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Dissociations Between Familiarity Processes in Explicit Recognition and Implicit Perceptual Memory

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Dual-process theories of recognition posit that a perceptual familiarity process contributes to both explicit recognition and implicit perceptual memory. This putative single familiarity process has been indexed by inclusion–exclusion, remember–know, and repetition priming measures. The present studies examined whether these measures identify a common familiarity process. Familiarity-based explicit recognition (as indexed by the inclusion–exclusion and the independence remember–know procedures) increased with conceptual processing. In contrast, implicit word-identification priming and familiarity-based word-stem completion (as indexed by inclusion–exclusion) increased with study–test perceptual similarity. These dissociations indicate that familiarity-based explicit recognition may be more sensitive to conceptual than to perceptual processing and is functionally distinct from the perceptual familiarity process mediating implicit perceptual memory.

A central goal of memory theorists is to specify the processes mediating mnemonic behavior. This goal poses the experimental challenge of decomposing performance on a memory task into the interaction of discrete mnemonic processes. One approach to this challenge has been the use of dissociations between memory tasks as evidence of discrete processes. A dissociation is evident when an experimental variable affects performance on one memory task but has no effect (single dissociation) or the opposite effect (double dissociation) on a second memory task. A single dissociation indicates a process mediating mnemonic behavior on one task but not the other. A double dissociation reveals two discrete processes, each unique to one mnemonic behavior (but see Dunn & Kirsner, 1988).

A fruitful dissociative approach has been that between explicit and implicit memory tasks. Explicit memory tasks, such as recall and recognition, make direct reference to prior experience. Recognition, for example, requires the judgment of whether a test stimulus was encountered in a particular study context. In contrast, implicit memory measures do not require direct remembrance of prior experience. One kind of implicit measure is repetition priming, a facilitation or bias in task performance due to prior experience with a stimulus. Examples of repetition priming include word-identification and word-stem completion priming. In a word-identification task participants attempt to identify briefly presented words. Typically, words recently encountered in a study phase will be identified more accurately than new (baseline) words. A word-stem completion task requires participants to complete a word stem (e.g., STO__) with the first response that comes to mind. Typically, participants are more likely to complete a stem with a recently encountered word (e.g., STORE) than with other legitimate completions (e.g., STOVE).

Studies using the task-dissociation approach have revealed numerous dissociations between performance on explicit tasks, such as recognition, and implicit tasks, such as word identification or word-stem completion (for reviews, see Richardson-Klavehn & Bjork, 1988; Roediger & McDermott, 1993; Schacter, 1987). For example, encoding manipulations of conceptual processing have great effects on recognition memory but little or no effect on word-identification (e.g., Jacoby & Dallas, 1981) and word-stem completion priming (e.g., Graf & Mandler, 1984; Graf, Mandler, & Haden, 1982; Roediger, Weldon, Stadler, &

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Riegler, 1992; but see Brown & Mitchell, 1994; Challis & Brodbeck, 1992). Double dissociations between explicit and implicit tasks also have been demonstrated. For example, when study consists of reading visually presented words and generating words from retrieval cues, word-identification priming is greater for the read words, whereas recognition is superior for the generated words (e.g., Jacoby, 1983; Winnick & Daniel, 1970). Word reading also leads to greater word-stem completion priming but worse word recognition than does picture naming (e.g., Madigan, 1983; Roediger et al., 1992; Weldon, Roediger, & Challis, 1989). These dissociations have been taken as evidence that distinct processes mediate explicit and implicit task performance.

Although the task-dissociation approach has furthered understanding of mnemonic processes, it has two important limitations. First, the dissociative approach is closely tied to the particular memory tasks used. Thus, rather than allowing direct measurement of processes, indirect inferences about processes must be made based on dissociations between particular tasks. Second, because the dissociative approach relies on dissociations between tasks as evidence for processes, this method cannot specify processes shared by implicit and explicit tasks. Because of this limitation, little is known about processes that may contribute to both implicit and explicit task performance.

A major attempt to specify memory processes that may operate across many memory tasks has come from dual-process theorists of recognition memory. These theorists have argued that recognition memory judgments are based on two distinct processes, recollection and familiarity (e.g., Atkinson & Juola, 1974; Gardiner, 1988; Jacoby, 1983, 1991; Jacoby & Dallas, 1981; Mandler, 1980). Recollection is thought to be a conscious, attention-demanding, search process that leads to the retrieval of some aspect or aspects of a prior experience. It is believed to be sensitive to encoding manipulations of conceptual processing, with greater conceptual processing leading to greater recollection. Recollection is posited to support recognition memory, but not perceptual repetition priming, at least under the conditions in which it is normally tested.

Familiarity, in contrast, is thought to be an unconscious, automatic process that demands minimal attention. Mandler (1980) argued that

> the phenomenal experience of familiarity can best be assigned to a process of intraitem integration. Repeated exposures of an event focus organizational processes on the perceptual, featural, and intrastructural aspects of the event; intraitem organization involves sensory and perceptual integrations of the elements of the target event. (p. 255)

Similarly, Jacoby and Dallas (1981) suggested that

> due to prior exposure, an item appears to jump out from the page. Because of this fluent processing, the item seems familiar and is judged to be old. Perceptual fluency and the form of recognition memory based on fluency are seen as depending on factors such as . . . the perceptual similarity of study and test versions of an item. (p. 333)

Finally, Yonelinas, Regehr, and Jacoby (1995) argued that familiarity "relies on perceptual characteristics and reflects the automatic or unconscious use of memory" (p. 822). Familiarity-based recognition is primarily thought to be perceptually mediated such that the degree of perceptual overlap between study and test stimuli affects the contributions of familiarity (see also Jacoby, 1983; Rajaram, 1993).

In addition to supporting recognition memory judgments, dual-process theorists posit that this familiarity process also mediates perceptual repetition priming effects, such as word-identification priming. Numerous studies have revealed that word-identification priming is influenced by perceptual processes: The more perceptually similar the study and test forms of a stimulus, the greater the priming. For example, visual word-identification priming is greater after visual study than after auditory study (i.e., is modality sensitive; e.g., Jacoby & Dallas, 1981), greater after word study than after picture study (i.e., is form sensitive; e.g., Winnick & Daniel, 1970), and greater when the study font matches the test font than when there is a change in font (i.e., is font sensitive; e.g., Jacoby & Hayman, 1987; for reviews, see Roediger & McDermott, 1993; Tenpenny, 1995). Conversely, manipulations of conceptual processing, such as depth-of-processing study manipulations, have little to no effect on word-identification priming (e.g., Jacoby & Dallas, 1981). Thus, implicit word-identification priming is thought to reflect fluent perceptual reprocessing or perceptual familiarity (e.g., Jacoby & Dallas, 1981). Explicit recognition is thought to be mediated both by this perceptual familiarity process and by recollection (e.g., Gardiner, 1988; Gardiner & Java, 1990; Gardiner & Parkin, 1990; Jacoby, 1983; Jacoby & Dallas, 1981; Mandler, 1989).

Although dual-process theories promise an integration of implicit and explicit task performance, they have been limited because experiments using the task-dissociation logic cannot directly measure processes within a task. Two alternative approaches to dissociating familiarity and recollection have been developed, the *process dissociation procedure* and the *remember–know procedure,* with these methods offering within-task process measures. The process dissociation procedure, advanced by Jacoby and his colleagues (Jacoby, 1991; see also, Jacoby, Toth, & Yonelinas, 1993; Jacoby, Yonelinas, & Jennings, in press), was designed to directly measure the contributions of recollection and familiarity within a task, such as recognition, and allows for comparison of the contributions of these processes across tasks. The remember–know procedure, in contrast, was designed to measure the subjective states of awareness—"remembering" or "knowing"—associated with memory performance, rather than the underlying processes on which these states of awareness are based (Gardiner, 1988; Tulving, 1985; see also Gardiner & Java, 1990, 1991; Rajaram, 1993; Richardson-Klavehn, Gardiner, & Java, 1996). To the extent that these phenomenological experiences arise from recollection and familiarity processes, respectively, then this procedure may index the contributions of these processes to memory performance (but see Gardiner, Java, & Richardson-Klavehn, in press; Richardson-Klavehn et al., 1996).

Application of the process dissociation procedure assumes that recollection and familiarity are independent processes such that task performance can be based on recollection alone, familiarity alone, or recollection and familiarity. Process measurement using this procedure requires two test conditions, one where recollection and familiarity both facilitate performance, termed the *inclusion* condition, and one where the two processes work in opposition, termed the *exclusion* condition. In a recognition memory experiment, for example, participants might study two sets of items, one critical set and a second less critical set (e.g., Jacoby, 1991). Following study, participants are then asked to perform yes–no recognition under either inclusion or exclusion test instructions. In the inclusion condition, participants are instructed to provide positive recognition responses to items from both the critical set and the second set. Under these instructions, positive recognition judgments to items from the critical set can be based on familiarity (F) alone, $F(1 - R)$; recollection (R) alone, $R(1 - F)$; or both familiarity and recollection, RF. Hence, $P(\text{"old"}|\text{inclusion}) = R + F(1 - R)$. In contrast, under exclusion instructions participants are asked to provide positive recognition judgments only to items from the second set; items from the critical set are to be treated as unstudied items in this condition. For the critical items, these instructions serve to pit recollection and familiarity in opposition: Recollection leads to a "new" judgment, whereas familiarity leads to an "old" judgment, such that $P(\text{"old"}|\text{exclusion}) = F(1 - R)$. With these two conditions, the inclusion–exclusion procedure allows for estimation of the contributions of recollection and familiarity within tasks such as recognition (e.g., Jacoby, 1991; Jennings & Jacoby, 1993) or word-stem completion (e.g., Debner & Jacoby, 1994; Jacoby et al., 1993; Toth, Reingold, & Jacoby, 1994). Recollection is computed by the equation $R = P(\text{"old"}|\text{inclusion}) - P(\text{"old"}|\text{exclusion})$. Familiarity is then derived by the equation $F = P(\text{"old"}|\text{exclusion})/(1 - R)$.

Process estimation performed with the inclusion–exclusion procedure relies on three assumptions. First, as just described, recollection and familiarity are assumed to be independent processes. Arguments for and against this assumption have been discussed elsewhere (e.g., Curran & Hintzman, 1995, 1997; Jacoby, Begg, & Toth, 1997; Jacoby et al., 1993; Jacoby, Toth, Yonelinas, & Debner, 1994; Jacoby et al., in press; Joordens & Merikle, 1993). Second, the probability of recollection is assumed to be the same under both inclusion and exclusion instructions. Violations of this assumption appear to be rare (for a discussion see Graf & Komatsu, 1994; Toth, Reingold, & Jacoby, 1995). Third, the criterion used for familiarity-based judgments is assumed to be the same across inclusion and exclusion instructions. Although this assumption is often satisfied, violations do occur (e.g., see Komatsu, Graf, & Uttl, 1995), and a number of methods of correcting for such criterion shifts have been proposed (e.g., Roediger & McDermott, 1994; Yonelinas et al., 1995).

