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Familiarity and recollection in item and associative recognition

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Recognition memory for item information (single words) and associative information (word pairs) was tested immediately and after retention intervals of 30 min and 1 day (Experiment 1) and 2 days and 7 days (Experiment 2) using Tulving's (1985) remember/know response procedure. Associative recognition decisions were accompanied by more "remember" responses and less "know" responses than item recognition decisions. Overall recognition performance and the proportion of remember responses declined at similar rates for item and associative information. The pattern of results for item recognition was consistent with Donaldson's (1996) single-factor signal detection model of remember/know responses, as comparisons based on A' between overall item recognition and remember item recognition showed no significant differences. For associative recognition, however, A' for remember responses was reliably greater than for overall recognition. The results show that recollection plays a significant role in associative recognition.

> Let somebody read a few times the following pairs of nouns: lake–sugar, boot–plate, girl–kangaroo, pencil–gasoline, palace–bicycle, railroad–elephant, book–toothpaste.... When I read those words I can imagine, as a series of strange pictures, how a lump of sugar dissolves in a lake, how a boot rests on a plate, how a girl feeds a kangaroo, and so forth. If this happens during the reading of the series, I experience in imagination a number of well-organized, though quite unusual, wholes. (Kohler, 1929, as cited in Murray, 1995, p. 63)

Item information represents the occurrence of individual events, such as the presentations of *lake* and *girl* in Kohler's list. Associative information represents relationships between items, as illustrated by Kohler's image of a boot resting on a plate. Hunt and his colleagues (e.g., Einstein & Hunt, 1980; Hunt & Einstein, 1981; Hunt & Seta, 1984) have argued that the encoding of item-specific information serves to enhance discriminative processes, whereas the encoding of relational information facilitates retrieval processes. This distinction has been shown to be important in accounting for a variety of aspects of memory performance, such as the relationship between recall and clustering (Einstein & Hunt, 1980), typicality effects (Hunt & Einstein, 1981), category size effects (Hunt & Seta, 1984), the concrete word advantage in recall (Marschark & Hunt, 1989), hyperamnesia (Burns, 1993; Klein, Loftus, Kihlstrom, & Aseron, 1989), the generation effect (Hirshman & Bjork, 1988), and priming effects (Dosher, 1991).

A number of studies have also provided empirical support for the distinction between item and associative information in memory. For example, recognition memory for item and associative information have different time courses at retrieval (Dosher, 1988; Gronlund & Ratcliff, 1989); different rates of forgetting over short retention intervals (Hockley, 1991, 1992) are differentially affected by natural language word frequency (Clark, 1992; Clark & Burchett, 1994; Hockley, 1994) and have different receiver-operating characteristics (ROCs; Yonelinas, 1997). Hockley and Cristi (1996) showed that subjects can distinguish between the frequency of occurrence of individual words and word pairs when the single words are also members of the word pairs. Finally, neurophysiological evidence also supports the distinction between item and associative information and indicates that the hippocampal region plays a fundamental and specialized role in associative learning (Eichenbaum & Bunsey, 1995).

The above studies used recognition tests to compare memory for item and associative information. Associative recognition provides a relatively pure test of memory for the relationships between events, in that, unlike free or cued recall, it does not require memory for the individual items. In this procedure, subjects study a list of random word pairs that can be represented as AB, CD, EF, GH, ... MN. Item recognition tests involve discriminating between individual words presented in the study list (A) and new words that had not been presented (X). Associative recognition requires distinguishing between intact or studied pairs (CD) and rearranged or new pairs (e.g., EH). Note that both intact and rearranged pairs consist of two old or studied words. Therefore, the discrimination between intact and rearranged pairs cannot be based on memory for the individual items of the test pairs, but rather it must be made solely on the basis of memory for the associations formed between individual items at study.

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One purpose of the present study was to assess the extent to which item recognition and associative recognition involve similar types of decisions. A common assumption of many current models of memory is that item recognition decisions are based on a signal detection type of assessment of familiarity or memory strength that varies on a single dimension (e.g., Gillund & Shiffrin, 1984; Hintzman, 1988; Hockley & Murdock, 1987; Humphreys, Bain, & Pike, 1989; Murdock, 1982, 1992). In the same manner, associative recognition decisions could also be based on the unitary strength of relational information (Humphreys, Pike, Bain, & Tehan, 1989). The facts that the mirror effect, a robust regularity of item recognition (see Glanzer & Adams, 1985), is also observed for associative recognition (Greene, 1996; Hockley, 1994) and that there is associative interference in tests of cued recall but not in pair recognition (Dyne, Humphreys, Bain, & Pike, 1990) are consistent with such a view.

