SD = .20$), $t(25) = 3.39$, $p < .005$). These effects were stable across response lag.

changes, taking into account the task demands, variations in the type of context manipulation and sensitivity to the temporal parameters of stimulus presentation.

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