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Dissociating measures of associative memory: Evidence and theoretical implications ☆

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Abstract

In four experiments, the authors investigated whether two measures of associative recognition memory (associative identification and associative reinstatement) are dissociable from one-another on the basis of their reliance on strategic retrieval and are dissociable from item recognition memory. Experiment 1 showed that deep encoding of relational information, but not of individual items, increased both types of associative memory significantly, as indexed by both measures, while it only marginally increased item memory. Experiments 2–4 showed that a short response deadline, a speeded recognition and an overlapping pairing condition interfered with associative identification, but left associative reinstatement unaffected. Associative reinstatement provides a measure of associative memory, but unlike associative identification, it is less reliant on strategic retrieval processes. We propose that associative familiarity underlies this measure. This process may index binding of information at encoding without involving the vivid, conscious re-experiencing characteristic of recollection at retrieval.

Keywords: Associative memory; Item memory; Recollection; Familiarity

The formation, retention and retrieval of new associations depend on memory for the individual items (item memory) and of their associations (associative memory). Recognition tasks of item memory typically require participants to discriminate between studied and unstudied items. There are two different ways to test associative memory on recognition tests. The typical way is an associative identification recognition task that requires participants to identify the associated information explicitly by discriminating between studied and novel combinations of items that they had already experienced (*associative identification*). In that test, item memory is equivalent for targets and distractors because all the

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items had been studied previously. Thus, participants must retrieve the relational information to make this distinction. The other way is a pair recognition task in which the reinstatement of the associated information improves recognition of the associated items without requiring explicit identification of the association (*associative reinstatement*). *Associative identification* requires explicit knowledge of the recovered associations akin to recall, especially in rejecting familiar items that are rearranged in a novel way. *Associative reinstatement* makes no such demands as participants are required to respond positively to all familiar items as ''studied old items'', but their recognition will be better for those items that appear as they had in the studied context. For example, when retrieving pairs such as AB and CD, participants in the identification condition have to distinguish these items explicitly from the rearranged pairs (e.g., accept AB, but reject AD). Rejecting AD demands explicit knowledge of the association as both items are familiar. In associative reinstatement, participants respond positively to both intact and rearranged pairs (AB and AD), but their performance should be better for those items that reinstate the initial studied context (AB > AD).

In this paper, we compare these two ways of testing associative memory to reveal the different demands these tests make on retrieval and, by doing so, illuminate the nature of associations. We report dissociations not only between item and associative memory, which have been well documented, but also between associative identification and associative reinstatement. As we noted, associative reinstatement is less reliant on effortful strategic retrieval processes and, thus, not only provides a different measure of associative memory, but also suggests that associative information may be represented differently. Such dissociations have interesting implications for how we conceptualize associative memory from a cognitive and neuropsychological perspective.

Although people have studied associative memory using both types of tests, to our knowledge, only one study by Castel and Craik (2003) has contrasted both measures in a single experiment. The advantage of doing so is that encoding is identical in the two cases as is the material at test, the only difference being the retrieval processes elicited by the different task demands. Consequently, such a comparison allows us to focus directly on possible differences between types of associative memory without the confounding effects of encoding and test material. Our study extends the work of Castel and Craik (2003), which found similar reductions on both measures in conditions of divided attention at encoding and in a group of older adults. Specifically, we test potential dissociations not only at encoding, but also at retrieval, where we believe the critical differences exist between the two measures.

We first review some of the literature on associative identification and associative reinstatement, two fields of study that are somewhat isolated from one-another.

Associative identification

An extensive portion of our knowledge of associative memory and of its distinct qualities relative to item memory comes from behavioural, neuroimaging and neuropsychological studies using associative identification recognition tasks. In terms of behavioural studies, manipulations such as repetition at study (Cleary, Curran, & Greene, 2001), increased rehearsal duration (Nairne, 1983), decreased lag between study and test (Hockley, 1991, 1992) and priming of items before study (Westerman, 2001) enhanced item memory but had little or no effect on associative identification. Relative to item memory, associative identification is enhanced for high frequency words (Clark, 1992), has a slower retrieval time (Gronlund & Ratcliff, 1989), shows distinct Receiver Operating Characteristics (Kelley & Wixted, 2001; Rotello, Macmillan, & Van Tassel, 2000; Yonelinas, 1997), and is associated with more self-reported judgements indexing conscious recollection (remember) and fewer judgments representing general feeling of oldness or familiarity (''know'' responses; Hockley & Consoli, 1999). With respect to special populations, greater decline in associative identification relative to item memory was documented in amnesic patients with bilateral damage to medial temporal lobe structures (Giovanello, Verfaellie, & Keane, 2003; Turriziani, Fadda, Caltagirone, & Carlesimo, 2004; but see Stark, Bayley, & Squire, 2002 for alternative findings), patients with Alzheimer's disease (Gallo, Sullivan, Daffner, Schacter, & Budson, 2004) and healthy older adults (Castel & Craik, 2003; Naveh-Benjamin, 2000).

These findings suggest that item and associative memory may rely on distinct neural substrates. This is supported by neuroimaging studies showing greater prefrontal, hippocampal and parietal activations for encoding of associations (Achim & Lepage, 2005a; Henke, Weber, Kneifel, Wieser, & Buck, 1999) and greater dorsolateral prefrontal cortex activation for retrieval of the associations on an associative identification recognition task (Lepage, Brodeur, & Bourgouin, 2003; Rugg, Henson, & Robb, 2003), especially when rejecting rearranged pairs, suggesting that this region is involved in post-retrieval monitoring (Achim & Lepage, 2005b). On the flip side, item memory retrieval is associated with a distinct pattern of activations in frontal, medial temporal and parieto-temporal regions, but is not associated with increased activations at encoding relative to associative memory (Achim & Lepage, 2005a).

Dual-process models of recognition memory (e.g., Atkinson & Juola, 1974; Jacoby, 1991; Mandler, 1980; Yonelinas, 1997) provide a framework to account for these dissociations. According to these models, recognition can be supported by two memory processes: *familiarity*, which refers to a generalized feeling of oldness that is rapid and relatively automatic; and *recollection*, which is a slow, effortful, recall-like process characterized by the retrieval of qualitative information regarding an event's occurrence. While both processes are involved in all recognition tasks, item recognition can rely on both familiarity and recollection, and associative memory is presumed to rely more heavily on recollection. In an associative identification recognition task, both processes work in concert when participants are presented with intact pairs, which are pairs that reinstate both the item and associative information. Recollection, however, must oppose item familiarity when presented with rearranged pairs. In this case, only item information is reinstated, and because both items are familiar, participants must recall or recollect the original associate of one of the items in order to reject the rearranged lures. Thus, one member of a pair is used as a retrieval cue for the other member (Humphreys, 1978; Mandler, 1980) and the instantiation of such a recall-like process involves extensive memory search and post-retrieval monitoring. Therefore, tests that require participants to discriminate between intact and rearranged items may provide a measure of associative memory only in a context that demands extensive use of strategic retrieval abilities, leaving undetected other associations that may exist.

Associative reinstatement

Instead of quantifying how associative memory can counteract the influence of item memory, we can measure how associative memory facilitates item memory (associative reinstatement). This idea stems from the encoding specificity hypothesis (Tulving & Thomson, 1973), which posits that a studied item is more likely to be recognized if it is presented at test in the context in which it was studied (intact pairing) rather than in a new context (rearranged pairing). Indeed, behavioural studies demonstrated that memory for a given item that was studied in a pair is better if it is tested with its original pair member then if it is tested alone or with another item (Humphreys, 1976; Light & Carter-Sobell, 1970; Thomson, 1972; Tulving & Thomson, 1971). Such enhancement occurs because recognition of an item depends on item and relation information (Humphreys, 1976, 1978). Typically, however, the magnitude of the enhancement is small [ranging from 9% to 16% (Humphreys, 1976; Tulving & Thomson, 1971)].