A different account of associative recognition has, however, been suggested. Humphreys (1978; Bain & Humphreys, 1988; Humphreys & Bain, 1983) and Clark (1992; Clark & Burchett, 1994; Clark & Hori, 1995; Clark, Hori, & Callan, 1993; see Clark & Gronlund, 1996, for a recent review) have argued that associative recognition decisions are based, at least in part, on a recall-like retrieval process. Subjects may classify AB as an old study pair by using A to recall B, and they may reject CF as a study pair by using C to recall D. Thus, pair recognition decisions could be based on an assessment of the familiarity of the association or on a recall-like or recollective process.

It has also been argued that item recognition can be based on more than one component or aspect of memory. For example, in Mandler's (1980, 1991) dual-process theory, it is assumed that item recognition can be based on a sense of undifferentiated familiarity or on retrieval of contextual and conceptual information. In recent years, a number of investigators have contrasted item recognition decisions that are accompanied by conscious recollection of specific details of the occurrence of the event with decisions based on a sense of familiarity in the absence of recollective experience. This approach involves asking subjects to classify old recognition memory decisions as either "remember" responses, which are accompanied by conscious recollection, or as "know" responses, which are associated with a feeling of familiarity without recollective experience (Tulving, 1985). A number of studies indicate that this subjective distinction produces principled outcomes (e.g., Conway & Dewhurst, 1995; Gardiner, 1988; Gardiner & Java, 1990, 1991; Gardiner, Java, & Richardson-Klavehn, 1996; Gardiner & Parkin, 1990; Knowlton & Squire, 1995; LeCompte, 1995; Rajaram, 1993). Recent electrophysiological studies have also shown that the evoked related potentials associated with recollected test items differ from those where the test items were judged old on the basis of familiarity (Duzel, Yonelinas, Mangun, Heinze, & Tulving, 1997; Smith, 1993; Wilding & Rugg, 1994).

The interpretation of remember and know responses is not without controversy, however. One question under debate concerns the degree to which these responses are reflections of confidence judgments rather than representing different components or bases of recognition memory. Gardiner and Java (1990) and Rajaram (1993) have argued that remember and know responses are not equivalent to confidence judgments, although, as Gardiner and Java noted, it is reasonable to expect a correlation between confidence and recollective experience.

In contrast, Donaldson (1996) and Hirshman and Master (1997) have argued that a single-factor signal detection type model can account for the patterns of results obtained with the remember/know response procedure. In Donaldson's (1996) model, there is a single continuum of mnemonic information that is divided by a recognition criterion such that items below the criterion are classified as new and items above the criterion are classified as old. A second, higher, criterion is established to partition the "old" responses. Items above the second criterion are labeled "remember," and items below are labeled "know." In this view, remember responses represent more conservative (or higher confidence) old responses than know responses.

Since remember responses in Donaldson's (1996) model represent old decisions with a more conservative decision criterion than overall (i.e., remember plus know) old decisions, bias-free estimates of recognition memory should produce equivalent values of discrimination when calculated on the overall hit and false-alarm rates as when calculated only on remember hit and false-alarm rates. That is, estimates of old versus new discriminability should be the same whether they are derived from hits and false alarms identified as remember responses or whether they are calculated from the overall hit and false-alarm rates, because bias-free estimates of discriminability are assumed to be independent of the placement of the recognition decision criterion. In an analysis of 17 published studies representing 80 conditions from 28 different experiments, Donaldson (1996) showed that estimates of discrimination (d' and A')[1] were largely equivalent for overall recognition performance and "remember" responses. Thus, most of the results obtained with the remember/know response procedure can be described by a single-factor signal detection type model.

The remember/know response paradigm has been used almost exclusively in studies of item recognition. One purpose of the present study was to contrast the pattern of remember/know responses in tests of both item recognition and associative recognition. The typical item recognition experiment, in which single events are presented relatively briefly in a series of similar events, may not afford subjects much opportunity to encode rich or elaborate details of their occurrence that are necessary to support recognition decisions based on recollection. Associative recognition, on the other hand, may provide a better task in which to distinguish recognition responses based on familiarity and recollection. If, as Kohler (1929, cited in Murray, 1995) suggested, when subjects form associations between random items they encode "a series of strange pictures," or "a number of well-organized, though quite unusual, wholes," then associative recognition may give rise to a greater proportion of responses accompanied by the recollection of vivid details of their occurrence.