In contrast to the inclusion–exclusion procedure, which aims to directly measure the processes mediating task performance and assumes process independence, the remember–know procedure provides measures of the subjective states of awareness of memory, "remembering" and "knowing," and these states are thought to be mutually exclusive (e.g., Gardiner & Java, 1993; Gardiner & Parkin, 1990; Gardiner et al., in press; Richardson-Klavehn et al., 1996; but see Jacoby et al., in press). In this procedure, participants are asked to make two kinds of memory judgments at time of test. First, they are asked to make a standard memory decision, such as judging whether a test word appeared in a prior study phase of an experiment. Then, for items in which participants indicate some memory of the encoding episode (e.g., by responding "yes" in yes–no recognition), they are asked to introspect about the subjective basis for their recognition judgment, either "remember" or "know." A "remember" response indicates that recognition was based on the explicit remembrance of some aspect or aspects of the study occurrence of the item. Such judgments are thought to provide a measure of conscious recollection (e.g., Gardiner & Java, 1990; Gardiner & Parkin, 1990). A "know" response, in contrast, is provided when the participant thinks the test word is familiar but does not explicitly recollect the study occurrence. These subjective "know" responses are thought to be a measure of familiarity-based recognition performance (e.g., Gardiner, 1988; Gardiner & Parkin, 1990). Further, these "know" judgments are thought to reflect conscious memorial states of feelings of familiarity (Richardson-Klavehn et al., 1996). Within the remember–know framework, these two subjective states of awareness are thought to be mutually exclusive such that memory judgments are associated with either "remembering" or "knowing," but not both (e.g., Gardiner & Java, 1993; Gardiner & Parkin, 1990; Gardiner et al., in press; Richardson-Klavehn et al., 1996).

The remember–know procedure, as mentioned above, aims to index the states of awareness associated with memory performance, rather than the underlying processes mediating performance, and Gardiner and his colleagues (Gardiner et al., in press; Gardiner & Java, 1993; Richardson-Klavehn et al., 1996) have recently argued that "remember" and "know" subjective responses should not be equated with recollection and familiarity processes. Nevertheless, some have relied on the remember–know method to measure recollection and familiarity processes, making the assumption that the subjective states of "remembering" and "knowing" may depend on recollection and familiarity processes, respectively. Such applications of the remember–know method may allow for comparison of processes within and across tasks, and it is this conceptualization of remember–know responses—as process measures—that will be considered here.

A considerable number of studies that used the remember–know method have revealed that manipulated variables can have differential effects on "remember" and "know" judgments (for reviews, see Gardiner & Java, 1993; Rajaram & Roediger, in press; Richardson-Klavehn et al., 1996), and many of these studies demonstrated that familiarity-based recognition, as indexed by "know" responses, parallels the familiarity that underlies word-identification and word-stem completion priming. As with perceptual repetition priming, "know" responses are invariant across conceptual processing manipulations but increase with study–test perceptual similarity. For example, whereas "remember" judgments increase with depth of processing, "know" judgments are either insensitive to level of conceptual processing (e.g., Gardiner, 1988; Gardiner et al., in press) or increase when encoding is focused on perceptual characteristics of stimuli (e.g., Rajaram, 1993). "Remember" judgments are also greater for test words studied as pictures than for test words studied as words, whereas "know" judgments are either similar for the two item types or greater for word-studied items than for picture-studied items (Dewhurst & Conway, 1994; Rajaram, 1993). Further, manipulations that decrease conceptual processing, such as division of attention at study, serve to reduce "remember" responses but not "know" responses (e.g., Gardiner & Parkin, 1990). Thus, both perceptual repetition priming and familiarity-based recognition, as indexed by "know" judgments, are insensitive to manipulations of conceptual processing and sensitive to the perceptual similarity between study and test stimuli. Such convergence suggests that explicit recognition judgments and implicit perceptual priming may be mediated by the same familiarity process.

Although results from numerous remember–know studies of recognition memory are consistent with the dual-process hypothesis that a single perceptual familiarity process mediates recognition judgments and perceptual priming (but see Java, 1994), this conclusion is complicated by studies that have demonstrated that familiarity-based recognition often does not parallel perceptual repetition priming when indexed by the inclusion–exclusion procedure. For example, both recollection-based and familiarity-based recognition are greater following word generation from a to-be-solved anagram than following word reading (Jacoby, 1991; Verfaellie & Treadwell, 1993; but see Jennings & Jacoby, 1993). This greater familiarity for the anagram-solved words occurs even though there is greater study–test perceptual similarity for the read words. Similarly, familiarity-based recognition is greater for words studied in the context of other associatively related words than for words studied among unrelated items (Jacoby & Kelley, 1991). This manipulation of associative context results in equivalent study–test perceptual similarity for both types of items. Nevertheless, familiarity increases when words occur among semantic associates, presumably because such a context leads to additional conceptual processing. Finally, the contributions of both recollection and familiarity to recognition are greater after semantic encoding than after nonsemantic–perceptual encoding (Komatsu et al., 1995; Toth, 1996; Wagner, Verfaellie, & Gabrieli, 1995). As argued by Jacoby and colleagues (e.g., Jacoby, 1991; Jacoby et al., 1993; Jennings & Jacoby, 1993; Toth, 1996), these findings suggest that familiarity is not entirely reliant on the perceptual match between study and test stimuli. Familiarity-based recognition appears to be sensitive to conceptual processing, at least when indexed by the inclusion–exclusion procedure.

This apparent effect of conceptual processing on familiarity in recognition contrasts with the relative insensitivity of perceptual repetition priming to conceptual processing. Jacoby (1991; Jacoby et al., 1993; Jennings & Jacoby, 1993) has suggested that this differential effect of conceptual processing indicates that familiarity is task specific: Depending on the retrieval context, familiarity-based memory performance may be more or less reliant on study–test perceptual similarity. For example, familiarity-based word-stem completion and word identification may be primarily sensitive to the overlap between study and test perceptual processing, whereas recognition, under certain circumstances, may be additionally sensitive to the overlap between study and test conceptual processing.

These divergent effects of perceptual and conceptual encoding manipulations on familiarity-based memory performance and subsequent arguments that familiarity is contextually specific raise a fundamental question about the process of familiarity: Do inclusion–exclusion, remember–know, and perceptual priming measures identify the same familiarity process? The present set of studies was designed to address this question by varying conceptual processing and study–test perceptual similarity across comparable inclusion–exclusion, remember–know, and perceptual priming studies. If the three kinds of procedures are measuring the same memory process, then conceptual and perceptual manipulations should have parallel effects on familiarity estimates and priming magnitudes. If two or more of these indices of familiarity are actually measuring different processes that simply share the label *familiarity,* then the conceptual and perceptual manipulations should have dissociable effects on familiarity estimates and priming magnitudes.

In Experiments 1 and 2, we examined the effects of conceptual processing and perceptual similarity on recollection-based and familiarity-based word recognition (Experiment 1) and on word-identification priming (Experiment 2). We used a picture–word study manipulation to simultaneously vary conceptual processing (greater for naming pictures than for reading words) and perceptual similarity (greater for word-studied than for picture-studied test words). To the extent that the familiarity process contributing to recognition memory (estimated using the inclusion–exclusion procedure) is the same perceptual process as that mediating word-identification priming, then familiarity-based recognition and word-identification priming should be similarly affected by the picture–word manipulation; both measures were expected to increase with perceptual similarity rather than with conceptual processing.

The inclusion–exclusion procedure has also been used to estimate familiarity in word-stem completion, typically an implicit measure of perceptual priming. It is unknown how familiarity estimates in such a test relate to inclusion–exclusion indices of familiarity-based recognition and to word-identification priming. In Experiment 3, we used the picture–word study manipulation in conjunction with a word-stem completion test under inclusion–exclusion instructions. To the extent that these are estimates of the same familiarity process, then they should be similarly affected by the picture–word manipulation; we expected it to have the same effects on familiarity-based word-stem completion as on familiarity-based recognition and on word-identification priming. Finally, in Experiment 4, we estimated familiarity in recognition with the remember–know procedure so that we could directly compare such subjective measures of familiarity-based recognition (Experiment 4) with estimates from the inclusion–exclusion procedure (Experiments 1 and 3) and perceptual repetition priming (Experiment 2). To the extent that the inclusion–exclusion procedure and the remember–know procedure are measuring the same familiarity process, then they should be similarly affected by the picture–word study manipulation; we expected it to have the same effects on "know" judgments in this experiment as on familiarity estimates from the inclusion–exclusion procedure.

Experiment 1

In Experiment 1, we directly compared the sensitivity of familiarity-based recognition to conceptual and perceptual processing by pitting the effects of conceptual processing against those of perceptual similarity. We used the inclusion–exclusion procedure to estimate the contributions of recollection-based and familiarity-based recognition of words studied as either pictures or words. In the first phase of the experiment, participants named pictures and read words. Picture naming typically leads to superior word recognition relative to word reading (e.g., Paivio, 1971, 1986), and this *picture superiority effect* is thought to be due to the more efficient access to semantic codes or the greater conceptual elaboration associated with picture naming (e.g., Durso & Johnson, 1980; Nelson, 1979; Weldon & Roediger, 1987; but see Weldon & Coyote, 1996). Following this phase, participants studied a second list of words presented auditorily. Finally, participants made yes–no recognition judgments under either inclusion or exclusion instructions. If familiarity-based recognition is more sensitive to conceptual processing, then familiarity should be greater for picture-studied than for word-studied test words. In contrast, if familiarity is more sensitive to study–test perceptual similarity, then familiarity should be greater for word-studied than for picture-studied test words.

Method

Participants

Thirty-four Stanford University undergraduates participated in this experiment for a $5 payment. Data from 2 participants were excluded on the basis of their responses on a postexperiment questionnaire (described later).

Design

A mixed two-variable (2 × 2) design was used. The within-subjects variable was study form (picture and word), and the between-subjects variable was test instruction (inclusion or exclusion). There were 16 participants in each between-subjects cell.

Materials

Blocks. For this and all subsequent experiments, stimuli were presented on a Macintosh LC III or IIsi computer with a monochrome monitor. The stimuli were 120 items selected from the Snodgrass and Vanderwart (1980) picture norms. The names (labels) of the pictured items were nouns from 4 to 7 letters in length with a range of word frequencies (1 to 76 occurrences per million; Kučera & Francis, 1967). The 120 items were divided into three 40-item blocks (Blocks A, B, and C) such that the blocks were equated for mean word length, mean word frequency, and mean name agreement ratings.

Study lists. Four 40-item visual study lists were created. Two lists, each consisting of 20 pictures and 20 words, were created from the Block A items such that across the lists each item appeared in both study forms. Similarly, two lists were created from the Block B items. Each list was pseudorandomized with the constraints that (a) there be no more than three consecutive pictures or words and (b) each half of the list had approximately the same number of pictures and words. Block C items formed a single 40-item auditory study list.

Test list. A 120-word recognition test list was created. It consisted of 40 visually studied items (Block A or B), 40 auditorily studied items (Block C), and 40 unstudied items (Block B or A). Counterbalancing of items as visually studied and unstudied was done across participants. Targets and foils varied with final test instructions. The test list was pseudorandomized such that (a) there were no more than three consecutive targets or foils, and (b) each half of the list had approximately the same numbers of items visually studied as pictures, visually studied as words, auditorily studied, and unstudied.

Procedure

The experiment consisted of three phases: a visual study of pictures and words, an auditory study, and a yes–no recognition test. Participants were told that they would be participating in two separate experiments. They were informed that the first experiment was designed to test how accurately and quickly people can name aloud items presented as pictures and read aloud items presented as words. In this phase, participants received one of the four visual study lists. Each item appeared in the center of the screen for 1 s, and participants were instructed to name aloud the picture or read aloud the word. A 1-s intertrial interval followed each response.

At the end of the visual study phase, participants were told that the second experiment would test their memory for auditorily presented words. In this phase, the auditory list was presented over headphones at a rate of one word every 2 s. Participants were instructed to remember the words for a subsequent memory test.

Immediately following presentation of the auditory list, participants received the 120-word yes–no recognition test list under either inclusion or exclusion instructions. Test words were presented one at a time in the center of the computer screen and remained on until the participant's response, with an intertrial interval of 500 ms. Participants in the inclusion condition were instructed to respond "yes" if they recognized the word as having been either in the initial visual study phase or in the second auditory study phase and to respond "no" if they did not recognize the word as having been in either phase. Participants in the exclusion condition were instructed to respond "yes" only if the word was from the auditory phase and to respond "no" to words from the visual phase and to new unstudied words. Participants were instructed to make their decisions as accurately and quickly as possible.