General global matching models of recognition memory (see Clark & Gronlund, 1996 for a review of these models) have been used to account for reinstatement effects. According to these models, individual memory representations are activated based on the match between the retrieval cue and the information in memory. For instance, the ICE model (Murnane, Phelps, & Malmberg, 1999) proposes that the individual activations of the item (I), context (C) and ensemble (E) or link between the item and the context are combined to form a global match value that serves as input to a decision process. Contrary to the dual process models proposed to account for the associative identification findings, these global matching theories do not include a recall-like, effortful retrieval process in their models, although some explicitly discuss the need of such a process (see Kelley & Wixted, 2001, for a similar criticism). Indeed, deliberate cue specification and memory search are not necessary because both the item and associative information are reinstated. Monitoring of retrieved associative information also is not necessary because retrieval of such information is not overtly required.

In the literature on reinstatement effects, there are many studies investigating the effect of different types of associative or contextual information on item recognition (e.g., general environment in which the test is given; see Smith & Vela, 2001 for review), but there are very few paired-associate studies investigating associative reinstatement. These studies suggest that associative reinstatement is dissociated from item memory in a way similar to that of associative identification. For instance, amnesic patients, older adults and young adults in a divided attention encoding condition show impaired associative reinstatement in addition to impaired associative identification (Castel & Craik, 2003; Goshen-Gottstein, Moscovitch, & Melo, 2000). These impairments were disproportionate relative to their performance on the item memory measures and suggest that associative memory as measured by these two ways can be reduced if binding of the associative information at encoding is compromised. There are no studies, however, contrasting these measures at retrieval.

Overview of experiments

In four experiments, we test potential dissociations between associative reinstatement and associative identification not only at encoding, but also at retrieval, where we believe the critical differences between the two measures lie. To these ends, we used a word-pair recognition paradigm where the two measures of associative memory can be derived and also permits a measure of item memory. Participants completed two explicit recognition tasks: a pair and an associative identification recognition task. The associative identification task requires participants to discriminate between intact and rearranged pairs and measures associative identification. The pair recognition task requires participants to distinguish pairs of old words, whether intact or rearranged, from new words. This task measures associative reinstatement and also provides a measure of item memory.

In Experiment 1, we varied the level of processing of the items and of the associations between items during the study phase to test whether associative identification and associative reinstatement are dissociable from item memory in ways that are similar. Deep encoding and processing of the relations between items should facilitate binding of individual pieces of information at the time of study, which is an operation necessary for the storage and retrieval of associative information. Thus, we expect that both measures of associative memory will benefit to a greater extent from the manipulation of levels-of-processing/depth of encoding than will item memory.

In Experiments 2–4, we interfered with the recall-like process, or the strategic retrieval component, instantiated more so in the associative identification recognition task than in the pair recognition task to test whether the two ways of measuring associative memory can be dissociated on that basis. In Experiments 2 and 3, we used a response deadline and a speed–accuracy trade-off manipulation, respectively. Given the serial nature of the retrieval sub-tasks (e.g., specification of memory cues, memory search and post-retrieval monitoring) and the evidence showing a slower time course of recollection relative to that of familiarity (Yonelinas, 2002), we expected time pressure to prevent participants from using these strategic retrieval abilities. In Experiment 4, the studied material was changed by mapping five associates per word, which is an overlapping manipulation similar to that used in fan effect experiments (Anderson, 1974). Adding associates to a given word interferes with the ability to use a recall-like process as one would need to recall all associates in order to exclude a rearranged pair on the associative identification recognition task. In Experiments 2–4, we expect that the identification measure will be hindered to a greater extent relative to the reinstatement measure and item memory.

Experiment 1

In Experiment 1, we investigated the effect of encoding manipulations designed to vary the depth of processing of individual words and of the association between words, on associative identification, associative reinstatement and item memory measures. Since introduced by Craik and Lockhart (1972), levels of processing manipulations have been used extensively in memory research. From a dual-process model standpoint, the typical findings are that meaning-based or deep encoding, as opposed to perceptual or shallow encoding, leads to large increases in recollection and smaller increases in familiarity (see Yonelinas, 2002 for review). We can extrapolate this dissociation to associative identification and item memory since they are thought to rely to a different extent on recollection and familiarity. We had two main goals in Experiment 1. First, using our paired-associate paradigm, we wanted to replicate the findings of the effect of deep encoding on associative identification. Following that, we wanted to see whether the same effects could be obtained with the associative reinstatement measure. Second, we wished to characterize the type of deep encoding manipulation that would be beneficial for associative memory measures. Mainly, we were also interested to test whether deep encoding of individual members of the pairs was sufficient to enhance associative memory, or whether deep processing of the relation between the words, in addition to this meaning-based processing of individual words, was necessary for such enhancement.

These encoding manipulations have been used mostly in single item recognition tasks, and consequently, involve deep encoding of individual items. We found only two associative identification recognition studies that used level of processing of the relational information on word-pair tasks (Henke et al., 1999; Wieser & Wieser, 2003). While pilot data reported in one of these studies (Henke et al., 1999) showed equivalent item memory enhancement after deep encoding of individual words and deep encoding of the relational information, the largest enhancement in associative identification was observed with deep encoding of the relational information.

We used three intentional encoding manipulations: (a) *shallow* encoding of the items and of the associations; (b) deep encoding of the items but shallow encoding of the associations (*deep items*), and (c) deep encoding of both the items and the associations (*deep associations*). We predicted that deep encoding of items (*deep items* and *deep associations*) would enhance item memory relative to the shallow condition, but made no predictions about differences between the two deep conditions on item memory.

Based on previous findings on levels-of-processing and processing of the relational information described above, we were confident that the deep associations condition would enhance the associative identification measure. We expected a smaller increase in associative identification following deep encoding of individual items (deep items) based Henke et al.'s (1999) findings, although we used different encoding tasks. As for the associative reinstatement measure, we expect that it would be modulated in a way similar to that seen with the identification measure. Alternatively, it may fail to dissociate itself from item memory, which would invalidate its use as a measure of associative memory.

Methods

Participants

Seventy-two undergraduate students from the University of Toronto who were native English-speakers

(42 women and 30 men, mean age = 19.65 years, mean number of years of education = 13.19) participated and received a course credit or a $10.00 CAN compensation payment. Twenty-four participants were assigned to one of three conditions (shallow, deep items and deep associations). Two participants were excluded and replaced because of failure to comply with the task instructions in one case and because of technical problems in the other case.

Materials and procedures

A total of 192 word pairs were created by combining one seven-letter noun (1st word) with a semantically unrelated six-letter noun (2nd word). Pairs were arranged into lists of 12 pairs, in which each word had two possible pairings (e.g., A–B or A–D and C–D or C–B). Lists were equated in terms of the first words', second words' and overall Kucera–Francis frequency (1st word: $M = 30.2$, range = 2–211; 2nd word: $M = 43.8$, range: 7–183, overall: $M = 37.0$, range = 2–211). Each list was assigned to one of four types of items (new pairs, half-old pairs, rearranged pairs and intact pairs) and to one of two test types (pair and associative identification recognition tasks). This list assignment was counterbalanced across participants so that each list was present equally in all test and item types.

At study, 120 word pairs plus six buffer pairs were presented (three buffer pairs at the beginning and at the end of the list). For both the pair and associative identification recognition tasks, 96 critical items were presented, including 24 *intact pairs*, which consisted of the previously studied pairs (e.g., A–B or C–D), 24 *rearranged pairs*, which were made of studied words rearranged to form new pairings (e.g., A–D or C–B), 24 *half-old pairs*, which were created by combining 24 words from 12 studied pairs with non-studied words (e.g., A–X or X–D), and 24 *new pairs*, which were composed of non-studied words (e.g., X–X). The latter two conditions were included so that participants could not use the presence of a single old or new word to determine their responses, but to encourage them to examine both items. Twelve non-critical test items consisting of the four types of pairs listed above were created from the buffer items. These items were presented at the beginning of each test type to provide practice. An additional practice phase preceded the practice with the buffer items and each test type to assure participants' understanding of the test instructions and response–key mapping. This initial practice phase included 16 trials using statements representing all possible test items [e.g., "2 new words" (new pair); "1 new and 1 old words" (half-old pair), "2 old words from different pairs" (rearranged pair), "2 old words from the same pairs" (intact pair)] with accuracy and response–speed feedback. At all phases, pairs were presented in a random order at the center of a 17-in. IBM computer screen using a white background and black, 18-point courier news font. E-Prime software was used for presentation and data collection.