Yonelinas (1997) has recently shown that ROCs differ for item and associative recognition. ROCs for item recognition were found to be curvilinear, whereas ROCs for associative recognition were linear. Yonelinas argued that item recognition relies on a combination of recollection and familiarity judgments, whereas associative recognition decisions are primarily based on recollection. Thus, Yonelinas's analyses and interpretation of ROCs for item and associative recognition would also predict that associative recognition decisions should be identified as remember responses to a much greater extent than item recognition decisions.

A second purpose of the present study was to further compare the forgetting rates of item and associative recognition memory. Murdock and Hockley (1989) observed no forgetting of associative information when recognition was tested over study–test lags ranging from 0 to 26 in a continuous recognition paradigm. Hockley (1991, 1992) found that the forgetting rate of item information was significantly greater than the forgetting rate of associative information in short-term within-session comparisons of recognition performance. The rate of forgetting of associative information may be less than the rate of forgetting of item information if associative recognition is based on recollection to a much greater extent than is item recognition.

In the present study, forgetting rates of item and associative recognition were compared over much longer retention intervals. This procedure also afforded an opportunity to compare changes in the proportions of remember and know responses for item and associative recognition over a wide range of retention intervals. In the two experiments described below, subjects studied a single list of random pairs of words with instructions to form associations between the members of each pair. Item and associative recognition were compared in an immediate test and in two delayed tests. Different single words and word pairs were presented on each test. In Experiment 1, the delayed tests were administered 30 min and 1 day later. In Experiment 2, the delayed tests followed 2 days and 7 days after study. Because the two experiments were identical in all other respects, they are described together.

EXPERIMENTS 1 AND 2

Method

Subjects. Fifty students enrolled in introductory psychology classes were recruited for each experiment. The students participated for course credit or for payment.

Apparatus and Stimuli. List generation, presentation, and response recording were controlled by laboratory computers. The keyboards were fitted with opaque covers that exposed the labeled response keys. The word pool consisted of 480 concrete nouns derived from Paivio, Yuille, and Madigan (1968). All words had an imageability rating of 5.0 or greater based on the Paivio et al. norms, in which words are rated on a scale from 1 to 7.

Procedure. The subjects were first told that they would be studying pairs of random words and that they should try to form associations between the members of each word pair so that they would be able to remember the pairs of words. They were encouraged to use interactive imagery or sentence generation strategies to form the associations. The subjects were then given instructions similar to those used by Gardiner and Java (1990, p. 25). These instructions asked the subjects to make a new/old discrimination for each test probe, explained the distinction between remember and know bases of recognition, and asked the subjects to classify old decisions as either remember or know responses.

In order to acquaint the subjects with item and associative recognition and the remember/know response procedure, they were first given a practice study and a test trial. The study list consisted of 30 random pairs of word. Each pair was presented for 3 sec in the center of the monitor with a 500-msec blank interval between presentations. The test list, which immediately followed, was composed of 6 old single words, 6 new single words, 6 intact or studied word pairs, and 6 rearranged word pairs, presented in random order. Rearranged pairs were constructed by combining the left member of one study pair and the right member of a different study pair. The left/right study order of the words was preserved in the rearranged pairs. The subjects responded, at their own pace, to each test probe by pressing the "T" key to indicate a new decision, the "U" key to indicate an old know decision, and the "O" key for an old remember decision. After the practice trial, the subjects were asked to provide the experimenter with an example of a remember response and a know response they made during the practice test. This provided an opportunity to ensure that the subjects understood the distinction between remember and know responses.

The study phase of the experiment consisted of a new list of 130 random pairs presented in the same manner as the practice study list. The first 5 and last 5 presentations were considered primacy and recency buffers and were not tested. The 120 critical pairs were subdivided into five consecutive blocks of 24 pairs. Three separate test lists were constructed by randomly selecting 2 old single words (one left pair member and one right pair member), 2 intact pairs, and 2 rearranged pairs from different study pairs within each block. The three test lists thus consisted of a different set of 10 old single words, 10 intact study pairs, and 10 rearranged pairs. Ten new single words were also added to each test list. The 40 test probes in each test list were presented in a random order.