After the recognition test, participants were given a questionnaire to assess their understanding of the test instructions. The questionnaire asked participants to explicitly state to which items (visually studied, auditorily studied, and unstudied) they were to respond "yes." Two participants were removed and replaced because their questionnaire responses indicated a failure to understand the test instructions.

Table 1
Mean Probability of Responding "Yes" Across Study Form and Test Instruction, and Estimates of Recollection and Familiarity Across Study Form in Experiment 1

Performance measure	Study form			
	Pictures	Words	Heard	New
Test instructions				
Inclusion	.93	.67	.73	.13
Exclusion	.22	.28	.66	.12
Process estimate				
Recollection	.71	.38	—	—
Familiarity	.77	.46	—	—

Note. Dashes indicate that estimates of recollection and familiarity were not computed for heard and new items.

Results

Picture names provided by participants in the study phase were consistent with those from the Snodgrass and Vanderwart (1980) norms (mean agreement = 86%). Test-phase words corresponding to pictures named that were inconsistent with the norms were dropped prior to data analysis. Unless otherwise indicated, an alpha level of .05 was used for all statistical tests.

Displayed in Table 1 are the probabilities of responding "yes" to test words across study form and test instruction and the process estimates. Prior to considering the effect of study form on recollection-based and familiarity-based recognition memory judgments, we analyzed base rate performance by examining the probabilities of responding "yes" to heard and new items.

Heard and New Items

Analyses of base rates were necessary to detect shifts in response criterion that may have occurred because of the test instructions (Graf & Komatsu, 1994; Roediger & McDermott, 1994; Yonelinas et al., 1995). A mixed two-variable analysis of variance (ANOVA) was performed with a between-subjects variable of test instruction (inclusion vs. exclusion) and a within-subjects variable of item type (new vs. heard). No shift in response criterion occurred across test instruction: The probability of responding "yes" was similar under inclusion (.43) and exclusion (.38) instructions, indicating a main effect of test instruction, $F(1, 30) = 1.49$, $MSE = 0.02$. Further, the Test Instruction × Item Type interaction was not reliable ($F < 1.0$), indicating that this pattern held for both heard items (hits) and new items (false alarms). The probability of responding "yes" to previously encountered heard items (.69) was higher than that for new items (.13), indicating successful discrimination between studied and unstudied items: main effect of item type, $F(1, 30) = 385.42$, $MSE = 0.01$.

Pictures and Words

A mixed two-variable ANOVA was performed on the probabilities of responding "yes" to words initially studied as pictures or as words, with a between-subjects variable of test instruction (inclusion vs. exclusion) and a within-subjects variable of study form (picture vs. word). Probabilities were higher under inclusion (.80) than exclusion (.25) instructions, indicating a main effect of test instruction, $F(1, 30) = 135.45$, $MSE = 0.04$. The probability of responding "yes" was higher for words studied as pictures (.58) than for words studied as words (.48), which indicated a main effect of study form, $F(1, 30) = 11.08$, $MSE = 0.02$. There was a Study Form × Test Instruction interaction, $F(1, 30) = 28.82$, $MSE = 0.02$. Simple effects comparisons indicated that the probability of responding "yes" was higher for picture-studied than for word-studied items under inclusion instructions, $F(1, 15) = 30.85$, but not under exclusion instructions, $F(1, 15) = 2.69, p > .10$.

Recollection and Familiarity

We derived estimates of recollection-based and familiarity-based recognition for the picture-studied and the word-studied items using the group means and the inclusion–exclusion equations: $R = P(\text{"old"}|\text{inclusion}) - P(\text{"old"}|\text{exclusion})$; $F = P(\text{"old"}|\text{exclusion})/(1 - R)$. Both recollection and familiarity were greater for words studied as pictures than for words studied as words (see Table 1). Because test instruction was a between-subjects variable, statistical analysis of these process estimates was precluded.

Discussion

Under inclusion instructions, recognition of words studied as pictures was more accurate than recognition of words studied as words. This replicates the typical picture superiority effect found in recognition memory (e.g., Madigan, 1983). Also, under exclusion instructions, participants were better able to exclude picture-studied than word-studied items, though not to a statistically significant degree. Process estimates revealed that the picture superiority effect in recognition is partially supported by greater recollection for words studied as pictures than for words studied as words. This is consistent with results from remember–know studies that demonstrated greater "remember" responses for picture-studied items than for word-studied items (Dewhurst & Conway, 1994; Rajaram, 1993). In addition, these findings complement those from other inclusion–exclusion and remember–know studies that demonstrated increased recollection-based recognition following greater conceptual processing (e.g., Gardiner, 1988; Gardiner et al., in press; Gregg & Gardiner, 1994; Jacoby, 1991; Jennings & Jacoby, 1993; Komatsu et al., 1995; Perfect, Williams, & Anderton-Brown, 1995; Rajaram, 1993; Toth, 1996; Verfaellie & Treadwell, 1993; Wagner, Verfaellie, et al., 1995).

Process estimates also revealed that familiarity contributes to the picture superiority effect. As with recollection, familiarity-based recognition was greater for picture-studied items than for word-studied items. This is consistent with the results of other inclusion–exclusion studies of recognition which demonstrated that as conceptual processing increases, so too does familiarity-based recognition (e.g., Jacoby, 1991; Jacoby & Kelley, 1991; Komatsu et al., 1995; Toth, 1996; Verfaellie & Treadwell, 1993; Wagner, Verfaellie, et al., 1995; but see Jennings & Jacoby, 1993). Collectively, these studies provide considerable evidence that familiarity-based recognition is sensitive to conceptual processing. The present results extend this conclusion because they suggest that familiarity-based recognition may be more sensitive to conceptual processing (greater for picture naming than for word reading) than to perceptual similarity (greater for word-studied than for picture-studied test words).

Although these findings are consistent with those of previous inclusion–exclusion studies of familiarity-based recognition, they are inconsistent with the results of remember–know studies that demonstrated equivalent "know" responses across similar picture–word manipulations or greater "know" responses for word-studied items (e.g., Dewhurst & Conway, 1994; Rajaram, 1993). Such inconsistencies raise the possibility that the subjective states of awareness indexed by the remember–know method are not direct measures of the recollection and familiarity processes indexed by the inclusion–exclusion procedure (Gardiner et al., in press; Richardson-Klavehn et al., 1996). The present findings are also inconsistent with results from perceptual repetition priming studies that found greater priming in word identification, word-stem completion, word-fragment completion, and picture identification when study and test stimuli were perceptually matched than when they were unmatched (e.g., Park & Gabrieli, 1995; Roediger et al., 1992; Winnick & Daniel, 1970). These differences suggest that the familiarity process mediating recognition may be functionally distinct from the familiarity process indexed by perceptual repetition priming.

Experiment 2

Experiment 2 was designed to compare perceptual repetition priming with familiarity-based recognition. In Experiment 1, familiarity-based recognition was more sensitive to conceptual than to perceptual processes. Perceptual repetition priming, in contrast, is insensitive to conceptual processing and sensitive to perceptual similarity. For example, previous studies have demonstrated that picture–word study manipulations lead to greater word-identification priming for word-studied than for picture-studied items (Kirsner, Milech, & Stumpfel, 1986; Weldon, 1991; Winnick & Daniel, 1970). In Experiment 2, we further examined the effects of picture–word study on word-identification priming using an experimental procedure identical to that used in Experiment 1, with the exception that the final test was implicit word identification. Participants first named pictures and read words. Then, in contrast to previous word-identification priming studies, participants studied an intervening word list presented auditorally. Finally, implicit word identification was performed. This procedure allowed for direct comparison of familiarity-based recognition (Experiment 1) with word-identification priming (Experiment 2). To the extent that the same familiarity process mediates both word-identification priming and recognition memory, then the picture–word effect in Experiment 2 is expected to parallel that found in Experiment 1.

Method

Participants

Sixteen Stanford University undergraduates participated in this experiment for a $5 payment.

Design

A single-variable within-subjects design was used; the variable of study form had two levels, picture and word.

Materials

The visual study lists and the auditory list were identical to those in Experiment 1. To avoid possible explicit contamination of the implicit word-identification test, we modified the test list from Experiment 1 by excluding the auditorily presented items. This resulted in an 80-word test list with an equal number of "old" and "new" items (i.e., 40 visually studied items and 40 unstudied items). This list was pseudorandomized such that it satisfied the constraints applied to the Experiment 1 list. Counterbalancing of items as studied and unstudied was performed across participants. In addition, 36 filler items were selected and divided into three 12-word practice lists, each consisting of a mix of high- and low-frequency words (Kučera & Francis, 1967).

Procedure

The experiment consisted of three phases: a visual study of pictures and words, an auditory study, and a word-identification test. The procedure and instructions for the first two phases were identical to those in Experiment 1, with one exception. In the auditory phase, participants were told that they would have to remember a randomly designated subset of the words and were asked to recall the last five words at the completion of study. We used this recall to ensure that, as in Experiment 1, participants studied the auditory list under intentional learning instructions. Following the auditory phase, participants advanced to the word-identification test phase. Prior to participants' beginning the test, we performed a titration procedure to determine the optimal presentation duration of test items for each participant. In this procedure, participants received three 12-item practice lists, one each at presentation durations of 17, 34, and 51 ms. Optimal presentation was defined as the duration at which participant performance was closest to 50% correct. To avoid item-specific effects during setting of the presentation rate, we counterbalanced the practice lists through the three presentation durations across participants. Presentation duration was 17 ms for 12 participants and 34 ms for 4 participants. Following determination of their presentation rates, we administered the word-identification test to participants. Each trial consisted of (a) a fixation cross (i.e., +) presented centrally for 83 ms, (b) a word presented for the determined duration of 17 or 34 ms, and (c) a backward mask (i.e., &&&&&&&&&) presented for 83 ms. Participants were told that, immediately following fixation, a word would centrally appear for a brief duration. Participants were asked to read the word out loud if possible and were told that they should guess if they were unsure. A 500-ms intertrial interval followed each response. The experimenter made a written record of responses.

Results

Picture names provided by participants in the study phase were consistent with those from the Snodgrass and Vander-

Table 2
Mean Proportions of Words Identified and Proportion of Priming in Experiment 2

Study form	Proportion identified	Priming
Picture	.45	.06
Word	.49	.11
New	.38	—

Note. Dash indicates that new items served as baseline when computing amount of priming.

wart (1980) norms (mean agreement = 87%). Test-phase words corresponding to pictures named that were inconsistent with the norms were dropped prior to data analysis.

Table 2 presents the proportions of words correctly identified at test and the amount of priming across study form. A within-subjects ANOVA with a variable of study form (picture vs. word vs. new) revealed that word identification differed across study form, $F(2, 30) = 14.57$, $MSE = 0.01$. Identification of word-studied items was superior to that of picture-studied items, $F(1, 30) = 4.57$, which was, in turn, superior to that of new items, $F(1, 30) = 10.39$. This pattern was further supported by a nonparametric rank order analysis ($p < .002$).

Discussion

Test words previously studied as words or pictures were identified more accurately than unstudied words. There was greater word-identification priming for word-studied than for picture-studied items, a perceptual specificity that is commonly found on this task (e.g., Kirsner et al., 1986; Weldon, 1991; Winnick & Daniel, 1970). Thus, perceptual repetition priming was sensitive to study–test perceptual similarity rather than to conceptual processing. If such priming is interpreted as an expression of familiarity, then it is a different familiarity from the recognition familiarity that was greater for picture-studied than for word-studied items in Experiment 1. Collectively, Experiments 1 and 2 demonstrate a double dissociation between the familiarity mediating word-identification priming (sensitive to perceptual similarity) and the familiarity mediating recognition memory (more sensitive to conceptual processing).