Participants were tested individually. During the study phase, participants were instructed to remember the words and their pairing for a later test. In the *shallow* condition, participants were asked to read each pair aloud. Each pair was presented for 5 s followed by a fixation cross, which was presented for 1 s. It took 12 min to study the 120 word pairs. In the *deep items* condition, participants were required to read each pair aloud and to rate, on a five-point scale, each member of the pairs on a different conceptual attribute. One word was rated for concreteness ("1" being concrete and "5" abstract) and the other word was rated on pleasantness ("1" being pleasant and "5" being unpleasant). Each pair was presented for 5 s followed by a fixation cross. The fixation cross remained until all ratings were completed. Participants took on average 19 min to study the 120 study pairs. In the *deep associations* condition, participants were asked to produce a sentence, aloud, that contained the two words, was meaningful, and maintained both the form (i.e., singular) and order as they appeared on the screen. Participants were required to generate a sentence even if the pair was no longer visible. Once the sentence was completed or on rare occasions, after a reasonable delay was allowed but no sentence was initiated, the examiner terminated the trial and a new word pair was presented. On average, participants took 13 min to study the 120 study pairs and were able to create complete sentences with 92% of the word pairs.

After the study task, participants from the three groups performed a pair and an associative identification old–new recognition tests in counterbalanced order. They were instructed to respond quickly and accurately. In the associative identification recognition task, participants were asked if they had seen the presented word pairing during the study task. That is, participants had to respond "old" only to intact pairs (associative identification). In the pair recognition task, participants were asked if they had studied both presented words previously, regardless of their pairing. That is, participants should respond "old" to intact as well as rearranged pairs (associative reinstatement). Participants keyed-in their "old" and "new" responses with their left and right index fingers using the "v" and "m" keys. The response–key mapping was counterbalanced across participants.

Results

The proportion of "old" responses to each pair type (new, half-old, rearranged and intact) in the pair and associative identification recognition tasks are presented in Tables 1 and 2, respectively. Again, the two tasks differ with regards to "old" responses to rearranged pairs, which are hits in the pair recognition task and false

Table 1
Mean proportion and standard deviation of "old" responses per pair type in the pair recognition task, item memory and associative reinstatement measures for Experiment 1

	Old responses per pair type				Item memory		Associative reinstatement	
	New	Half	Rearranged	Intact	Rearranged − new	d'	Intact − rearranged	d'
Shallow	.10 (.10)	.26 (.12)	.63 (.18)	.65 (.16)	.53 (.20)	1.82 (.82)	.02 (.14)	.03 (.44)
Deep items	.08 (.08)	.35 (.16)	.84 (.13)	.91 (.11)	.76 (.16)	2.61 (.77)	.07 (.07)	.40 (.35)
Deep associations	.08 (.12)	.26 (.14)	.71 (.12)	.84 (.12)	.63 (.15)	2.16 (.65)	.13 (.11)	.49 (.44)

Table 2
Mean proportion and standard deviation of "old" responses per pair type in the associative identification recognition task and associative identification measure for Experiment 1

	Old responses per pair type				Associative identification	
	New	Half	Rearranged	Intact	Intact − rearranged	d'
Shallow	.03 (.07)	.13 (.12)	.34 (.19)	.56 (.18)	.22 (.25)	.63 (.84)
Deep items	.03 (.08)	.13 (.10)	.58 (.16)	.68 (.14)	.10 (.14)	.28 (.38)
Deep associations	.01 (.02)	.05 (.06)	.15 (.14)	.73 (.17)	.57 (.23)	1.86 (.86)

alarms in the associative identification recognition task. Item memory, associative identification and associative reinstatement scores were calculated using two methods: one using signal detection theory (d' scores), and the second using subtractions of proportions of old responses (e.g., hit minus false alarm rates). Both sets of scores for the item memory and associative reinstatement measures, and for the associative identification measure are presented in Tables 1 and 2, respectively. Analyses were done on both sets of scores and, unless a different pattern of results was obtained, we only report analyses on scores derived using the signal detection theory. To calculate these d' scores of item memory, associative identification and associative reinstatement, hit rates and false alarm rates of 0 or 1 were adjusted to 0.02 and 0.98, respectively. We derived our item memory measure from the hit rate to rearranged pairs and false alarm rate to new pairs in the pair recognition task because the rearranged pairs reinstate the studied item information, without the studied association. To compute the associative reinstatement measure, we first derived a d' score using the intact pairs and new pairs in the pair recognition task. The intact pairs reinstate both the item and associative information. We then calculated the difference between this score and the item memory score derived from the rearranged pairs (see Murnane et al., 1999 for a similar procedure). For the subtractive method, we simply calculated the difference in hit rates between rearranged and intact pairs on the pair recognition task. To compute the associative identification measure, we used the false alarm rate to rearranged pairs and the hit rate to intact pairs in the associative identification recognition task.

In this section, to evaluate the effects of our three encoding manipulations, we report analyses of variance (ANOVAs) carried separately on our primary measures of item memory, associative reinstatement and associative identification. In addition, we report results of t-test analyses (planned contrast) that inform us on the effect of each encoding manipulation on the primary measures in relation to the other two manipulations. For brevity, we then only report results of the analyses (ANOVAs and t-tests) of the raw hit rates and false alarm rates that help characterize the findings obtained on our primary associative measures [e.g., describe whether poor associative identification is due to changes in the false alarm rate only, hit rate only, or in both (mirror effect)]. ANOVAs and t-test analyses were also done on hit rates and false alarm rates that were corrected for response bias (by subtracting the false alarm rate to new pairs), but these are not reported here because they yielded the same pattern of results as that obtained with the raw data.

Item memory was significantly affected by the encoding manipulations [$F(2,69) = 6.75$, $p < 0.01$, partial $\eta^2 = .16$]. This effect was due to the enhancement of item memory in the deep items group relative to the shallow group [$t(46) = 3.45$, $p = .001$, $d = 1.00$] and deep associations groups [$t(46) = 2.20$, $p < .05$, $d = 0.64$]. While we expected greater item memory in the deep associations group relative to the shallow group, our results revealed only a trend supporting this, but the item memory difference was not significant [$t(46) = 1.60$, $p = .12$, $d = 0.46$].

If associative information is stored in memory, reinstatement of this information at test may enhance performance on what is essentially an item memory task (i.e., greater hit rate to intact pairs relative to rearranged pairs). The associative reinstatement measure was significantly affected by the encoding manipulations [$F(2,69) = 8.45$, $p = .001$, partial $\eta^2 = .20$]. Both deep encoding groups' associative reinstatement scores were higher than that of the shallow group [deep items: $t(46) = 3.23$, $p < .01$, $d = 0.94$; deep associations: $t(46) = 3.64$, $p = .001$, $d = 1.05$]. However, the deep items and deep associations groups did not differ on this measure ($t < 1$). A slightly different pattern of results was obtained for the deep item group using the subtractive method to derive the associative reinstatement measure (i.e., hit rate to intact pairs minus hit rate to rearranged pairs on the pair recognition task). While the associative reinstatement score of the deep item group still fell in-between those of the other two groups, it was not significantly greater than that of the shallow group [$t(46) = 1.61$, $p = .12$, $d = 0.49$], but instead, was significantly reduced relative to the deep associations group [$t(46) = 2.07$, $p < .05$, $d = 0.62$]. The overall effect of the encoding manipulation [$F(2, 69) = 5.51$, $p < .01$, partial $\eta^2 = .14$] and the difference between the shallow and deep association groups' associative reinstatement [$t(46) = 2.88$, $p < .01$, $d = 0.84$] were similar to those obtained using signal detection. This discrepancy in results is due to the deep items group's very high hit rates, which are at the upper range of the normal distribution of hit rates (while the differences in raw hit rates are constant regardless of the levels of the hit rates, the differences become larger when converted in z-space in situations where the hit rates are either extremely low or high relative to situations in which they are in the mid-range). Despite these conflicting results, we can conclude that both deep encoding conditions modulate associative reinstatement to a different extent than they do item memory.