The first test immediately followed the study list. The subjects responded as they had in the practice trial. In Experiment 1, the second test was given 30 min after the first. During the delay, the subjects were given a face recognition experiment that consisted of 24 novel study faces and 32 test faces, of which half were old and half were new. The remember/know response procedure was also used in this experiment. (This study is reported as Experiment 1 by Hockley, Hemsworth, & Consoli, 1999.) The remainder of the interval was occupied in conversation with the experimenter. For the third test in Experiment 1, the subjects returned at the same time the following day. In Experiment 2, the subjects finished the first session after the immediate test and returned at the same time 2 days and 7 days following the first session to complete the second and third tests, respectively.

Results

Four subjects in Experiment 1 and 3 subjects in Experiment 2 were excluded from the analyses either because they did not complete all three tests or because they did

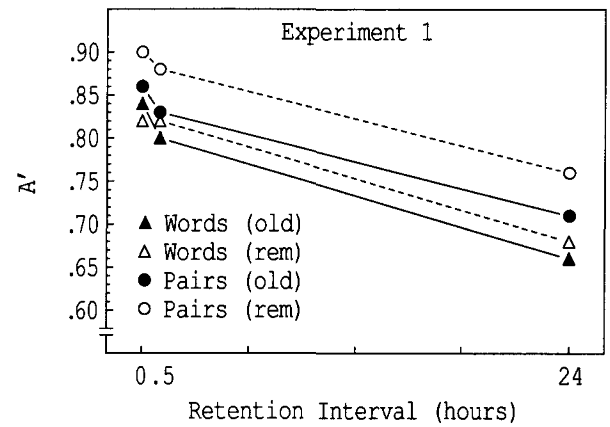

Figure 1. Mean estimates of *A′* for item and associative recognition for overall old and remember responses as a function of retention interval for Experiment 1.

not follow instructions. The .05 level of significance was used for all statistical comparisons.

Overall recognition performance. In order to assess overall recognition performance, A' and d' were calculated on the basis of all old responses for each subject in each condition. Mean A' values for overall recognition as a function of retention interval are shown as solid lines in Figures 1 and 2 for Experiments 1 and 2, respectively. Only the analyses of variance (ANOVAs) based on A' are reported since the analyses for d' showed the same statistical patterns of results. Overall associative recognition performance was more accurate than item recognition performance in Experiment 1 [$F(1,45) = 3.59$, $MS_e = 0.023$]. Overall performance did not differ reliably between item and associative recognition in Experiment 2 [$F(1,46) = 1.17$, $MS_e = 0.022$]. The decline in performance as a function of retention interval was highly significant in both Experiment 1 [$F(2,90) = 42.2$, $MS_e = 0.017$] and Experiment 2 [$F(2,92) = 44.32$, $MS_e = 0.031$].

The interaction between type of recognition test and retention interval provides an evaluation of the difference in the rate of forgetting between item and associative information.[2] Although the decrease in performance over retention interval was somewhat greater for item information than for associative information, the interaction between type of test and retention interval was not statistically reliable in either Experiment 1 [$F(2,90) < 1$] or Experiment 2 [$F(2,92) = 2.22$, $MS_e = 0.020$]. Thus, overall forgetting rates were similar for item and associative recognition.

Remember versus know responses. The mean proportions of correct remember and know responses for item and associative recognition at each retention interval are given in the left half of Table 1. Remember and know responses were analyzed separately. In Experiment 1, the proportion of remember responses was greater for associative recognition than for item recognition [$F(1,45) = 24.70$, $MS_e = 0.069$]. Remember responses declined as a function of retention interval [$F(2,90) = 72.92$, $MS_e = 0.031$], and this decrease was similar for both item and associative responses in that the interaction between type of test and retention interval was not reliable [$F(2,90) = 2.63$, $MS_e = 0.021$]. The analysis of remember responses in Experiment 2 showed a similar pattern of effects: The proportion of remember responses was greater for associative recognition than for item recognition [$F(1,46) = 12.24$, $MS_e = 0.049$], and remember responses decreased as retention interval increased [$F(2,92) = 134.96$, $MS_e = 0.029$]. In Experiment 2, however, the decline in remember responses was significantly greater for associative recognition than for item recognition [$F(2,92) = 4.39$, $MS_e = 0.024$]. This result could have been due to floor effects at the longest retention interval.