Experiment 3

Familiarity in recognition, as indexed by the inclusion–exclusion procedure (Experiment 1), differs from perceptual repetition priming, as indexed by word-identification priming (Experiment 2). Familiarity has also been indexed by word-stem completion, typically an implicit measure of perceptual memory. Previous estimates of familiarity-based stem completion, as indexed by inclusion–exclusion, have revealed that this familiarity process is sensitive to perceptual similarity and insensitive to conceptual processing (e.g., Jacoby et al., 1993; Toth et al., 1994). For example, Jacoby et al. (1993) found that a read-anagram manipulation had opposite effects on recollection- and familiarity-based stem completion, with recollection increasing with conceptual processing (greater for anagram-solved words) but familiarity increasing with study–test perceptual similarity (greater for read words). By using the picture–word manipulation in conjunction with an inclusion–exclusion word-stem completion test, the present experiment was designed to compare familiarity in word-stem completion with familiarity in recognition memory (Experiment 1) and with word-identification priming (Experiment 2). The design and procedure were identical to those of Experiment 1, with two exceptions. First, the final test was word-stem completion instead of yes–no recognition. Second, the materials were slightly modified in order to meet the constraints of this word-stem completion test. If there is a shared familiarity process mediating both word-stem completion and recognition memory, then the picture–word manipulation should have the same effect on familiarity-based word-stem completion in this experiment as it had on familiarity-based recognition in Experiment 1. Alternatively, if the same familiarity process mediates perceptual repetition priming and word-stem completion, then the picture–word manipulation should have the same effect on familiarity-based word-stem completion in this experiment as it had on perceptual repetition priming in Experiment 2.

Method

Participants

Thirty-two Stanford University undergraduates participated in this experiment for a $5 payment.

Design

A mixed two-variable (2 × 2) design was used. The within-subjects variable was study form (picture and word), and the between-subjects variable was test instruction (inclusion or exclusion). There were 16 participants in each between-subjects cell.

Materials

Blocks. The stimuli were 90 items selected from the Snodgrass and Vanderwart (1980) picture norms. The names (labels) of the pictured items were nouns from 4 to 10 letters in length with a range of word frequencies (1 to 198 occurrences per million; Kučera & Francis, 1967). Items were selected such that there was a minimum of five possible completions for each three-letter stem (e.g., chi___) and each stem was unique. From the 90 items, two 30-item blocks (Blocks A and B) were created such that the blocks were similar in mean word length, mean word frequency, mean name agreement ratings, and mean number of possible stem completions. The remaining 30 items composed an additional block (Block C).

Study lists. Four visual study lists were created. Two lists, each consisting of 15 pictures and 15 words, were created from Block A items such that across the lists each item appeared in both study forms. Similarly, two lists were created from Block B items. Each list was pseudorandomized as in Experiment 1. The items in Block C formed an auditory study list.

Test list. A 90-item word-stem completion test list was created. The test list consisted of three-letter word-stems: 30 from visually studied items (Block A or B), 30 from auditorily studied items (Block C), and 30 from unstudied items (Block B or A). Counterbalancing of items as visually studied and unstudied was done across participants. The test list was pseudorandomized such that (a) there were no more than three consecutive stems from the visual study phase, from the auditory study phase, or from new unstudied items, and (b) each half of the list had approximately the same number of stems from the visually studied pictures, the visually studied words, the auditorily studied words, and the unstudied words.

Procedure

The experiment consisted of three phases: a visual study of pictures and words, an auditory study, and a word-stem completion test under inclusion or exclusion instructions. The procedure for the first two phases was identical to that in Experiment 1. Immediately following presentation of the auditory list, participants received the 90-item word-stem completion test. Test stems were presented one at a time in the center of the computer screen and remained on until the participant's response, with an intertrial interval of 500 ms. Participants in the inclusion condition were instructed to try to complete each stem with an item that had been presented in either the visual study phase or the auditory phase, and, if they could not do so, to complete the stem with the first response that came to mind. Participants in the exclusion condition were instructed to complete each stem with an item that had been presented in the auditory phase and not to complete stems with items that had been encountered in the visual study phase. Further, they were instructed that if they generated a completion and remembered that it had previously been presented in the first phase, then they should generate a different completion for the stem. Finally, if they could not complete a stem with an item from the auditory phase, then they were instructed to give the first response that came to mind as long as it was not an item from the visual phase. The experimenter recorded the participants' verbal responses. Participants were instructed to make their decisions as accurately and quickly as possible. Upon test completion, a questionnaire explicitly assessed participants' understanding of the test instructions. On the basis of the questionnaire responses, we concluded that all participants understood the experimental instructions.

Results

Picture names provided by participants in the study phase were consistent with those from the Snodgrass and Vanderwart (1980) norms (mean agreement = 90%). Test-phase words corresponding to pictures named that were inconsistent with the norms were dropped prior to data analysis.

Displayed in Table 3 are the probabilities of completing a word-stem with the target item across study form and test instruction and the process estimates. Prior to considering the effect of study form on recollection-based and familiarity-based stem completion, we analyzed base rate performance by examining the completion probabilities for heard and new items in order to detect shifts in response criterion that may have occurred because of test instruction.

Heard and New Items

A mixed two-variable ANOVA was performed, with a between-subjects variable of test instruction (inclusion vs. exclusion) and a within-subjects variable of item type (new vs. heard). No shift in response criterion occurred across test instruction: The probability of completing a stem with the target word was similar under inclusion (.50) and exclusion (.46) instructions, which indicated a main effect of test instruction, $F(1, 30) = 1.38$, $MSE = 0.02$. The probability of completing a stem with the target word was higher for heard (.62) than for new (.35) items, which indicated a main effect of item type, $F(1, 30) = 284.26$, $MSE = 0.01$. The interaction was not reliable, $F < 1.0$.

Table 3
Mean Proportions of Word Stems Completed With Target Items Across Study Form and Test Instruction, and Estimates of Recollection and Familiarity Across Study Form in Experiment 3

Performance measure	Study form: Pictures	Words	Heard	New
Test instructions				
Inclusion	.50	.67	.63	.37
Exclusion	.20	.50	.60	.32
Process estimate				
Recollection	.30	.16	—	—
Familiarity	.28	.60	—	—

Note. Dashes indicate that estimates of recollection and familiarity were not computed for heard and new items.

Pictures and Words

A mixed two-variable ANOVA was performed on the probabilities of completing a stem with the target word for words studied as pictures or as words, with a between-subjects variable of test instruction (inclusion vs. exclusion) and a within-subjects variable of study form (picture vs. word). Probabilities were higher under inclusion (.58) than exclusion (.35) instructions, indicating a main effect of test instruction, $F(1, 30) = 30.15$, $MSE = 0.03$. The probability was higher for words studied as words (.58) than for words studied as pictures (.35), which indicated a main effect of study form, $F(1, 30) = 70.35$, $MSE = 0.01$. The interaction was reliable, $F(1, 30) = 5.94$, $MSE = 0.01$. Simple effects comparisons revealed a higher probability for word-studied than for picture-studied items under both inclusion, $F(1, 15) = 27.00$, and exclusion, $F(1, 15) = 43.58$, instructions, with the interaction indicating a greater difference between word- and picture-studied items in the exclusion condition.

Recollection and Familiarity

Estimates of the contributions of recollection and familiarity across study form were derived from the group means for the picture-studied and word-studied items (see Table 3). Recollection was greater for picture-studied items, but familiarity was greater for word-studied items. To compare study-induced increments in familiarity with standard measures of priming, we subtracted the target completion rate for new items (.35, collapsed across test instruction), which reflects preexperimental familiarity, from the familiarity estimates for picture- and word-studied items. Study-induced familiarity was greater for word-studied (.26) than for picture-studied (−.06) items. Because test instruction was a between-subjects variable, statistical analysis of these process estimates was precluded.

Discussion

Under inclusion instructions, participants were more accurate at completing stems with words studied as words than with words studied as pictures. Under exclusion instructions, participants were more likely to fail to exclude word-studied completions than picture-studied completions. Process estimates revealed that recollection was greater for picture-studied than for word-studied items. Previous inclusion–exclusion and remember–know studies similarly have reported increased recollection-based word-stem completion with increased conceptual processing (Jacoby et al., 1993; Java, 1994; Toth et al., 1994). The present pattern also complements inclusion–exclusion and remember–know studies that demonstrated greater recollection-based recognition following greater conceptual processing (e.g., Experiment 1; Dewhurst & Conway, 1994; Gardiner, 1988; Gardiner et al., in press; Gregg & Gardiner, 1994; Jacoby, 1991; Jennings & Jacoby, 1993; Komatsu et al., 1995; Rajaram, 1993; Perfect et al., 1995; Toth, 1996; Verfaellie & Treadwell, 1993; Wagner, Verfaellie, et al., 1995).

Familiarity-based stem completion, in contrast, was greater for word-studied than for picture-studied items. As perceptual similarity increased, so too did familiarity. This finding converges with the results of previous studies that demonstrated greater familiarity-based stem completion for read items than for anagram-solved items (Jacoby et al., 1993) and for read items than for generated items (Toth et al., 1994). In addition, this finding parallels the results of word-identification and word-stem completion priming studies that demonstrated greater priming for word-studied than for picture-studied items (e.g., Experiment 2; Roediger et al., 1992; Winnick & Daniel, 1970). The present results, however, demonstrate that familiarity-based stem completion and familiarity-based recognition are differentially affected by conceptual processing and perceptual similarity. Experiments 1 and 3 thus reveal a double dissociation between the familiarity mediating recognition memory (more sensitive to conceptual processing) and the familiarity mediating word-stem completion (sensitive to study–test perceptual similarity).

Experiment 4

The effects of picture–word study on familiarity-based word recognition as indexed by the inclusion–exclusion procedure (Experiment 1) are inconsistent with findings from previous studies of familiarity in recognition as indexed by the remember–know procedure (e.g., Dewhurst & Conway, 1994; Rajaram, 1993). Such divergence suggests that these two procedures may not index the same familiarity process (Gardiner et al., in press; Richardson-Klavehn et al., 1996). The effects of the picture–word study manipulation on familiarity as indexed by perceptual repetition priming (Experiment 2) and by inclusion–exclusion word-stem completion (Experiment 3) parallel those found in previous remember–know studies (e.g., Dewhurst & Conway, 1994; Rajaram, 1993). In Experiment 4, we further examined the effects of picture–word study on familiarity-based word recognition by using subjective "remember" and "know" responses as process indices. The experiment was identical to Experiment 1 with the exception that participants performed the final recognition test using the remember–know method. Participants first named pictures and read words. Then, in contrast to previous remember–know studies of recognition, an intervening study list was presented auditorily. Finally, participants performed yes–no recognition using the remember–know method. This procedure allowed for direct comparison of familiarity-based recognition as indexed by subjective "know" judgments (Experiment 4) with familiarity-based recognition derived using the inclusion–exclusion method (Experiment 1).

In this experiment, the remember–know measures of recollection and familiarity were examined under both a mutual exclusivity and an independence assumption (Jacoby et al., in press; Yonelinas & Jacoby, 1995). Typical application of the remember–know procedure results in mutually exclusive subjective responses (i.e., participants cannot respond both "remember" and "know"), and Gardiner and colleagues (Gardiner & Java, 1993; Gardiner et al., in press; Richardson-Klavehn et al., 1996) have argued that the states of awareness giving rise to these responses are also likely to be mutually exclusive. Treatment of the proportions of "remember" and "know" responses as process measures results in application of an assumption that recollection and familiarity are mutually exclusive. Jacoby and colleagues have suggested that process measures from the inclusion–exclusion and remember–know procedures may converge if an independence assumption is applied to the remember–know procedure (Jacoby et al., in press; Yonelinas & Jacoby, 1995; but see Gardiner et al., in press; Richardson-Klavehn et al., 1996). To the extent that this is the case, then picture–word study should have the same effects on the "know" responses computed under independence as on the familiarity estimates in Experiment 1.