A second and more typical way to measure associative memory is the associative identification measure that tests the ability to discriminate intentionally between items that reinstate item information only (rearranged pairs) from items that reinstate studied items and associations (intact pairs) on the associative identification recognition task. The encoding manipulations had a significant effect on associative identification [$F(2, 69) = 31.15$, $p < .001$, partial $\eta^2 = .47$]. As predicted, the associative identification score was greater following deep associations than shallow [$t(46) = 5.04$, $p = .001$, $d = 1.45$] and deep items encoding [$t(46) = 8.23$, $p < .001$, $d = 2.54$]. The deep associations group's enhanced associative identification ability was characterized by a mirror effect relative to the shallow group; that is, they had lower false alarm rate to rearranged pairs [$t(46) = 3.85$, $p < .001$, $d = 1.13$] and higher hit rates to intact pairs [$t(46) = 3.42$, $p < .001$, $d = 0.99$]. In contrast, the beneficial effect of deep associations encoding relative to deep items encoding was more asymmetrical with an important decrease of the false alarm rate [$t(46) = 9.69$, $p < .001$, $d = 2.80$], but comparable hit rate to intact pairs [$t(46) = 1.21$, $p = .23$, $d = 0.35$]. Unexpectedly, there was a slightly, although not significantly, higher associative identification score following shallow than deep items encoding [$t(46) = 1.80$, $p = .08$, $d = 0.56$]. This result contrasts with Henke et al.'s findings based on which the opposite result was anticipated, that is, greater associative identification following deep items than shallow encoding. This reduced associative identification ability was solely due to the deep item's group difficulty in rejecting rearranged pairs [$t(46) = 4.59$, $p < .001$, $d = 1.33$] as this group's ability to accept intact pairs was superior to that of the shallow group [$t(46) = 2.56$, $p < .05$, $d = 0.74$]. In sum, deep encoding of associative information facilitates the ability to discriminate intentionally between studied and unstudied associations. While deep encoding of the individual items was sufficient to support endorsement of studied associations (intact pairs), it severely disrupted the ability to reject familiar lures (rearranged pairs).

Discussion

Our first goal in Experiment 1 was to see whether both associative memory measures can be dissociated from item memory. Our results support this idea and demonstrate that the associative reinstatement measure, like the associative identification measure, is dissociable from item memory. It is important to consider, while interpreting these results, that the magnitude of the associative reinstatement effect (i.e., the actual gain in performance), though numerically small in comparison to associative identification, is consistent and comparable to values reported in the literature. This pattern holds throughout our subsequent experiments.

In the current experiment, associative identification and associative reinstatement measures were both strongly positively affected by the deep processing of the associations relative to shallow processing and this enhancement was greater than the trend seen in item memory based on the magnitude of the effect sizes (Cohen's d of 1.05 and 1.45 for the associative memory measures and 0.46 for the item memory measure). Interestingly, the effect of deep encoding on the associative identification measures was characterized by a mirror effect indicating that both the ability to accept intact pairs and the ability to reject rearranged pairs are altered. In addition, despite an item memory gain following deep encoding of items relative to deep encoding of associations, deep encoding of items led to much poorer associative identification ability and similar or mildly reduced associative reinstatement benefit.

In addition to supporting a dissociation between item and associative memory measures, the latter results hint at a dissociation between associative identification and associative reinstatement. The deep items and shallow items encoding manipulation had opposite effects on the two measures of associative memory. Whereas associative reinstatement was enhanced by deep over shallow encoding, associative identification showed the opposite effect. Thus, we found a significant interaction on a 2 (shallow items, deep items) × 2 (d' associative reinstatement, d' associative identification) repeated measure ANOVA [$F(1, 46) = 17.06$, $p < .001$, partial $\eta^2 = .27$], though the *t*-test analyses conducted separately on these two measures did not reach statistical significance. Although these opposite effects of levels of processing see ms counterintuitive, we propose that this possible dissociation between measures of associative memory occurs mainly at the time of retrieval rather than at the time of encoding or binding of the information in memory. As noted in the Introduction, the reliance on strategic retrieval processes is particularly important to reject familiar items on the associative identification recognition task, and the more familiar these items are (the higher the item memory), the more effortful it is to oppose this feeling of familiarity. Thus, although the deep items group can bind and store associative information (as indicated by better associative reinstatement than the shallow group), this group's superior item memory heightens the likelihood that familiar lures (rearranged pairs) will be mistakenly endorsed on the associative identification recognition task. In fact, this difficulty is the main reason underlying the deep items group's associative identification deficits while their ability to endorse intact pairs, which are also highly familiar items, is comparable, or superior, to that of the two other groups. The latter ability may represent an instance wherein heightened item familiarity supports recognition of the intact pairs and compensates for a reduction in recollection. In Experiments 2–4, we will further test the dissociation between associative reinstatement and associative identification measures at retrieval.

Our second goal was to characterize the type of deep encoding manipulation that would be beneficial for associative memory measures. Based on the associative reinstatement data, deep encoding of the associations is advantageous for the encoding and binding of associative information in memory relative to shallow encoding. As noted in the Results section, the deep items' group reinstatement score fell between those of the other two groups both when signal detection and subtractive scoring methods were used. However, significance levels differed when contrasting the deep item group's reinstatement score with those of the other two groups depending on whether the analyses were conducted on scores based on signal detection or the subtractive method. The deep items' group score was significantly different from those of the shallow group, but not from that of the deep associations group, using the signal detection method, but was significantly different from that of the deep associations, but not from that of the shallow group, using the subtractive method. This discrepancy may be related to the conversion of very high hit rates in *z*-scores, which would maximize the magnitude of the reinstatement effect for the deep item group. As for the associative identification data, our findings are contrary to those of Henke et al. (1999) who showed enhanced associative identification scores following both deep encoding of single items and deep encoding of the associations relative to shallow encoding. Indeed, the enhanced effect of deep encoding on the associative identification measure was only seen when the relation between the items was deeply processed, but not when items were deeply processed individually. This disparity in findings between our study and Henke et al.'s (1999) may be due to methodological differences. For instance, our shallow encoding may be deeper than that used by Henke et al. (i.e., intentional encoding with word reading versus incidental encoding with vowel counting) and Henke's deep items may have encouraged deep encoding of the associations and binding more so than our manipulation (same conceptual judgement on both members of the pairs versus distinct conceptual judgements on each member of the pairs). Taken together, results on the associative reinstatement and associative identification (including the false alarm and hit rates used to derive them) indicate that deep processing of the associations is the more beneficial strategy to encode and bind associative information. Therefore, we used this encoding strategy in Experiments 2–4 to investigate whether associative reinstatement and associative identification measures are dissociable at retrieval.

Experiment 2

In Experiment 2, we investigated the effect of a response speed deadline manipulation designed to interfere with recall-like, strategic retrieval processes (e.g., elaboration of cues, launch of extensive memory searches and effective monitoring of the retrieved information) on associative reinstatement, associative identification and item memory measures. Our main goal was to test whether the two measures of associative memory (associative reinstatement and associative identification) are dissociable from one-another at retrieval on the basis of their reliance on such processes. As noted in the Introduction, the associative identification measure is effortful and demanding in terms of retrieval processes while the associative reinstatement measure is not because both the item and associative information are reinstated, which minimizes the need to specify memory search cues. As well, the retrieval of associative information is not overtly required, which minimizes the need for post-retrieval monitoring of associative information.

Response speed deadline manipulations are known to influence performance on associative identification recognition tasks (Gronlund & Ratcliff, 1989; Jones & Jacoby, 2001; Light, Patterson, Chung, & Healy, 2004; Rotello & Heit, 2000). Typically, the associative identification ability is optimal in a long response deadline condition (response provided after 1000 ms or longer) relative to a short deadline condition (response provided within 850 or 1000 ms). Specifically, hit rates are consistently reduced in a short, relative to a long, deadline, while the false alarm rates are usually unaffected in experiments with extended response windows (e.g., 0–850 or 1000 ms; Jones & Jacoby, 2001; Light et al., 2004) or increased when limited short lags are used (responses provided between 500 and 850 ms or between 750 and 1100 ms; Rotello & Heit, 2000). As for item recognition, accuracy increases above chance earlier than accuracy for word-pair associations, which suggests that item memory is less affected in the short deadline conditions than is associative memory (Gronlund & Ratcliff, 1989). Taken together, these findings suggest that the deadline manipulation interferes with the recall-like process used preferentially in associative identification recognition tasks.