The analyses of know responses revealed an identical pattern of results in Experiments 1 and 2. The proportion of know responses was greater for item recognition than for associative recognition in Experiment 1 [$F(1,45) = 10.12$, $MS_e = 0.041$] and Experiment 2 [$F(1,46) = 4.67$, $MS_e = 0.049$], and know responses increased reliably over retention interval in Experiments 1 and 2 [$F(2,90) = 10.26$, $MS_e = 0.021$; and $F(2,92) = 15.35$, $MS_e = 0.023$, respectively]. The increase in the proportion of know responses with retention interval did not differ significantly between item and associative information in either Experiment 1 [$F(2,90) = 1.51$, $MS_e = 0.020$] or Experiment 2 [$F(2,92) < 1$].

The mean proportion of incorrect remember and know responses to new test probes are shown in the right half of Table 1. More false alarms were assigned a know response than a remember response in both Experiment 1 [$F(1,45) = 117.31$, $MS_e = 0.050$] and Experiment 2 [$F(1,46) = 156.92$, $MS_e = 0.046$]. Separate analyses of remember and know false positives revealed that the proportion of remember false alarms was greater for item recognition than for associative recognition in Experi-

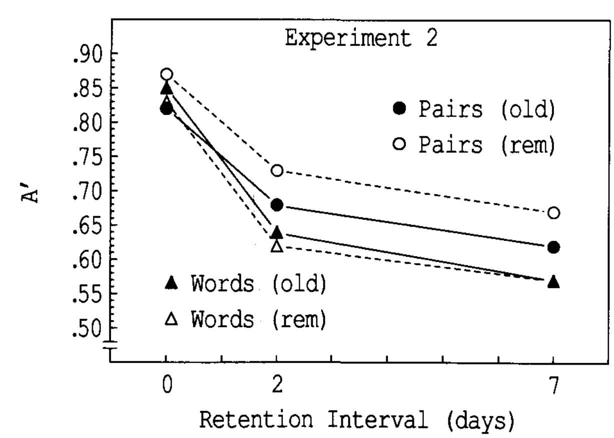

Figure 2. Mean estimates of *A′* for item and associative recognition for overall old and remember responses as a function of retention interval for Experiment 2.

Table 1
Mean Proportions of Remember (Rem) and Know Responses to Old and New Test Probes on Each Test for Item and Associative Recognition in Experiments 1 and 2

	Old Tests				New Tests			
	Item		Pair		Item		Pair	
Test	Rem	Know	Rem	Know	Rem	Know	Rem	Know
				Experiment 1				
1	.53	.22	.74	.10	.05	.16	.05	.19
2	.54	.20	.67	.14	.10	.19	.06	.20
3	.28	.27	.41	.22	.11	.24	.08	.27
				Experiment 2				
1	.53	.21	.66	.14	.06	.13	.05	.20
2	.22	.30	.34	.26	.11	.24	.07	.27
3	.21	.30	.22	.25	.13	.28	.08	.24

ment 1 [$F(1,45) = 4.39$, $MS_e = 0.011$] and in Experiment 2 [$F(1,46) = 4.39$, $MS_e = 0.011$]. In Experiments 1 and 2, incorrect remember responses increased with test delay [$F(2,90) = 7.13$, $MS_e = 0.008$; and $F(2,92) = 5.79$, $MS_e = 0.049$, respectively]. The interaction between type of test and retention interval was not reliable in either analysis [$F(2,90) = 1.33$, $MS_e = 0.007$; and $F(2,92) = 1.63$, $MS_e = 0.011$, respectively].

The proportion of incorrect know responses also increased with test delay in Experiments 1 and 2 [$F(2,90) = 7.74$, $MS_e = 0.019$; and $F(2,92) = 9.03$, $MS_e = 0.252$, respectively] and did not differ between item and associative recognition (Fs < 1). The increase in know false alarms with test delay did not differ reliably for item and associative recognition in Experiment 1 [$F(2,90) < 1$] but was greater for item recognition than for associative recognition in Experiment 2 [$F(2,92) = 4.44$, $MS_e = 0.079$].