Method

Participants

Seventeen Stanford University undergraduates participated in this experiment for a $5 payment. Data from 1 participant were excluded on the basis of postexperiment questionnaire responses.

Design

A two-variable (2 × 2) within-subjects design was used. The variables were study form (picture and word) and test response (remember and know).

Materials

The visual study lists, the auditory study list, and the yes–no recognition test list were identical to those in Experiment 1.

Procedure

The experiment consisted of three phases: a visual study of pictures and words, an auditory study, and a yes–no recognition test. The procedure for the first two phases was identical to that in Experiment 1. Immediately following the auditory study phase, participants were given the 120-word yes–no recognition test and instructed to say "yes" to items that they had encountered in the first and second phases of the experiment. In addition, participants were asked to indicate the basis on which they were making their recognition judgments by making an additional response, "remember" or "know," whenever they responded "yes." *Remember* was defined as recognition of a word based on conscious awareness of some aspect or aspects of what was experienced at the time the item was studied (e.g., aspects of the physical appearance of the item, or something that happened in the room, or what one was thinking when encountering the item). *Know* was defined as recognition that the word had previously been encountered without conscious recollection of any aspects of its prior occurrence. As an example, participants were told that "know" was similar to what they would sense upon recognizing someone in the street without being able to recollect anything about the person. The experimenter began the recognition test only after the participant clearly understood these instructions.

During test, words were presented one at a time in the center of the computer screen and remained on until the participant had made a response ("yes–remember," "yes–know," or "no"). A 500-ms intertrial interval followed each response. Participants were instructed to make their decisions as accurately and quickly as possible. Upon completion of the test, a final questionnaire explicitly assessed participants' understanding of the test instructions. On the basis of questionnaire responses, 1 participant was excluded and replaced.

Results

Picture names provided by participants in the study phase were consistent with those from the Snodgrass and Vanderwart (1980) norms (mean agreement = 85%). Test-phase words corresponding to pictures named that were inconsistent with the norms were dropped prior to data analysis.

Three analyses were performed. First, overall recognition scores were examined collapsed across "remember" and "know." Then, "remember" and "know" responses were analyzed (a) under the standard remember–know exclusivity assumption and (b) under an independence assumption (following Jacoby et al., in press; Yonelinas & Jacoby, 1995).

Overall Recognition

A within-subjects ANOVA performed on the probabilities of responding "yes" to a test item, with a variable of study form (picture vs. word vs. heard vs. new), indicated that these probabilities differed: main effect of study form, $F(3, 45) = 135.00$, $MSE = 0.01$. Picture-studied items were better recognized (.95) than heard items (.72), $F(1, 45) = 32.97$; heard items were better recognized than word-studied items (.53), $F(1, 45) = 22.59$; and word-studied items were discriminated from new items (.17), $F(1, 45) = 79.76$.

Remember–Know Under Exclusivity

A two-variable within-subjects ANOVA on the probabilities of responding "remember" and "know" (see Table 4), with variables of study form (picture vs. word vs. heard vs. new) and response type ("remember" vs. "know"), revealed an interaction between these variables, $F(3, 45) = 42.96$, $MSE = 0.02$. There were more "remember" responses for picture-studied than for word-studied items, $F(1, 45) = 107.16$, but more "know" responses for word- than for picture-studied items, $F(1, 45) = 6.45$. "Know" responses were greater than "remember" responses for new items, $F(1, 45) = 4.16$.

Table 4
Mean Probability of Responding "Remember" and "Know" Across Study Form in Experiment 4

Performance measure	Study form			
	Pictures	Words	Heard	New
Remember	.82	.26	.48	.03
Know	.13	.27	.24	.14

Rajaram (1993, 1996) has suggested that because "remember" and "know" responses are mutually exclusive, rather than statistically independent, treatment of "remember" and "know" as levels of a variable, such as response type, may be inappropriate. Alternatively, computation of the ratio of "remember" responses to overall recognition (remember/recognition) across the levels of the critical variable may more appropriately allow for inferences about the effects of this variable on "remember" and "know." Because familiarity is of central interest here, we computed the ratio of "know" responses to overall recognition (know/recognition) across the levels of study form (picture vs. word). This ratio indicates the proportion of overall recognized items that were given "know" responses for pictures and words. Consistent with the interaction analyses, this ratio was greater for word-studied (.49) than for picture-studied (.15) items, $F(1, 15) = 32.42$, $MSE = 0.03$.

Remember–Know Under Independence

Jacoby and colleagues (e.g., Jacoby et al., in press; Yonelinas & Jacoby, 1995) have suggested that independence best describes the relationship between recollection and familiarity. Further, Knowlton and Squire (1995) have demonstrated that the processes indexed by "remember" and "know" judgments are likely to be redundant or independent, rather than mutually exclusive. Thus, remember–know estimates, under exclusivity, may provide inaccurate process measures (see also Lindsay & Kelley, 1996). Specifically, Jacoby et al. (in press) argued that under exclusivity, "remember" responses yield an unbiased measure of recollection but "know" responses underestimate familiarity. Remember–know test instructions ask participants to respond "remember" when they consciously recollect the study occurrence, $P(\text{"remember"}) = R$, and to respond "know" when an item is familiar but not recollected, $P(\text{"know"}) = F(1 - R)$. Assuming that participants follow these instructions, then they will respond "remember" both when an item is recollected but not familiar, $R(1 - R)$, and when an item is recollected and familiar, RF. Thus, while "remember" judgments may serve as an unbiased estimate of recollection, "know" judgments are biased under an exclusivity assumption because they are provided only when an item is familiar but not recollected, $F(1 - R)$. "Knowing" that is accompanied by "remembering," RF, will be attributed to recollection, resulting in "know" responses underestimating familiarity. Jacoby et al. (in press) suggested a means of converting remember–know estimates under exclusivity to estimates under independence. Recalculation of familiarity under independence consists of computing the proportion of items that were "known" out of the proportion of items that were not "remembered": $F =$ "know"/(1 − "remember"). Jacoby et al.'s recalculation has been termed *independence remember–know* (IRK) and may provide a better estimate of familiarity (Jacoby et al., in press; Yonelinas & Jacoby, 1995; but see Gardiner et al., in press; Richardson-Klavehn et al., 1996).

We calculated familiarity values for each participant with the IRK calculation. Familiarity scores for 5 participants could not be computed in this manner because these participants had "remember" scores of 1.0, which makes the denominator of the IRK familiarity score 0. A within-subjects ANOVA, with a variable of study form (picture vs. word) was performed on the familiarity values for the remaining 11 participants. In contrast to "know" responses under exclusivity, familiarity as estimated using the IRK recalculation was greater for picture-studied (.74) than for word-studied (.33) items, $F(1, 10) = 27.46$, $MSE = 0.03$.

Discussion

Recognition was greater for words studied as pictures than for words studied as words, which replicates the picture superiority effect in recognition. This advantage for picture-studied items was supported by a greater proportion of "remember" responses for these items compared with word-studied items. This replicates the results of previous remember–know studies which demonstrated that "remember" responses increase with conceptual processing (e.g., Dewhurst & Conway, 1994; Gardiner, 1988; Gardiner et al., in press; Gregg & Gardiner, 1994; Perfect et al., 1995; Rajaram, 1993). In addition, this finding converges with inclusion–exclusion indices of recollection-based recognition (e.g., Experiment 1) and word-stem completion (e.g., Experiment 3).

"Know" responses, as computed under exclusivity, also were greater for word-studied than for picture-studied items. This finding converges with the results of previous remember–know studies (Dewhurst & Conway, 1994; Rajaram, 1993) and with inclusion–exclusion measures of familiarity in word-stem completion (Experiment 3). In addition, this pattern parallels findings from perceptual repetition priming studies (Experiment 2; see also Roediger et al., 1992; Winnick & Daniel, 1970). It should be noted, however, that although variables' effects on "know" responses often parallel their effects on perceptual priming, this is not always the case. Java (1994) demonstrated that "know" responses are not positively related to perceptual priming, which suggests that these responses do not index the same familiarity process that is indexed by perceptual priming (for a similar discussion, see Richardson-Klavehn et al., 1996).

The greater sensitivity of "know" responses, under exclusivity, to study–test perceptual similarity than to conceptual processing is inconsistent with findings on familiarity-based recognition indexed using the inclusion–exclusion procedure (Experiment 1). This divergence between remember–know and inclusion–exclusion indices of familiarity raises the possibility that "know" responses do not index the same familiarity process as that indexed by the inclusion–exclusion procedure (Gardiner et al., in press; Richardson-Klavehn et al., 1996). Indeed, Gardiner and colleagues have argued that subjective "remember" and "know" judgments are not process measures and that "know" judgments, like "remember" judgments, reflect conscious rather than unconscious states of awareness.

Recalculation of "know" responses under independence resulted in the convergence of findings on this measure of familiarity-based recognition with findings on familiarity estimates from the inclusion–exclusion procedure. In marked contrast to the "know" responses under exclusivity, familiarity, as computed using the IRK recalculation, was greater for picture-studied than for word-studied items. A similar pattern is found when the IRK method is applied to the remember–know data from Rajaram (1993, Experiment 2) and Dewhurst and Conway (1994, Experiment 1). This convergence suggests that, to the extent that remember–know judgments index underlying recollection and familiarity processes, inconsistencies between remember–know and inclusion–exclusion measures of familiarity-based recognition may be due to differences in the assumed relationship between these processes.

Although the present and previous remember–know studies demonstrate a familiarity advantage for picture-studied test words when recollection and familiarity are assumed to be independent, these findings merit cautious interpretation for two reasons. First, in each of these studies, there is a high hit-rate for picture-studied items that could restrict the range of familiarity computed with the IRK calculation. In this case, this calculation may provide an overestimate of familiarity and thus yield a familiarity advantage for the picture-studied items. Arguing against this account of the present findings, however, are results from other IRK analyses. For example, Yonelinas and Jacoby (1995) applied the IRK approach to the data from several other remember–know studies (e.g., Gardiner, 1988; Rajaram, 1993) and found considerable overlap between the effects of conceptual processing on familiarity as indexed by the IRK and the inclusion–exclusion methods. As with the present study, these analyses reveal that as conceptual processing increases, so too do estimates of familiarity-based recognition (see also, Gardiner et al., in press). It is important that this is the case even when recognition performance is not near ceiling. Nevertheless, a second reason for cautious interpretation of the present convergence between inclusion–exclusion and IRK measures of familiarity is that application of an independence assumption to remember–know data does not always result in convergence between familiarity measures from these two procedures (Gardiner et al., in press; Richardson-Klavehn et al., 1996).

In summary, the present study demonstrates that both recollection and familiarity, when indexed by IRK, are more sensitive to conceptual processing than to perceptual processing. These findings converge with process estimates indexed by the inclusion–exclusion procedure. These results suggest that familiarity-based recognition differs from familiarity in word-stem completion, as indexed using the inclusion–exclusion procedure (Experiment 3), and from familiarity as indexed by perceptual repetition priming (Experiment 2).