Based on these previous studies, we required participants in our *short deadline* condition to provide their answers before the test pair disappeared after 1000 ms of presentation (0–1000 ms window) and participants in our *long deadline* to provide their answers immediately following the 1000 ms test pair presentation (1000–2500 ms window). Because associative identification requires more recall-like, strategic retrieval processes than reinstatement, we predicted that participants in the short deadline condition would perform poorly on the associative identification measure in comparison to participants in the long deadline condition, but expected less or no change on the item memory and associative reinstatement measures because these measures do not rely on such self-initiated, strategic retrieval processes.

Methods

Participants

Forty-eight undergraduate students from the University of Toronto who are native English-speakers (32 women and 16 men, mean age = 20.00 years, mean number of years of education = 13.33) participated and received a course credit or compensation of $10.00 CAN. Twenty-four participants were assigned to one of two conditions (accuracy, speed). One participant was excluded and replaced because of failure to comply with the task instructions.

Materials and procedures

The materials and the study procedure were identical to those used with the deep associations group in Experiment 1. The short and long deadline groups were successful in generating sentences with 94% and 93% of the studied pairs and the study phase lasted an average of 16 and 15 min, respectively. The only differences between the two groups pertained to the response time constraints. Participants in the short deadline group were to provide their answers before the test pair disappeared after 1000 ms of presentation (0–1000 ms window) and participants in the long deadline were to provide their answer during the fixation period immediately following the 1000 ms test pair presentation (1000–2500 ms window). In the short deadline, participants received a warning stating ‘‘faster’’ when answers were not yet recorded at 1200 ms and participants in the long deadline condition received a warning stating ‘‘wait’’ when answers were recorded during the first 1000 ms. Only responses recorded before the test pair offset time (within the 1000 ms) for the short deadline group and responses recorded after the test pair offset time (between 1000 and 2500 ms) were recorded and included in our analyses. Each test pair was followed by a fixation cross which was presented for 1000 ms for the short deadline and 1500 ms for the long deadline. This difference was included to give approximately the same time to both groups between their answer and the onset of the next test item (the mean time between the responses and the onset of the next test pair was 1120 ms for the short deadline group and 982 ms for the long deadline group). Out of a total of 96 trials per task, an average of 25.46 trials on the item recognition task and 24.83 trials on the pair recognition task were skipped or excluded for the short deadline group. Almost no trials were skipped or excluded for the long deadline group (0.74 and 0.52 trials out of 96 were excluded for the pair and associative identification recognition tasks, respectively). A pattern of results identical to that described below was obtained when all trials were included in the analyses.

Results

The proportion of ‘‘old’’ responses to each pair type (new, half-old, rearranged and intact) in the pair and associative identification recognition tasks are presented in Tables 3 and 4, respectively. As in Experiment 1, our primary measures of item memory and associative reinstatement (Table 3) as well as of associative identification (Table 4) were derived using signal-detection and subtractive calculation methods. Because comparable results were obtained on scores derived from both methods, we report only the set of results obtained on the scores expressed in d'. Again, we only report results of t-test analyses carried separately on the primary measures and results of the t-test analyses of the hit rates and false alarm rates that help characterize the findings obtained on our primary measures. t-test analyses were also done on corrected hit rates and false alarm rates

Table 3
Mean proportion and standard deviation of "old" responses per pair type in the pair recognition task, item memory and associative reinstatement measures for Experiment 2

	Old responses per pair type				Item memory		Associative reinstatement	
	New	Half	Rearranged	Intact	Rearranged – new	d'	Intact – rearranged	d'
Short deadline	.23 (.16)	.42 (.20)	.48 (.23)	.58 (.21)	.24 (.22)	.80 (.71)	.10 (.19)	.31 (.57)
Long deadline	.11 (.10)	.30 (.15)	.73 (.15)	.84 (.12)	.62 (.16)	1.94 (.70)	.11 (.13)	.42 (.47)

Table 4
Mean proportion and standard deviation of "old" responses per pair type in the associative identification recognition task and associative identification measure for Experiment 2

	Old responses per pair type				Associative identification	
	New	Half	Rearranged	Intact	Intact – rearranged	d'
Short deadline	.09 (.12)	.19 (.14)	.35 (.18)	.45 (.17)	.09 (.22)	.30 (.69)
Long deadline	.05 (.08)	.09 (.10)	.24 (.15)	.78 (.13)	.54 (.18)	1.62 (.74)

(corrected by subtracting the false alarm rate to new pairs). These are reported only if a different pattern of results is obtained relative to that obtained with the raw data.

The deadline condition had an unexpectedly important adverse effect on item memory [$t(46) = 5.59$, $p < .001$, $d = 1.61$]. Despite this item memory decline, associative reinstatement was unaffected ($t < 1$) suggesting that this measure does not depend on the use of strategic retrieval processes. As predicted, the associative identification measure was reduced in the short deadline group relative to the long deadline group [$t(46) = 6.44$, $p < .001$, $d = 1.86$] and this decline was primarily due to a decrease in hit rates to intact pairs [$t(46) = 7.66$, $p < .001$, $d = 2.23$], while there was a smaller difference in the false alarm rate to rearranged pairs [$t(46) = 2.30$, $p < .05$, $d = 0.67$] that was no longer significant when this measure was corrected for baseline response bias [short deadline group: $M = 0.26$, $SD = 0.20$; long deadline group: $M = 0.19$, $SD = 0.12$;$t(46) = 1.37$, $p = .18$, $d = 0.41$].

Discussion

First, the short deadline condition impeded participants' associative identification ability, affecting primarily the hit rate to intact pairs having a lesser effect on the false alarm rate relative to a long deadline condition, which is a pattern consistent with previous experiments (Jones & Jacoby, 2001; Light et al., 2004). Second, as predicted, the deadline manipulation left the associative reinstatement measure unaffected, suggesting a dissociation between the two measures of associative memory based on retrieval processes. Third, the deadline had an unexpected, important detrimental effect on item memory which appeared to be of equal magnitude (based on the effect sizes) to the decline in associative identification.

This proportional decline was surprising to us given our assumption that item memory is less dependant on recall-like processes than is associative identification recognition. From a dual process perspective, some decline in item memory is expected in situations that disrupt recollection because this measure is not process pure and both familiarity and recollection contribute to it. Thus, a reduction in recollection should result, as in the present study, in poorer item memory. However, because associative identification is more reliant on recollection, a disproportionate decline should be observed, that is, the item memory decline should be less important than that seen in associative identification. Our results imply that the time frame used in the deadline condition may not have solely affected associative-based tasks and recollection, but also measures that rely on item information and item familiarity. Furthermore, a decline in item familiarity in the short deadline condition helps us account for the asymmetrical effect on the associative identification recognition tasks (disproportionate effect on hit rates and false alarm rate to rearranged pairs). As noted in the Introduction, item familiarity and recollection work hand-in-hand to accept intact pairs and a reduction in either or both processes results in a reduced hit rates. In contrast, these two processes oppose each other when rearranged pairs are presented so that a decline in item familiarity should result in lower false alarm rates, while a decrease in recollection should result in higher false alarm rates. Thus, it is theoretically possible that these effects cancelled each other when both processes are reduced, as it may be the case in the current experiment, and affect the false alarm rate to a lesser extent.

While these results do not dissociate associative identification from item memory, they, nevertheless, confirm the dissociation between the associative reinstatement and both the associative identification and item memory.

We further investigate these dissociations at retrieval in Experiment 3 using a speed–accuracy trade-off manipulation, which we believe, may be less detrimental to item familiarity than was the deadline manipulation.

Experiment 3

Our goal in Experiment 3 was identical to that of Experiment 2, namely, to verify whether time pressure at retrieval can interfere with strategic retrieval processes and, consequently, dissociate associative identification from associative reinstatement. While response speed was imposed in Experiment 2, it was self-determined by participants in Experiment 3 using a speed–accuracy trade-off manipulation. Participants were required to answer as quickly as possible (*speed group*) or instructed to answer as accurately as possible (*accuracy group*). We thought that stressing the importance of response speed may discourage participants from using elaborate retrieval strategies, while stressing the importance of accuracy may encourage the use of such strategies. Thus, we predicted that participants in the speeded condition would perform poorly on the associative identification measure relative to participants in the accuracy condition. As for the associative reinstatement measure, we expected minimal or no group differences because we believe this measure does not rely on self-initiated, strategic retrieval processes. With regards to item memory, we expected minimal group differences given our assumption that item memory, like associative reinstatement, is less dependent on retrieval strategies. However, item memory may be hindered in the speeded group to the same extent as associative identification, as it was in the deadline condition.