Recollection versus recognition. Following Donaldson (1996), mean estimates of d' and A' for overall recognition and for remember responses for item and associative information as a function of retention interval were compared. The means for A' based on remember responses as a function of retention interval are shown as dashed lines in Figures 1 and 2. ANOVAs with item versus associative tests, retention interval, and overall old versus remember responses as factors are reported for the A' estimates, but the analyses based on d' showed a similar pattern of effects. In Experiment 1, associative recognition was more accurate than item recognition [$F(1,45) = 13.32$, $MS_e = 0.031$], performance declined as a function of retention interval [$F(2,90) = 70.60$, $MS_e = 0.018$], and the discrimination of remember responses was greater than overall recognition [$F(1,45) = 9.40$, $MS_e = 0.009$]. The only significant interaction was between type of information and type of response [$F(1,45) = 7.56$, $MS_e = 0.007$], indicating that the difference between remember and overall recognition was greater for associative recognition than for item recognition.

In Experiment 2, associative recognition was more accurate than item recognition [$F(1,46) = 14.15$, $MS_e = 0.024$], and performance declined with test delay [$F(2,92) = 83.34$, $MS_e = 0.033$]. The main effect of type of response was not reliable [$F(1,46) = 3.48$, $MS_e = 0.015$]. However, as in Experiment 1, the interaction between type of information and type of response was significant [$F(1,46) = 7.93$, $MS_e = 0.016$], again showing that the difference between remember responses and overall recognition was greater for associative recognition than for item recognition. No other interaction approached significance.

Mean estimates of B''_D, the appropriate measure of the decision criterion associated with A' (Donaldson, 1993), for item and associative recognition responses on each test are presented in Table 2. B''_D ranges from -1 to $+1$; positive values reflect conservative performance, and negative values indicate liberal responding.

The criteria estimates were analyzed in the same manner as was done for A'. In Experiment 1, B''_D was much higher for remember responses than for overall old responses [$F(1,45) = 157.06$, $MS_e = 0.491$]. The criteria were greater overall for item recognition than for associative recognition [$F(1,45) = 3.87$, $MS_e = 0.729$] and increased with retention interval [$F(2,90) = 6.04$, $MS_e = 0.188$]. This increase was greater for associative recognition than for item recognition [$F(2,90) = 6.18$, $MS_e = 0.261$]. No other interaction reached significance.

Table 2
Mean Estimates of B''_D for Overall Old Responses and Remember (Rem) Responses for Item and Associative Recognition on Each Test of Experiments 1 and 2

	Experiment 1		Experiment 2	
Response	Item	Pair	Item	Pair
		Test 1		
Old	.12	−.27	.13	−.17
Rem	.87	.56	.71	.74
		Test 2		
Old	−.05	−.08	.20	.13
Rem	.66	.73	.87	.88
		Test 3		
Old	.20	.02	.14	.31
Rem	.81	.79	.82	.89

In Experiment 2, mean estimates of B''_D were also much greater for remember responses than for overall old responses [$F(1,46) = 202.39$, $MS_e = 0.333$]. Overall, criteria estimates did not differ between item and associative recognition [$F(1,46) < 1$]. Estimates of B''_D increased with retention interval [$F(2,92) = 10.71$, $MS_e = 0.199$], but this effect was greater for associative recognition than for item recognition [$F(2,92) = 5.84$, $MS_e = 0.141$] and was greater for old associative recognition responses than for remember associative recognition responses [$F(2,92) = 7.07$, $MS_e = 0.072$]. Thus, the important and consistent finding of the analyses of criteria placement was that the criteria estimates were much higher for remember responses than for overall old responses.

DISCUSSION

The present study was designed to compare item and associative recognition in terms of the degree to which both types of recognition decisions are accompanied by conscious recollection and with respect to their relative rates of forgetting. In terms of overall recognition performance, the forgetting rates of item and associative information were comparable. The present findings, therefore, demonstrate that the difference in forgetting rates between item and associative recognition observed by Hockley (1991, 1992) is limited to recognition memory over the short term and does not persist when memory is assessed over much longer retention intervals.

The reason why item and associative forgetting rates differ over short retention intervals but are similar over longer intervals is not clear. It is, however, interesting to note that the general form of the forgetting function for both cued recall and recognition is characterized by a faster forgetting rate during the first 15–20 min following study and a slower forgetting rate over longer intervals (see McBride & Dosher, 1997; Rubin & Wenzel, 1996). It is possible that these two phases of the forgetting function reflect the separate contributions of short- and long-term memory. If this is indeed the case, then it would be reasonable to conclude that item and associative forgetting rates differ in terms of their short-term memory components, but not with respect to the long-term memory component.