General Discussion

The present studies revealed multiple double dissociations between different measures of a putative single familiarity process. There were four main findings. First, word recognition was better following picture naming than following word reading (Experiment 1). This picture superiority effect, thought to be due to the greater conceptual processing associated with picture naming, was mediated by greater recollection-based and familiarity-based recognition, as indexed by the inclusion–exclusion procedure. Second, the picture–word manipulation, which inversely manipulated conceptual and perceptual processing, produced a word superiority effect in implicit word identification. Greater perceptual similarity led to greater perceptual repetition priming (Experiment 2). Third, the picture–word manipulation had opposite effects on recollection-based and familiarity-based word-stem completion (Experiment 3). As indexed by the inclusion–exclusion procedure, recollection increased with conceptual processing, whereas familiarity increased with perceptual similarity. Finally, the picture–word manipulation had similar effects on recollection-based and familiarity-based recognition, as indexed by the independence remember–know procedure (Experiment 4). Both recollection and familiarity increased with conceptual processing, rather than with perceptual similarity.

The present set of studies was designed to determine whether the inclusion–exclusion procedure, the remember–know procedure, and perceptual repetition priming identify the same familiarity process. Collectively, these studies reveal double dissociations between familiarity-based recognition and perceptual repetition priming and between familiarity-based recognition and familiarity-based word-stem completion. These dissociations indicate that there is not a single familiarity process shared by explicit recognition and implicit perceptual memory. Rather, the familiarity process mediating recognition is functionally separable from the familiarity process indexed by perceptual priming tasks.

Familiarity in Implicit Perceptual Memory

Perceptual repetition priming is thought to reflect enhanced fluency in perceptual reprocessing of a stimulus that is due to recent perceptual processing of the stimulus (e.g., Jacoby & Dallas, 1981). This fluency or familiarity, as indexed by word-identification priming, appears to be a perceptual process because manipulations that decrease study–test perceptual similarity decrease priming (e.g., anagram vs. read, Allen & Jacoby, 1990; picture naming vs. word reading, Winnick & Daniel, 1970; see also Table 5). Manipulations of conceptual processing have little or no effect on word-identification priming (e.g., semantic vs. nonsemantic processing, Jacoby & Dallas, 1981; full vs. divided attention, Gabrieli, Stone, et al., 1995). The present studies provide further support for the assertion that word-identification priming reflects a perceptual fluency or *perceptual familiarity* process. When perceptual similarity and conceptual processing are inversely manipulated, word-identification priming increases with perceptual similarity (Experiment 2; see also Winnick & Daniel, 1970).

The familiarity process mediating word-stem completion, typically an implicit task, also appears to be sensitive to perceptual processing. Experiment 3 revealed that familiarity-based stem completion, as indexed by the inclusion–exclusion procedure, was greater after word reading than after picture naming. Previous reports have also demonstrated that familiarity-based stem completion is insensitive to conceptual manipulations (e.g., Jacoby et al., 1993; Toth et al., 1994). Thus, as with perceptual familiarity in word-identification priming, familiarity-based stem completion is sensitive to perceptual similarity and insensitive to conceptual processing.

The present and previous studies further suggest that familiarity-based stem completion, as indexed by the inclusion–exclusion procedure, depends almost entirely on the

Table 5
Comparisons Across Multiple Measures of Familiarity

Study manipulation	Perceptual priming: Word identification	Conceptual priming: Category-exemplar generation	Inclusion–exclusion		Remember–know[a]	
			Recollection	Familiarity	Remember	Know
Semantic vs. nonsemantic	=	↑	↑	↑	↑	=/↓
Word generation vs. word reading	↓	↑	↑	↑	↑	=
Picture naming vs. word reading	↓	↑	↑	↑	↑	=/↓
Full vs. divided attention	=	↑	↑	=	↑	=
Patient with right occipital lobe lesion vs. controls	↓	=	=	=	=	=
Amnesics vs. controls	=	=	↓	=	↓	↓

Note. (↑) indicates that the measure of familiarity is greater for the first factor level; (↓) indicates that the measure of familiarity is greater for the second factor level; (=) indicates that the manipulation does not affect the measure of familiarity. All references are cited in the text.
[a]Data are from the exclusivity remember–know procedure.

perceptual match between study and test form. In Experiment 3, the study of items in picture form did not enhance familiarity beyond baseline levels. Similarly, Jacoby et al. (1993, in press) found that auditory study produced little to no increment in familiarity-based visual stem completion and in familiarity-based visual fragment completion beyond baseline levels. These results contrast with those of studies that demonstrated reduced but reliable cross-form and cross-modality perceptual priming. For example, Experiment 2 revealed word-identification priming for picture-studied items. Similarly, cross-form word-fragment completion priming (e.g., Weldon & Jackson-Barrett, 1993; Weldon & Roediger, 1987) and cross-modality word-identification and word-stem completion priming (e.g., Blaxton, 1989; Keane, Gabrieli, Fennema, Growdon, & Corkin, 1991; Kelley, Jacoby, & Hollingshead, 1989) have repeatedly been demonstrated.

The basis for such cross-modality and cross-form priming on perceptual tasks and for the apparent absence of these effects on familiarity-based stem completion and fragment completion (as indexed by inclusion–exclusion) is unclear. One possibility is that such priming reflects recollective processes contributing to implicit task performance (e.g., Jacoby et al., 1993). To the extent that recollection is the basis of cross-modality and cross-form priming, then such priming should be enhanced by manipulations that enhance recollection, such as depth of processing, and diminished by conditions that diminish recollection, such as division of attention during encoding and amnesia. Although division of attention appears to eliminate picture-to-word priming on implicit word-fragment completion tests (Weldon & Jackson-Barrett, 1993), studies manipulating both depth of processing and modality have demonstrated that greater conceptual processing does not increase cross-modality word-stem completion priming (e.g., Craik, Moscovitch, & McDowd, 1994). Further, amnesic patients demonstrate normal cross-modality priming (e.g., Graf, Shimamura, & Squire, 1985; Vaidya, Gabrieli, Keane, & Monti, 1995), which suggests that cross-modality priming is not dependent on recollection. Richardson-Klavehn and Gardiner (1996) have suggested that cross-modality priming may appear to reflect contamination by recollection when examined with the inclusion–exclusion procedure because items produced automatically (due to fluent reprocessing) may nevertheless be subsequently recognized. Because the inclusion–exclusion procedure does not distinguish between retrieval volition and memory awareness, this subsequent recollection leads to the conclusion that cross-modality priming is due to contamination by recollection.

Alternatively, cross-modality and cross-form priming effects may reflect more efficient access to lexical (word-unit) representations (e.g., Weldon, 1991, 1993). This lexical activation account suggests that many initial processing tasks result in access to a modality- and form-independent lexical representation for a stimulus. When processing at test requires access to this lexical representation, then performance will be enhanced by prior stimulus processing. The lexical activation hypothesis can account both for cross-modality and cross-form priming and for the intact status of these priming effects in amnesics. Such an account suggests that cross-modality and cross-form priming are mediated by fluent reprocessing. Additional study should serve to further clarify the basis of these priming effects and their dependence on recollection and familiarity processes.

Familiarity in Explicit Recognition Memory

Recollection, according to dual-process theorists (e.g., Jacoby & Dallas, 1981; Mandler, 1980), is a conscious, attention-demanding process that is sensitive to conceptual processing (e.g., Jacoby, 1991). Previous studies that used the inclusion–exclusion and remember–know procedures have demonstrated that recollection increases with conceptual elaboration (e.g., Gardiner, 1988; Gardiner et al., in press; Gregg & Gardiner, 1994; Jacoby, 1991; Jennings & Jacoby, 1993; Rajaram, 1993; Toth, 1996; Verfaellie & Treadwell, 1993; Wagner, Verfaellie, et al., 1995). The present studies provide further support for this characterization of recollection, with recollection being greater after picture naming than after word reading (Experiments 1 and 4).

Familiarity-based recognition, in contrast, has sometimes been thought to be perceptual rather than conceptual and possibly the same process as the perceptual familiarity mediating perceptual repetition priming (e.g., Jacoby & Dallas, 1981). The present studies do not support these assertions. Picture naming increased familiarity-based recognition as indexed by the inclusion–exclusion procedure (Experiment 1) and the independence remember–know procedure (Experiment 4), whereas word reading led to greater word-identification priming (Experiment 2) and greater familiarity-based word-stem completion (Experiment 3). Thus, as noted by Jacoby and colleagues (Jacoby, 1991; Jacoby et al., 1993; Jennings & Jacoby, 1993; Toth, 1996), familiarity-based recognition is sensitive to conceptual processing. Further, the present results suggest that familiarity-based recognition may be more reliant on conceptual than on perceptual processes. These dissociations between *recognition familiarity* and perceptual familiarity indicate that the familiarity mediating explicit recognition is functionally separable from the familiarity mediating implicit perceptual memory.

Although the present studies demonstrate that recognition familiarity is more sensitive to conceptual than to perceptual processing, a finding consistent with previous reports (Jacoby, 1991; Toth, 1996; Verfaellie & Treadwell, 1993; Wagner, Verfaellie, et al., 1995; but see Jennings & Jacoby, 1993), these findings do not rule out any sensitivity of recognition familiarity to study–test perceptual similarity. In these experiments, the picture–word manipulation had opposite effects on conceptual processing and study–test perceptual similarity. Thus, direct measurement of the effects of perceptual similarity on recognition familiarity was not possible. Studies that manipulate perceptual similarity between study and test stimuli, and hold conceptual processing constant, are needed to directly assess the sensitivity of familiarity-based recognition to perceptual similarity. In this vein, studies that vary the match between study and test modalities often reveal little to no effect on word recognition, which suggests that familiarity-based recognition is minimally affected by perceptual familiarity (e.g., Rajaram, 1993).

Other investigations into the possible role of perceptual familiarity in recognition have manipulated perceptual fluency at test (e.g., Jacoby & Whitehouse, 1989; Johnston, Dark, & Jacoby, 1985; Johnston, Hawley, & Elliott, 1991; Whittlesea, Jacoby, & Girard, 1990). For example, fluency of test word processing has been varied by changing the amount of visual noise used to mask recognition test words (Whittlesea, 1993; Whittlesea et al., 1990) or by providing a brief masked presentation of the test word just prior to its occurrence (Jacoby & Whitehouse, 1989). These manipulations lead to increases in both hits and false alarms, which suggests that fluency of perceptual processing can be used as an attributional source for recognition judgments. However, Whittlesea (1993) showed that manipulations of test word perception also can influence fluency of conceptual processing. Such findings suggest that manipulations of test word perception may conflate perceptual and conceptual fluency. It is, however, unclear how the present studies of recognition familiarity, which used manipulations across study and test, can be integrated with these studies that manipulated perception of recognition test words. One possibility is that such manipulations of test word processing affect a process or processes different from those investigated in the present studies. Alternatively, these manipulations may provide support for the assertion that recognition familiarity is additionally sensitive to perceptual processing, and future studies that manipulate study–test perceptual similarity while holding conceptual processing constant could reveal this sensitivity.

The present studies, nevertheless, indicate that recognition familiarity is distinct from perceptual familiarity. This raises the following question: What is the relationship (if any) between the familiarity in explicit tasks and that in implicit tasks? One possibility may be that recognition familiarity relies on the same process or processes that mediate conceptual repetition priming. As with recognition familiarity, conceptual repetition priming tasks are sensitive to conceptual processing and insensitive to study–test perceptual similarity (see Table 5). For example, in a category-exemplar generation task, participants are provided a category label (e.g., FRUIT) and are asked to generate the first few exemplars that come to mind (e.g., ORANGE, APPLE, GRAPE). Exemplars that were recently studied are more likely to be generated than exemplars that were unstudied. This priming may be thought to reflect more fluent conceptual reprocessing of a stimulus because of the recent conceptual processing of the stimulus. Evidence for the conceptual nature of this priming comes from studies demonstrating that priming in category-exemplar generation is enhanced by study manipulations that increase conceptual elaboration or processing, such as semantic versus nonsemantic study (e.g., Hamann, 1990), word generation versus word reading (e.g., Srinivas & Roediger, 1990), picture naming versus word reading (Vaidya & Gabrieli, 1997; but see Weldon & Coyote, 1996), and full versus divided attention (Gabrieli, Stone, et al., 1995; Mulligan & Hartman, 1996). These studies indicate that the *conceptual familiarity* thought to mediate conceptual priming is distinct from the perceptual familiarity mediating perceptual priming. Further, they demonstrate that recognition familiarity and conceptual familiarity are similarly affected by a number of conceptual manipulations (although this does not hold for manipulations of attention). Additional research examining the relationship between conceptual priming and familiarity in recognition should serve to clarify whether there is a shared conceptual familiarity process mediating explicit and implicit task performance.