Methods

Participants

Forty-eight undergraduate students from the University of Toronto who are native English-speakers (26 women and 22 men, mean age = 19.46 years, mean number of years of education = 13.25) participated and received a course credit or compensation of $10.00 CAN. Twenty-four participants were assigned to one of two conditions (accuracy, speed). Two participants were excluded and replaced because of failure to comply with the task instructions.

Materials and procedures

The materials and the study procedure were identical to those used with the deep associations group in Experiment 1. The accuracy and speed groups were successful in generating sentences with 93% and 96% of the studied pairs and the study phase lasted, on average, 14 and 15 min, respectively. The only differences between the two groups pertained to the retrieval instructions. In the *accuracy* condition, participants were instructed to respond as accurately as possible, and in the *speed* condition, they were instructed to respond as quickly as possible. Participants in the speed group complied with test instructions as their mean reaction time per test item was faster than that of participants in the accuracy group in the pair recognition task [speed: $M = 1253$ ms, $SD = 304$ ms; accuracy: $M = 2364$ ms, $SD = 799$ ms] and the associative identification recognition task [speed: $M = 1283$ ms, $SD = 335$ ms; accuracy: $M = 2196$ ms, $SD = 652$ ms].

Results

The proportion of "old" responses to each pair type (new, half-old, rearranged and intact) in the pair and associative identification recognition tasks are presented in Tables 5 and 6, respectively. Our primary measures of item memory and associative reinstatement (Table 5) and of associative identification (Table 6) were again derived using signal detection and subtractive methods and we report only results of analyses carried on the signal detection scores given that results were comparable using both methods. *t*-test analyses were carried separately on the primary measures and on the hit rates and false alarm rates (raw and corrected for baseline response bias). Again, the later results on raw hit and false alarm rates are reported only if they help characterize the findings obtained on our primary measures. We do not report the results of the analyses on the corrected hit and false alarm rates because the pattern is indistinguishable to that obtained with the raw data.

Item memory and associative reinstatement did not differ between the accuracy and speed groups [item memory: $t(46) = 1.06$, $p = .30$, $d = .31$; associative reinstatement: $t < 1$]. As expected, the associative identification measure was reduced in the speed group relative to the accuracy group [$t(46) = 3.41$, $p = .001$, $d = .99$] and this decline was characterized by a mirror effect showing a higher false alarm rate to rearranged pairs [$t(46) = 2.56$, $p < .05$, $d = .75$] and a lower hit rate to intact pairs [$t(46) = 3.25$, $p < .01$, $d = .99$].

Discussion

First, the speeded condition impeded participants' associative identification ability, affecting both the hit rate and false alarm rate. The effect on the hit rates is consistent with previous speed deadline experiments (Experiment 2; Jones & Jacoby, 2001; Light et al., 2004; Rotello & Heit, 2000). The effect on the false alarm rate, while it is not always found in response deadline experiments (Jones & Jacoby, 2001; Light et al., 2004; but see Rotello & Heit, 2000), confirms our assumption that the speed–accuracy manipulation has a particularly

Table 5
Mean proportion and standard deviation of "old" responses per pair type in the pair recognition task, item memory and associative reinstatement measures for Experiment 3

	Old responses per pair type				Item memory		Associative reinstatement	
	New	Half	Rearranged	Intact	Rearranged − new	d'	Intact − rearranged	d'
Speed	.13 (.09)	.40 (.17)	.76 (.18)	.85 (.16)	.62 (.19)	2.05 (.78)	.09 (.13)	.37 (.45)
Accuracy	.07 (.08)	.28 (.18)	.74 (.14)	.85 (.09)	.66 (.14)	2.27 (.61)	.11 (.13)	.42 (.54)

Table 6
Mean proportion and standard deviation of "old" responses per pair type in the associative identification recognition task and associative identification measure for Experiment 3

	Old responses per pair type				Associative identification	
	New	Half	Rearranged	Intact	Intact − rearranged	d'
Speed	.02 (.04)	.08 (.09)	.27 (.16)	.69 (.18)	.42 (.26)	1.28 (.89)
Accuracy	.01 (.03)	.06 (.08)	.16 (.12)	.82 (.09)	.66 (.17)	2.09 (.75)

strong effect on the recall-like processes, including those necessary to reject familiar items. Second, the speed–accuracy manipulation left the associative reinstatement measure unaffected, and unlike Experiment 2, also left the item memory unaffected.

Together with results from Experiment 2, these findings imply that associative reinstatement and associative identification measures can be dissociated at retrieval. Based on our assumption that this dissociation is related to recall-like strategic retrieval processes, interfering with such processes should impede the ability to reject familiar pairs on the associative identification recognition task to a greater extent than the ability to accept intact pairs because these two abilities make different demands on such recall-like processes. This was not the case in Experiments 2 and 3, and similar or greater effects were seen on the hit rates relative to the false alarm rates. In fact, to our knowledge, very few studies have reported success in affecting false alarm rates to rearranged items. Besides the deep items condition in Experiment 1, we found only one study that successfully affected both the hit and false alarm rates using a deadline condition (Rotello & Heit, 2000) and other studies have achieved a similar mirror effect by increasing the familiarity of items at study by providing multiple presentation of the pairs and by then administering the associative identification recognition task under a short deadline (Jones & Jacoby, 2001; Light et al., 2004). The use of overlapping word pairs that generates interference at retrieval [similar to a fan effect paradigm (Anderson, 1974)], however, has been shown consistently to affect the false alarm rate to rearranged pairs with variable effects on the hit rates (Verde, 2004). We used a similar paradigm in Experiment 4 to hinder the use of processes necessary to apply a recall-like strategy to reject familiar lures in order to provide additional evidence for the dissociation between associative memory measures.

Experiment 4

In Experiment 4, our goal was to confirm the dissociation between effortful and more automatic measures of associative memory. For one group, we changed the material to hamper participants' ability to use recall-like processes implicated in rejecting familiar lures. One way to achieve this is to increase the number of associates of a given word (i.e., overlapping word-pairs; Verde, 2004). In order to reject a familiar lure, participants must recall all the studied associates. Increasing the number of associates impairs participants' ability to use this strategy and compels them, instead, to rely on familiarity for these items. This method is similar to that used in fan effect experiments (Anderson, 1974). In these experiments, increasing the number of associates hinders memory as the associations compete and interfere with one another at retrieval due to limitation in cognitive resources. We predict that the use of overlapping pairs (i.e., each word is paired with five associates) relative to unique, one-to-one pairs (i.e., each word has only one associate) will interfere with the effortful measure of associative memory (rejecting rearranged pairs and associative identification) but will affect the automatic measures less (associative reinstatement and accepting intact pairs). Item memory may also increase in the overlapping condition given that one of the words is repeated, but this increase may be minimal given that the second word of each pair was presented only once.

Methods

Participants

Forty-eight undergraduate students from the University of Toronto who are native English-speakers (28 women and 20 men, mean age = 20.09 years, mean number of years of education = 13.25) participated and received a course credit or compensation of $10.00 CAN. Twenty-four participants were assigned to one of two conditions (*overlapping pairing*, *one-to-one pairing*).

Materials and procedures

The study and test procedures are the same as those for the deep associations group from Experiment 1. The material is different for the *overlapping* group. Instead of a one-to-one pairing (A–B, C–D, E–F, G–H, I–J), the material is arranged in an overlapping pairing or one-to-five pairing (A–B, A–D, A–F, A–H, A–J), so that the first member of the pair has five associates. A total of 192 word pairs were created by combining a seven-letter noun (1st word) with a semantically unrelated six-letter noun (2nd word). Pairs were arranged into 16 lists of 12 pairs, in which two words (1st word) were matched with five associates each (2nd word) and the remaining two words were matched with one associate. These latter two pairs were used to create half pairs for the test phase. Lists were equated in terms of the first words' and second words' Kucera–Francis frequency (1st word: $M = 25.6$, range: 13–43; 2nd word: $M = 43.9$, range: 7–183).