The present study also showed that the proportion of correct remember responses was greater for associative recognition than for item recognition, whereas the proportion of correct know responses was greater for item recognition. These differences were obtained both when associative recognition was more accurate than item recognition (Experiment 1) and when item recognition performance and associative recognition performance were comparable (Experiment 2). Thus, associative recognition was accompanied by conscious recollection to a greater extent than was item recognition. This advantage was seen across all retention intervals of Experiment 1 and up to the 2-day retention interval of Experiment 2, but it was absent by the 7-day test of Experiment 2.

The conclusion that associative recognition decisions are based on recollection to a greater extent than are item recognition decisions must, however, be qualified. It is possible that the task demands of the remember/know procedure may require subjects to engage in additional processing at retrieval that they may not normally carry out (or carry out to the same extent) in more standard recognition procedures.[3] It is also reasonable to assume that recollection may play a more modest role in both item recognition and associative recognition when subjects attempt to make old and new recognition decisions as quickly as possible. Thus, we cannot conclude that associative recognition decisions are routinely based on recollection to a greater extent than are item recognition decisions. The results from the remember/know procedure do, though, demonstrate that information that supports recollection is more available for associative recognition judgments than for item recognition judgments.

The forgetting functions for remember responses parallel the findings reported by Gardiner and Java (1991). They found that the probability of remember responses in item recognition is initially greater than that of know responses, but remember responses decline sharply over 24 h, whereas know responses remain relatively unchanged over 1 week. In the present study, there was also an initial advantage for remember over know responses and a marked decline in remember responses over 24 h. The decline in the proportion of remember responses was comparable for both item recognition and associative recognition.

As discussed in the introduction, Donaldson (1996) and Hirshman and Master (1997) have argued that remember and know recognition judgments are based on the same underlying memorial information, and remember responses are made with a higher decision criterion than know responses. In support of this view, Donaldson showed that decision criterion estimates are higher for remember responses than for overall old responses and that d' and A' are approximately equal when calculated for all old decisions and when they are based only on remember responses. The estimates of the criterion values for item and associative recognition in Experiments 1 and 2 were also found to be higher for remember responses than for overall old decisions. Furthermore, the estimates of A' for item recognition were statistically equivalent for overall recognition performance and for old decisions classified as being recollected. Thus, the present results for item recognition are consistent with Donaldson's single-factor account of the remember/know procedure.

For associative recognition, however, A' was consistently and significantly greater for remember responses than for overall recognition decisions. This result indicates that remember and know decisions for associative recognition are not based on the same memorial information with different decision criteria, but, rather, they are based on different information, and the information that supports remember responses leads to more accurate discrimination.

It is interesting to note that know responses for associative recognition showed no discrimination between old and new pairs. The proportion of false-positive know responses was actually greater than the proportion of correct know responses at almost all retention intervals (see Table 1). When recollection failed, the subjects may have based their know responses on the familiarity of the individual items of the test pair. Since old and new, or rearranged, test pairs were both composed of old items, familiarity of the individual items in the test pairs would not provide any basis for discriminating between old and new pairs.

In summary, several investigators have argued that associative recognition is based more on recollection, whereas item recognition is based more on familiarity (e.g., Clark, 1992; Humphreys, 1978; Yonelinas, 1997). The results of the present study using Tulving's (1985) remember/know response procedure showed that associative recognition is accompanied by conscious recollection to a greater extent than is item recognition. Moreover, the pattern of remember and know responses for associative recognition, unlike item recognition, cannot be easily described by a single-factor signal detection type of decision process. Thus, the present findings provide further support for the view that recollection plays a significant role in associative recognition. The associative recognition results also demonstrate that the remember/know response procedure can be an effective method for distinguishing the contributions of familiarity and recollection in recognition memory.

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NOTES

1. Both d' and A' are estimates of recognition performance that are theoretically independent of the decision criterion. A' varies from 0 to 1 with .5 representing chance performance. A' is equivalent to percent correct on a two-alternative forced-choice recognition test. Donaldson (1993) has shown that d' is a slightly better measure when performance is unbiased and that A' is a better measure when criterion changes occur.

2. Slamecka (1985) argued for using the interaction term as a direct comparison of forgetting rates and this approach has been endorsed by Baddeley (1990, pp. 254–255) and Gardiner and Java (1991, see note 1). It is also relevant to note that the rate of forgetting has been shown not to depend on the degree of original learning (Baddeley, 1990; Slamecka & McElree, 1983; Underwood, 1964).

3. We thank an anonymous reviewer for pointing out this possibility.

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