Neuropsychological Evidence for Distinct Familiarity Processes

The present dissociations between recognition familiarity and perceptual familiarity indicate that these two processes are functionally distinct. These processes also appear to be anatomically separable. A patient (M. S.) who, because of a right occipital lobe lesion, failed to show normal word-identification priming and visual word-stem completion priming (Fleischman et al., 1995; Fleischman, Vaidya, Lange, & Gabrieli, in press; Gabrieli, Fleischman, Keane, Reminger, & Morrell, 1995) nevertheless had normal recognition memory performance. This pattern of impaired implicit visual memory and intact explicit recognition memory further challenges the assertion that a single perceptual familiarity process mediates both visual priming and recognition. To more directly examine this issue, Wagner, Stebbins, Burton, Fleischman, and Gabrieli (1995) measured the contributions of familiarity and recollection to M. S.'s intact recognition using both the remember–know and inclusion–exclusion procedures. By both measures, M. S. showed intact recollection-based and familiarity-based recognition. Further, M. S.'s recognition familiarity was more sensitive to conceptual than to perceptual processing. Thus, both functional and anatomic dissociations indicate that implicit perceptual priming and explicit recognition memory are not mediated by the same perceptual familiarity process.

Although the present findings indicate that perceptual familiarity and recognition familiarity are distinct processes, it still is unclear whether a shared conceptual familiarity process underlies both implicit and explicit memory. Evidence from amnesic patients, who demonstrate impaired explicit recognition but intact implicit perceptual and conceptual priming, can directly address this question. To the extent that the familiarity process that mediates the intact conceptual priming in amnesia also contributes to recognition memory, then amnesics should demonstrate normal familiarity-based recognition. Consistent with this possibility, recollection-based recognition was impaired in amnesia, but familiarity-based recognition was found to be intact, as indexed by the inclusion–exclusion procedure (Verfaellie & Treadwell, 1993). In contrast, remember–know indices of recollection and familiarity indicate that both recollection and familiarity in recognition may be impaired in amnesia (Knowlton & Squire, 1995). Further research examining the status of familiarity-based and recollection-based recognition in amnesia should serve to clarify whether the same familiarity process mediates explicit recognition and conceptual priming.

Recollection, Familiarity, and Source Monitoring

Throughout this article, recollection and familiarity have been considered from the framework of dual-process models of recognition memory. Recollection and familiarity have been assumed to be functionally independent and discrete processes that mediate memory performance. Within this framework, recollection reflects the controlled retrieval of episodic information, whereas familiarity reflects automatic undifferentiated feelings of memory. The present results, considered within this framework, suggest that both of these bases of recognition are reliant on conceptual processes and, further, that the familiarity process contributing to recognition is functionally distinct from perceptual repetition priming.

Recently, however, some have argued that recollection and familiarity process measures, when indexed by inclusion–exclusion, likely reflect a distinction between memory for information that allows list discrimination in a particular task (i.e., memory for information that specifies whether the item should be included or excluded) and memory of all other aspects of the episode that do not allow for such discrimination (e.g., Dodson & Johnson, 1996; Gruppuso, Lindsay, & Kelley, 1997; Mulligan & Hirshman, 1997; Yonelinas & Jacoby, 1996). This perspective is related to the source monitoring framework of Johnson and colleagues (e.g., Johnson, Hashtroudi, & Lindsay, 1993), because recollection estimates are thought to index retrieval of source discriminating information, termed *criterial recollection* (Yonelinas & Jacoby, 1996) or *diagnostic recollection* (Mulligan & Hirshman, 1997). Within the context of the present memory studies, such diagnostic or criterial recollection may include recollection of the study modality (visual vs. auditory), of the study form (picture vs. word), of the study task (naming pictures vs. reading words vs. trying to remember words), or of the study list (List 1 vs. List 2). From this source perspective, the familiarity measure provided by the inclusion–exclusion procedure is thought to provide more than just a measure of undifferentiated feelings of prior exposure that are due to automatic perceptual or conceptual reprocessing of stimuli. Rather, familiarity is also thought to index retrieval of nonsource identifying information. As an illustration of such nondiagnostic information, Mulligan and Hirshman (1997) provided the example of recollecting that an item was related to an object in the experimental room. Such retrieval would not be sufficient to determine whether the item should be included or excluded.

The present studies, when considered within this framework, suggest that memory for diagnostic or criterial source discriminating information increases with conceptual processing. Recollection was greater for picture-studied than for word-studied items. Consistent with this pattern are results from Mulligan and Hirshman (1997) demonstrating that diagnostic recollection increases with conceptual processing. In the present inclusion–exclusion recognition study (Experiment 1), familiarity also was found to increase with conceptual processing rather than with study–test perceptual similarity. One possible interpretation of this increase is that this index of familiarity reflects increases in retrieval of information that is not source discriminating. Although further studies are necessary to adequately address this possibility, three aspects of the present studies argue against this account. First, the present findings demonstrate that both recollection-based and familiarity-based recognition increase with conceptual processing (Experiment 1). Mulligan and Hirshman have argued that variables that increase diagnosticity (recollection) should yield decreases or minimal effects on estimates of nondiagnostic recollection (familiarity). Given the present increase in familiarity-based recognition with the increase in recollection-based recognition, this suggests that the present familiarity estimates may not reflect retrieval of nondiagnostic information. Second, the contributions of nondiagnostic retrieval to familiarity estimates are likely to be considerable when the two study conditions are similar in materials and orienting task (e.g., Gruppuso et al., 1997; Mulligan & Hirshman, 1997). As noted above, the present design provided multiple means of discriminating between the first and second study lists (modality, form, orienting task, and study list). Finally, the present results demonstrate that familiarity estimates vary across task context even when the information that is diagnostic of source is held constant across tasks. In the context of word recognition, familiarity increased with conceptual processing. In the context of word-stem completion, familiarity increased with study–test perceptual similarity. Thus, although nondiagnostic recollection may have contributed to estimates of familiarity-based memory performance, the present studies demonstrate that familiarity-based recognition and familiarity-based perceptual memory are differentially sensitive to conceptual and perceptual processing.

Conclusions

In summary, the present findings reveal that the inclusion–exclusion procedure and the remember–know procedure (under independence) do not index the same familiarity process as that indexed by perceptual repetition priming. Recognition familiarity is more sensitive to conceptual processing than to perceptual processing, whereas perceptual familiarity is insensitive to conceptual processing and sensitive to perceptual processing. These dissociations indicate that the same familiarity process does not mediate explicit recognition and implicit perceptual memory. Future research may reveal whether recognition familiarity is sensitive to study–test perceptual similarity and whether a conceptual familiarity process mediates both explicit and implicit memory performance.

References

Allen, S. W., & Jacoby, L. L. (1990). Reinstating study context produces unconscious influences of memory. *Memory & Cognition, 18*, 270–278.

Atkinson, R. C., & Juola, J. F. (1974). Search and decision processes in recognition memory. In D. H. Krantz, R. C. Atkinson, R. D. Luce, & P. Suppes (Eds.), *Contemporary developments in mathematical psychology: Vol. 1. Learning, memory, and thinking* (pp. 243–293). San Francisco: Freeman.

Blaxton, T. A. (1989). Investigating dissociations among memory measures: Support for a transfer appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 657–668.

Brown, A. S., & Mitchell, D. B. (1994). A reevaluation of semantic versus nonsemantic processing in implicit memory. *Memory & Cognition, 22,* 533–541.

Challis, B. H., & Brodbeck, D. R. (1992). Level of processing affects priming in word fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 595–607.

Craik, F. I. M., Moscovitch, M., & McDowd, J. M. (1994). Contributions of surface and conceptual information to performance on implicit and explicit memory tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 864–875.

Curran, T., & Hintzman, D. L. (1995). Violations of the independence assumption in process dissociation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 531–547.

Curran, T., & Hintzman, D. L. (1997). Consequences and causes of correlation in process dissociation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 496–504.

Debner, J. A., & Jacoby, L. L. (1994). Unconscious perception: Attention, awareness, and control. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 304–317.

Dewhurst, S. A., & Conway, M. A. (1994). Pictures, images, and recollective experience. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 1088–1098.

Dodson, C. S., & Johnson, M. K. (1996). Some problems with the process dissociation approach to memory. *Journal of Experimental Psychology: General, 125,* 181–194.

Dunn, J. C., & Kirsner, K. (1988). Discovering functionally independent mental processes: The principle of reversed association. *Psychological Review, 95,* 91–101.

Durso, F. T., & Johnson, M. K. (1980). The effects of orienting tasks on recognition, recall, and modality confusion of pictures and words. *Journal of Verbal Learning and Verbal Behavior, 19,* 416–429.

Fleischman, D. A., Gabrieli, J. D. E., Reminger, S., Rinaldi, J., Morrell, F., & Wilson, R. (1995). Conceptual priming in perceptual identification for patients with Alzheimer's disease and a patient with right occipital lobectomy. *Neuropsyhology, 9,* 187–197.

Fleischman, D. A., Vaidya, C. L., Lange, K. L., & Gabrieli, J. D. E. (in press). A dissociation between perceptual explicit and implicit memory processes. *Brain and Cognition.*

Gabrieli, J. D. E., Fleischman, D. A., Keane, M. M., Reminger, S. L., & Morrell, F. (1995). Double dissociation between memory systems underlying explicit and implicit memory in the human brain. *Psychological Science, 6,* 76–82.

Gabrieli, J. D. E., Stone, M. V., Shackleton, K., Galan, J. B., Thompson-Schill, S. L., Seeley, W., & Chari, A. (1995). *Attention and implicit memory for words.* Unpublished manuscript.

Gardiner, J. M. (1988). Functional aspects of recollective experience. *Memory & Cognition, 16,* 309–313.

Gardiner, J. M., & Java, R. I. (1990). Recollective experience in word and nonword recognition. *Memory & Cognition, 18,* 23–30.

Gardiner, J. M., & Java, R. I. (1991). Forgetting in recognition memory with and without recollective experience. *Memory & Cognition, 19,* 617–623.

Gardiner, J. M., & Java, R. I. (1993). Recognizing and remembering. In A. F. Collins, S. E. Gathercole, M. A. Conway, & P. E. Morris (Eds.), *Theories of memory* (pp. 163–188). Hillsdale, NJ: Erlbaum.

Gardiner, J. M., Java, R. I., & Richardson-Klavehn, A. (in press). How level of processing really influences awareness in recognition memory. *Canadian Journal of Experimental Psychology.*

Gardiner, J. M., & Parkin, A. J. (1990). Attention and recollective experience in recognition memory. *Memory & Cognition, 18,* 579–583.

Graf, P., & Komatsu, S. (1994). Process dissociation procedure: Handle with caution! *European Journal of Cognitive Psychology, 6,* 113–129.

Graf, P., & Mandler, G. (1984). Activation makes words more accessible, but not necessarily more retrievable. *Journal of Verbal Learning and Verbal Behavior, 23,* 553–568.

Graf, P., Mandler, G., & Haden, P. E. (1982). Simulating amnesic symptoms in normal subjects. *Science, 218,* 1243–1244.