At study, 120 word pairs, from 12 randomly selected lists, plus six buffer pairs were presented (three buffer pairs at the beginning and at the end of the list). All study pairs were overlapping (one-to-five mapping). At test, each set of five overlapping pairs (with the common first word) was split across tasks (pair and item recognition task) and pair types (intact, rearranged, half). Note that the rearranged and half-old pairs were pre-determined to ensure the words were not semantically related. The non-studied four lists of 12 pairs were used to create the new pairs. As in Experiment 1, each test type included 96 critical items (24 intact pairs, 24 rearranged pairs, 24 half-old pairs and 24 new pairs) and 12 non-critical, practice, test items created from the buffer items. On average, participants in both groups took 14 minutes to study the 120 study pairs and were able to create complete sentences with 92% of the word pairs.

Results

The proportion of "old" responses to each pair type (new, half-old, rearranged and intact) in the pair and associative identification recognition tasks are presented in Tables 7 and 8, respectively. Again, we used the signal detection as well as a subtractive calculation method to derive our primary measures of item memory and associative reinstatement (Table 7) and measure of associative identification (Table 8). Similar results were obtained on scores from both calculation methods and we report only results on the d' measures. As in the previous experiments, t-test analyses were carried separately on the primary measures and on the raw hit rates and false alarm rates. For brevity, results on the latter analyses are reported only if they help characterize the findings obtained on our primary measures. The same analyses were carried out on corrected hit and false alarm rates and are not reported here because the pattern of result is identical to that obtained with the uncorrected measures.

The overlapping manipulation did not enhance item memory despite the repetition at study of the first word in each rearranged test pair ($t < 1$). Similarly, associative reinstatement was unaffected by the overlapping manipulation ($t < 1$). This confirms results of Experiments 2 and 3 showing that this measure is sheltered from manipulations that affect strategic retrieval processes. As expected, associative identification was reduced in the overlapping group relative to the one-to-one group [$t(46) = 2.32$, $p < .05$, $d = .70$]. This decline was solely due to an increase in the false alarm rate [$t(46) = 3.50$, $p = .001$, $d = 1.03$], but there was no difference in the hit rate to intact pairs ($t < 1$).

Discussion

Results from Experiment 4 confirm findings obtained with the retrieval manipulations in Experiments 2 and 3 suggesting a dissociation between associative identification, associative reinstatement and item memory. Indeed, the overlapping manipulation, like the deadline and speeded conditions used in Experiments 2 and 3, interfered with the associative identification measure, but left the associative reinstatement measure unchanged.

Another interesting finding is the observed dissociation between two scores derived from the associative identification recognition task: (a) false alarm rate to rearranged pairs, which is the failure to use a test item as a partial cue to recollect its original associate in order to reject familiar lures; (b) hit rate to intact pairs, which is the ability to recognize associative information overtly when the environment reinstates both the item and associative information. The ability to reject rearranged pairs is diminished when the effective use of a controlled and effortful recall-like process, which involves extensive memory search is obstructed. Accepting intact pairs, on the other hand, is unaffected because its reliance on such retrieval processes is minimal, which makes this task less effortful. Like us, Verde (2004) found higher false alarm rates to rearranged pairs when using overlapping pairs relative to non-overlapping ones. Crucially, our findings are not related to changes in item memory, which is equivalent across the two conditions, and suggest that the recollection component involved in accepting intact pairs and in rejecting rearranged pairs may be affected differently. As noted previously, because item memory contributes to both the false alarm rate to rearranged pairs and the hit rate to intact pairs, effects on item

Table 7
Mean proportion and standard deviation of "old" responses per pair type in the pair recognition task, item memory and associative reinstatement measures for Experiment 4

	Old responses per pair type				Item memory		Associative reinstatement	
	New	Half	Rearranged	Intact	Rearranged − new	*d'*	Intact − rearranged	*d'*
Overlapping	.06 (.08)	.18 (.11)	.70 (.13)	.79 (.12)	.64 (.19)	2.24 (.75)	.09 (.09)	.34 (.38)
One-to-one	.07 (.07)	.24 (.13)	.71 (.17)	.82 (.13)	.64 (.15)	2.19 (.52)	.11 (.10)	.40 (.36)

Table 8
Mean proportion and standard deviation of "old" responses per pair type in the associative identification recognition task and associative identification measure for Experiment 4

	Old responses per pair type				Associative identification	
	New	Half	Rearranged	Intact	Intact − rearranged	*d'*
Overlapping	.01 (.03)	.06 (.07)	.36 (.18)	.77 (.11)	.40 (.19)	1.20 (.62)
One-to-one	.02 (.03)	.09 (.09)	.20 (.13)	.74 (.15)	.54 (.20)	1.67 (.78)

memory may compensate for decreases in associative memory (e.g., increased item memory results in increased hit rates and poor item memory reduces the false alarm rate). However, this dissociation was not obtained in our other experiments. We believe that the difficulty in replicating this pattern of results is partly due to changes in item memory, which may have veiled the effect of our manipulations on the hit rates to intact pairs (deep items encoding Experiment 1) or false alarm rate to rearranged pairs (deadline Experiment 2).

In sum, we found that measures that do not necessitate cue specification and extensive memory search because good retrieval cues are provided by the environment (associative reinstatement measure and hit rate to intact pairs) are not impeded by this manipulation. Only the recall-like process necessary to reject familiar lures is hindered.

General discussion

The present studies extend our knowledge of associative recognition memory by contrasting two measures of associative memory: associative identification and associative reinstatement. Associative identification is the typical measure of associative memory and requires participants to identify the associated information explicitly by discriminating between studied and novel combinations of items that they had already experienced. Associative reinstatement, a measure inspired by the encoding specificity hypothesis (Tulving & Thomson, 1973), is derived by quantifying the advantage observed in item memory on a pair recognition task when old items are presented in their studied pairing relative to a novel or recombined pairing. Though consistently found, the magnitude of associative reinstatement typically is smaller than that of associative identification, a pattern we observed in our studies. While associative identification requires explicit knowledge of the recovered associations akin to recall, especially in rejecting familiar items that are rearranged in a novel way, associative reinstatement makes no such demands as participants are required to respond to all familiar items. Thus, the two measures of associative memory appear to differ in terms of the demands they place on retrieval processes.

In four experiments, we compared these two measures to one another, and to a measure of item memory, to highlight potential dissociations at encoding and at retrieval. Table 9 provides a recapitulation of results obtained with all the manipulations used by reporting the effect sizes (Cohen's *d*). Because effect size are independent from scaling differences across measures, we find them helpful, particularly in contrasting the results obtained on the associative reinstatement to those obtained on the associative identification and item memory measures. The study had two central findings: (1) the associative reinstatement and associative identification measures are dissociable from item memory; and (2) the associative reinstatement and associative identification measures are dissociable from one another based on their reliance on self-initiated strategic retrieval processes. We describe these findings and their theoretical implications.

The first main finding is that the associative reinstatement and associative identification measures are dissociable from item memory. Thus, both associative memory measures index memory of association despite the fact that associative reinstatement is derived from what is essentially an item memory task. This was supported by results from Experiment 1 showing that associative reinstatement and associative identification were positively affected by deep processing of the association between items during encoding and to a greater extent than was item memory.

Table 9
Summary of effect sizes (Cohen's *d*) obtained in Experiments 1–4

	Item memory	Associative reinstatement	Associative identification
Experiment 1			
Shallow vs. deep items	−1.00*	−0.94*(−0.49)	+0.56
Shallow vs. deep associations	−0.46	−1.05*	−1.45*
Deep items vs. deep associations	+0.64*	−0.23 (−0.62*)	−2.54*
Experiment 2: Short vs. long deadline	−1.61*	−0.19	−1.86*
Experiment 3: Speed vs. accuracy	−0.31	−0.10	−0.99*
Experiment4: Overlapping vs. one-to-one	+0.09	−0.18	−0.70*

Note. Analyses were done using d' scores except those reported in parentheses, which are derived using the subtractive calculation method.
* Statistically significant differences between groups; the direction of the effect is represented by the +/−sign.

The second main finding is that measures of associative memory are dissociable based on the demands they place on retrieval processes. Specifically, we found that the associative reinstatement measure, unlike the associative identification measure, is unaffected by manipulations at test that limit the effective use of self-initiated strategic retrieval processes [e.g., deadline (Experiment 2), speeded recognition (Experiment 3) and overlapping condition (Experiment 4)].

One may argue that the reinstatement measure is too small to vary thereby calling our conclusions into question as they are based on null effects. There are a number of reasons for rejecting this argument. First, previous studies using similar word-pair paradigms have shown that amnesia (Goshen-Gottstein et al., 2000), dividing attention at encoding and normal aging (Castel & Craik, 2003) reduce this measure significantly. This is consistent with our findings from Experiment 1 and suggests that the measure can vary when there is interference with relational processing at encoding. The absence of an effect, therefore, is meaningful when considered alongside conditions that alter the magnitude of reinstatement. Furthermore, these findings are robust, based on Cohen's *d* effect sizes. Second, one must also keep in mind that a score close to zero does not necessarily represent a floor effect given that negative scores are also included. Third, it is important to consider that the magnitude of the associative reinstatement effect (i.e., the actual gain in performance), though numerically small in comparison to associative identification, is consistent, shows a large effect size and is comparable to values reported in the literature. In addition, the magnitude of this effect is quite large in relation to that obtained with other types of reinstatement [e.g., environmental reinstatement effects (Murnane et al., 1999, Smith & Vela, 2001)]. Despite being numerically small, the latter effects were considered theoretically important and warranted the inclusion of associative memory parameters to general global matching models of recognition memory (Clark & Gronlund, 1996; Murnane et al., 1999).

Our results have interesting implications on how we conceptualize associative memory. As noted in the Introduction, studies using the associative reinstatement measure have used global matching models whereas studies concerned with dissociations between item and associative identification have used dual process models of recognition memory. Both types of framework are consistent with our findings when associative identification and associative reinstatement are taken separately, but neither provides a parsimonious account of findings across both measures.

For instance, global matching models of associative identification recognition memory, such as the ICE model (Murnane et al., 1999), accounts for the dissociations between associative memory measures and item memory following deep associations relative to shallow encoding in Experiment 1, but would not predict dissociations obtained across the different measures of associative memory found in all other conditions used (Experiments 2–4), mainly because this model does not include a recall-like parameter. The distinct effects of the retrieval manipulations on different types of associative memory measures illustrate the necessity of such recall-like process to optimize the associative identification measure, especially the ability to reject familiar lures (Diana, Reder, Arndt, & Park, 2006; Kelley & Wixted, 2001). However, such a process is not needed in all situations and retrieval of associative information may occur in a more automatic fashion when good retrieval cues are provided by the environment and when such retrieval is not overtly required.

By contrast, dual process models include such a process, recollection, which is defined as an effortful, consciously controlled and recall-like process (Atkinson & Juola, 1974; Jacoby, 1991; Mandler, 1980). Based on a dual process framework, most of the manipulations used in our experiments were expected to interfere with recollection (see Yonelinas, 2002, for review), and thus, affect associative memory to a greater degree than item memory. This proved to be the case for associative identification [manipulations affected the hit rate primarily (short deadline—Experiment 2), the false alarm rate to rearranged pairs primarily (deep items encoding—Experiment 1; overlapping pairing—Experiment 4) or resulted in a mirror effect affecting both equally (shallow—Experiment 1; speeded recognition—Experiment 3)]. This was not true, however, for associative reinstatement (unaffected by all retrieval manipulations used in Experiments 2–4) and the hit rate to intact pairs (unaffected by the overlapping pairings—Experiment 4) on the pair recognition task, two measures that do not rely on self-initiated retrieval strategies implicated in recollection. The latter findings challenge the view that all associative memory relies on recollection; associative reinstatement clearly does not. This being said, the nature of associative reinstatement remains poorly understood. We consider three possibilities:

(1) It is a species of item familiarity. Our findings from Experiments 1 and 2, however, argue against this idea. We showed that associative reinstatement and item memory, which is thought to rely heavily on familiarity, were affected to a different extent by the level of processing encoding manipulation. We also showed that a short response deadline had no effect on associative reinstatement, while it severely disrupted item memory.

(2) Associative reinstatement is akin to associative priming. Evidence that associative priming and associative reinstatement are dissociable from one another (Goshen-Gottstein & Moscovitch, 1995a, 1995b) argues against this proposal. Goshen-Gottstein et al. (2000) demonstrated that amnesic participants achieved intact performance relative to healthy matched controls on an associative priming task (i.e., lexical decision), but were impaired on the associative reinstatement measure. In fact, their performance on the associative reinstatement was at chance, indicating that there was no contribution from priming on this test, whereas controls performed at a level comparable to that in the present study.

(3) Associative reinstatement relies on familiarity for associations, which is distinct from familiarity of individual items. Associative familiarity may index one's ability to bind individual pieces of information at encoding. Such binding is not implicated in encoding of individual items or item familiarity, but may be a necessary foundation or precursor of recollection. The process mediating reinstatement does not involve the vivid, conscious re-experiencing of the retrieved event as does recollection. This proposal regarding reinstatement parsimoniously accounts for our data and is consistent with the ICE model of associative identification recognition, especially the "E" parameter that represents the ensemble or link between item and context. Whatever model best accounts for the data on reinstatement, the important point is that it differs from dual process models needed to account for associative identification.

The dissociation we found between measures of associative memory suggests that they assess different representations. Associative reinstatement taps representations that consist primarily of associations formed between the two words without the detailed context in which the associations were acquired. In addition, although representation of the items themselves is accessible to consciousness, their newly-formed associations may not be. For this reason, associative reinstatement is affected little by strategic, retrieval processes which rely on conscious awareness. By contrast, the representation that associative identification taps is more contextually rich and the associations accessible to consciousness, making it easier to recollect them and more amenable to strategic operations at retrieval.

The dissociations among item familiarity, associative reinstatement, and associative identification which we found, and their interpretation, also have important implications for studies of the neuropsychological basis of associative memory and recollection. Using single items as memoranda, a number of investigators have argued that recollection (Eldridge, Knowlton, Furmanski, Bookheimer, & Engel, 2000; Holdstock, Gutnikov, Gaffan, & Mayes, 2000; Moscovitch & McAndrews, 2002; Yonelinas et al., 2002) is mediated by the hippocampus whereas familiarity is mediated by peri-hippocampal structures such as the peri-rhinal cortex (but see Squire, Stark, & Clark, 2004). Likewise, our results, together with earlier ones of Goshen-Gottstein and Moscovitch (1995a, 1995b) and others (Gabrieli, 1998), suggest that associations, like memory for single items, can be formed at different levels and can be mediated by different structures. Associations which support reinstatement, and based on familiarity, may be mediated by peri-rhinal cortex; associations which support identification, and based on recollection, may be mediated by the hippocampus; and associations which support implicit memory are likely to be perceptual in nature and mediated by posterior neocortex. Such a neuropsychological dissociation among the different forms of association is consistent with the findings of the present study, though they have yet to be tested directly in patients with lesions or in functional neuroimaging experiments. Encouraging, supportive evidence is provided by Mayes et al. (2004) who studied a patient with lesions restricted to the hippocampus. They showed that only cross-domain associations are hippocampally-dependent, but not within domain ones which can be based on associative familiarity. Similarly, in a recent functional neuroimaging study that used an associative identification procedure comparable to our own, Caza et al. (2004) reported the greatest hippocampal activation for rejection of recombined pairs, the condition that is most implicated in recollection.

Conclusions

Our findings show that measures of associative memory can be dissociated from one another, suggesting that they are based on different types of representations. Specifically, they reveal that associative memory may not always rely on a recall-like process such as recollection but may depend, instead, on a type of familiarity that is specific to relational information. Associative reinstatement occurs when good retrieval cues are provided by the environment and when retrieval of the associated information is not overtly required. This measure indexes one's ability to bind pieces of information at encoding, which is a necessary step for later recollection. However, associative memory assessed by reinstatement may lack the conscious and vivid qualities of recollection and be dependent only on a feeling of familiarity for associations. By contrast, associative identification places higher demands on retrieval strategies and relies on recollection, a recall-like process, especially to reject combinations of highly familiar items which were not associated at encoding. Our findings and interpretation have important implications for our understanding of the neuropsychological basis of associations and the performance of different populations, such as older adults and people with neurological disorders, on tests of associative memory.

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