Graf, P., Shimamura, A., & Squire, L. (1985). Priming across modalities and priming across category levels: Extending the domain of preserved function in amnesia. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 386–396.

Gregg, V. H., & Gardiner, J. M. (1994). Recognition memory and awareness: A large effect of study–test modalities on "know" responses following a highly perceptual orienting task. *European Journal of Cognitive Psychology, 6,* 137–147.

Gruppuso, V., Lindsay, D. S., & Kelley, C. M. (1997). The process dissociation procedure and similarity: Defining and estimating recollection and familiarity in recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 259–278.

Hamann, S. B. (1990). Level-of-processing effects in conceptually driven implicit tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 16,* 970–977.

Jacoby, L. L. (1983). Remember the data: Analyzing interactive processes in reading. *Journal of Verbal Learning and Verbal Behavior, 22,* 485–508.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language, 30,* 513–541.

Jacoby, L. L., Begg, I. M., & Toth, J. P. (1997). In defense of independence: Violations of assumptions underlying the process-dissociation procedure? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 484–495.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: General, 3,* 306–340.

Jacoby, L. L., & Hayman, C. A. G. (1987). Specific visual transfer in word identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 456–463.

Jacoby, L. L., & Kelley, C. M. (1991). Unconscious influences of memory: Dissociations and automaticity. In D. Milner & M. Rugg (Eds.), *The neuropsychology of consciousness* (pp. 201–233). London: Academic Press.

Jacoby, L. L., Toth, J. P., & Yonelinas, A. P. (1993). Separating conscious and unconscious influences of memory: Measuring recollection. *Journal of Experimental Psychology: General, 122,* 1–16.

Jacoby, L. L., Toth, J. P., Yonelinas, A. P., & Debner, J. A. (1994). The relationship between conscious and unconscious influences: Independence or redundancy? *Journal of Experimental Psychology: General, 123,* 216–219.

Jacoby, L. L., & Whitehouse, K. (1989). An illusion of memory:

False recognition influenced by unconscious perception. *Journal of Experimental Psychology: General, 118,* 126–135.

Jacoby, L. L., Yonelinas, A. P., & Jennings, J. M. (in press). The relationship between conscious and unconscious (automatic) influences: A declaration of independence. In J. Cohen & J. W. Schooler (Eds.), *Scientific approaches to the question of consciousness.* Hillsdale, NJ: Erlbaum.

Java, R. I. (1994). States of awareness following word stem completion. *European Journal of Cognitive Psychology, 6,* 77–92.

Jennings, J. M., & Jacoby, L. L. (1993). Automatic versus intentional uses of memory: Aging, attention, and control. *Psychology and Aging, 8,* 283–293.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114,* 3–28.

Johnston, W. A., Dark, V. J., & Jacoby, L. (1985). Perceptual fluency and recognition judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 11,* 3–11.

Johnston, W. A., Hawley, K. J., & Elliott, J. M. (1991). Contribution of perceptual fluency to recognition judgments. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 210–223.

Joordens, S., & Merikle, P. M. (1993). Independence or redundancy? Two models of conscious and unconscious influences. *Journal of Experimental Psychology: General, 122,* 462–467.

Keane, M. M., Gabrieli, J. D. E., Fennema, A. C., Growdon, J. H., & Corkin, S. (1991). Evidence for a dissociation between perceptual and conceptual priming in Alzheimer's disease. *Behavioral Neuroscience, 105,* 326–342.

Kelley, C. M., Jacoby, L. L., & Hollingshead, A. (1989). Direct versus indirect tests of memory for source: Judgments of modality. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 15,* 1101–1108.

Kirsner, K., Milech, D., & Stumpfel, V. (1986). Word and picture identification: Is representational parsimony possible? *Memory & Cognition, 14,* 398–408.

Knowlton, B. J., & Squire, L. R. (1995). Remembering and knowing: Two different expressions of declarative memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 699–710.

Komatsu, S., Graf, P., & Uttl, B. (1995). Process dissociation procedure: Core assumptions fail, sometimes. *European Journal of Cognitive Psychology, 7,* 19–40.

Kučera, H., & Francis, W. N. (1967). *Computational analysis of present-day American English.* Providence, RI: Brown University Press.

Lindsay, D. S., & Kelley, C. M. (1996). Creating illusions of familiarity in a cued recall remember/know paradigm. *Journal of Memory and Language, 35,* 197–211.

Madigan, S. (1983). Picture memory. In J. C. Yuille (Ed.), *Imagery, memory, and cognition: Essays in honour of Allan Paivio* (pp. 65–89). Hillsdale, NJ: Erlbaum.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review, 87,* 252–271.

Mandler, G. (1989). Memory: Conscious and unconscious. In P. R. Solomon, G. R. Goethals, C. M. Kelley, & B. R. Stephens (Eds.), *Memory: Interdisciplinary approaches* (pp. 84–106). New York: Springer-Verlag.

Mulligan, N. W., & Hartman, M. (1996). Divided attention and indirect memory tests. *Memory and Cognition, 24,* 453–465.

Mulligan, N. W., & Hirshman, E. (1997). Measuring the bases of recognition memory: An investigation of the process dissociation framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23,* 280–304.

Nelson, D. L. (1979). Remembering pictures and words: Appearance, significance, and name. In L. S. Cermak & F. I. M. Craik (Eds.), *Levels of processing in human memory* (pp. 45–76). Hillsdale, NJ: Erlbaum.

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

Paivio, A. (1986). *Mental representation: A dual coding approach.* Hillsdale, NJ: Erlbaum.

Park, S. M., & Gabrieli, J. D. E. (1995). Perceptual and conceptual components of implicit memory for pictures. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 1583–1594.

Perfect, T. J., Williams, R. B., & Anderton-Brown, C. (1995). Age differences in reported recollective experience are due to encoding effects, not response bias. *Memory, 3,* 169–186.

Rajaram, S. (1993). Remembering and knowing: Two means of access to the personal past. *Memory & Cognition, 21,* 89–102.

Rajaram, S. (1996). Perceptual effects on remembering: Recollective processes in picture recognition memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 365–377.

Rajaram, S., & Roediger, H. L. (in press). Remembering and knowing as states of consciousness during recollection. In J. D. Cohen & J. W. Schooler (Eds.), *Scientific approaches to the question of consciousness.* Hillsdale, NJ: Erlbaum.

Richardson-Klavehn, A., & Bjork, R. A. (1988). Measures of memory. *Annual Review of Psychology, 39,* 475–543.

Richardson-Klavehn, A., & Gardiner, J. M. (1996). Cross-modality priming in stem completion reflects conscious memory, but not voluntary memory. *Psychonomic Bulletin and Review, 3,* 238–244.

Richardson-Klavehn, A., Gardiner, J. M., & Java, R. I. (1996). Memory: Task dissociations, process dissociations, and dissociations of consciousness. In G. Underwood (Ed.), *Implicit cognition* (pp. 85–158). Oxford, England: Oxford University Press.

Roediger, H. L., & McDermott, K. B. (1993). Implicit memory in normal human subjects. In F. Boller & J. Grafman (Eds.), *Handbook of neuropsychology* (Vol. 8, pp. 63–131). Amsterdam: Elsevier.

Roediger, H. L., & McDermott, K. B. (1994). The problem of differing false-alarm rates for the process dissociation procedure: Comment on Verfaellie and Treadwell (1993). *Neuropsychology, 8,* 284–288.

Roediger, H. L., Weldon, M. S., Stadler, M. L., & Riegler, G. L. (1992). Direct comparison of two implicit memory tests: Word fragment and word stem completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18,* 1251–1269.

Schacter, D. L. (1987). Implicit memory: History and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13,* 501–518.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 174–215.

Srinivas, K., & Roediger, H. L. (1990). Classifying implicit memory tests: Category association and anagram solution. *Journal of Memory and Language, 29,* 389–412.

Tenpenny, P. L. (1995). Abstractionist versus episodic theories of repetition priming and word identification. *Psychonomic Bulletin and Review, 2,* 339–363.

Toth, J. P. (1996). Conceptual automaticity in recognition memory: Levels-of-processing effects on familiarity. *Canadian Journal of Experimental Psychology, 50,* 123–138.

Toth, J. P., Reingold, E. M., & Jacoby, L. L. (1994). Toward a redefinition of implicit memory: Process dissociations following elaborative processing and self-generation. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20,* 290–303.

Toth, J. P., Reingold, E. M., & Jacoby, L. L. (1995). A response to Graf and Komatsu's (1994) critique of the process-dissociation procedure: When is caution necessary? *European Journal of Cognitive Psychology, 7,* 113–130.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychologist, 26,* 1–12.

Vaidya, C. J., & Gabrieli, J. D. E. (1997). Functional dissociations between implicit and explicit conceptual memory. *Abstracts of the Psychonomic Society, 1,* 5.

Vaidya, C. J., Gabrieli, J. D. E., Keane, M. M., & Monti, L. A. (1995). Perceptual and conceptual memory processes in global amnesia. *Neuropsychology, 9,* 580–591.

Verfaellie, M., & Treadwell, J. R. (1993). Status of recognition memory in amnesia. *Neuropsychology, 7,* 5–13.

Wagner, A. D., Stebbins, G. T., Burton, K. W., Fleischman, D. A., & Gabrieli, J. D. E. (1995). *Anatomic and functional dissociations between recognition fluency and perceptual fluency.* Poster presented at the annual conference of the Cognitive Neuroscience Society, San Francisco, CA.

Wagner, A. D., Verfaellie, M., & Gabrieli, J. D. E. (1995). *Multiple fluency processes? Dissociations between fluency underlying recognition memory and perceptual identification.* Poster presented at the annual conference of the Psychonomic Society, Los Angeles, CA.

Weldon, M. S. (1991). Mechanisms underlying priming on perceptual tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 17,* 526–541.

Weldon, M. S. (1993). The time course of perceptual and conceptual contributions to word fragment completion. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 1010–1023.

Weldon, M. S., & Coyote, K. C. (1996). The failure to find the picture superiority effect in implicit conceptual memory tests. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 22,* 670–686.

Weldon, M. S., & Jackson-Barrett, J. L. (1993). Why do pictures produce priming on the word-fragment completion test? A study of encoding and retrieval factors. *Memory & Cognition, 21,* 519–528.

Weldon, M. S., & Roediger, H. L. (1987). Altering retrieval demands reverses the picture superiority effect. *Memory & Cognition, 15,* 269–280.

Weldon, M. S., Roediger, H. L., & Challis, B. H. (1989). The properties of retrieval cues constrain the picture superiority effect. *Memory & Cognition, 17,* 95–105.

Whittlesea, B. W. A. (1993). Illusions of familiarity. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 19,* 1235–1253.

Whittlesea, B. W. A., Jacoby, L. L., & Girard, K. (1990). Illusions of immediate memory: Evidence of an attributional basis for feelings of familiarity and perceptual quality. *Journal of Memory and Language, 29,* 716–732.

Winnick, W. A., & Daniel, S. A. (1970). Two kinds of response priming in tachistoscopic word recognition. *Journal of Experimental Psychology, 84,* 74–81.

Yonelinas, A. P., & Jacoby, L. L. (1995). The relation between remembering and knowing as bases for recognition: Effects of size congruency. *Journal of Memory and Language, 34,* 622–643.

Yonelinas, A. P., & Jacoby, L. L. (1996). Noncritical recollection: Familiarity as automatic, irrelevant recollection. *Consciousness & Cognition, 5,* 131–141.

Yonelinas, A. P., Regehr, G., & Jacoby, L. L. (1995). Incorporating response bias in a dual-process theory of memory. *Journal of Memory and Language, 34,* 821–835.

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