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Acta Psychologica 98 (1998) 211–230

acta psychologica

On the relationship between recognition familiarity and perceptual fluency: Evidence for distinct mnemonic processes

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Abstract

Fluent reprocessing of perceptual aspects of recently experienced stimuli is thought to support repetition priming effects on implicit perceptual memory tests. Although behavioral and neuropsychological dissociations demonstrate that separable mnemonic processes and neural substrates mediate implicit and explicit test performance, dual-process theories of memory posit that explicit recognition memory judgments may be based on familiarity derived from the same perceptual fluency that yields perceptual priming. Here we consider the relationship between familiarity-based recognition memory and implicit perceptual memory. A select review of the literature demonstrates that the fluency supporting implicit perceptual memory is functionally and anatomically distinct from that supporting recognition memory. In contrast to perceptual fluency, recognition familiarity is more sensitive to conceptual than to perceptual processing, and does not depend on modality-specific sensory cortices. Alternative possible relationships between familiarity in explicit memory and fluency in implicit memory are discussed. © 1998 Elsevier Science B.V. All rights reserved.

PsycINFO classification: 2343

Keywords: Explicit memory; Declarative memory; Implicit memory; Nondeclarative memory; Recognition memory; Priming; Process dissociation; Dual-process theories

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PII S0001-6918(97)00043-7

1. Introduction

Experience is recorded as multiple mnemonic representations, with remembrance of the past corresponding to retrieval of these representations. Memory can be probed using a variety of retrieval cues, generally classified as explicit (or direct) and implicit (or indirect), with different cues eliciting the recovery of different kinds of representations. Explicit tests refer directly to an episode and require conscious recollection of an aspect of the episode. Recognition, for example, requires a judgment of whether a test stimulus was encountered in a particular spatiotemporal learning context. Implicit tests, in contrast, make no reference to any particular episode. Rather, memory is measured indirectly as a change in test-phase performance that is attributable to a particular study-phase experience. One kind of implicit measure is repetition priming, a facilitation or bias in task performance due to prior processing of a stimulus. Priming is thought to reflect an enhancement in the fluency with which a test-stimulus is processed. Priming can be perceptual when it reflects fluent reprocessing arising from prior processing of stimulus form, or conceptual when it reflects fluent reprocessing arising from prior processing of stimulus meaning.

Behavioral studies of healthy adults have demonstrated functional dissociations between performance on explicit and implicit tests and on perceptual and conceptual implicit tests (for reviews see, Richardson-Klavehn and Bjork, 1988; Roediger and McDermott, 1993). For example, recognition accuracy is enhanced by conceptual encoding and is often unaffected by changes in perceptual form, whereas perceptual priming is greatest when study and test perceptual forms match and is unaffected by manipulations of conceptual encoding (e.g., Jacoby, 1983; Jacoby and Dallas, 1981; Winnick and Daniel, 1970). Similarly, conceptual and perceptual implicit memory are dissociable using manipulations that vary the extent of conceptual encoding or the match between study and test perceptual form (e.g., Blaxton, 1989; Srinivas and Roediger, 1990). These dissociations suggest that these implicit and explicit measures index functionally distinct processes and representations.

Neuropsychological and neuroimaging studies have demonstrated anatomic dissociations between performance on explicit, implicit perceptual, and implicit conceptual tests. For example, damage to medial temporal and diencephalic structures impairs performance on explicit, but not implicit, memory tests (for reviews see, Schacter et al., 1993; Squire, 1992; Squire et al., 1993). In contrast, lesions of modality-specific sensory cortices selectively impair implicit perceptual memory (Fleischman et al., 1995; Fleischman et al., in press; Gabrieli et al., 1995; Keane et al., 1995; Vaidya et al., in press), whereas damage to temporal, parietal, and frontal cortices impairs implicit conceptual memory (e.g., Gabrieli et al., 1994; Keane et al., 1991; Salmon et al., 1988). Neuroimaging studies provide convergent evidence revealing: (a) activation in medial temporal structures during recognition and cued recall (e.g., Buckner et al., 1995; Gabrieli et al., 1997; Schacter et al., 1996; Squire et al., 1992), but not during perceptual priming (Schacter et al., 1996); (b) decreased activation in extrastriate cortex associated with visual priming (e.g., Buckner et al., 1995; Squire et al., 1992); and (c) decreased activation in left inferior frontal cortex associated with conceptual priming (e.g., Demb et al., 1995; Raichle et al., 1994; Wagner et al., in press). Thus, anatomic and functional dissociations suggest that distinct processes and neural substrates mediate explicit, implicit perceptual, and implicit conceptual memory (e.g., Cohen and Squire, 1980; Gabrieli et al., 1994; Schacter, 1992; Squire, 1992).

Although it is widely held that explicit and implicit tests index unique mnemonic processes, it is less clear whether performance on these measures may also rely on shared processes. One class of memory models – dual-process models of recognition memory – posit that a common process supports both recognition judgments and perceptual priming. From the dual-process perspective, recognition judgments can be based on two distinct processes, recollection and familiarity. Recollection is thought to consist of the conscious remembrance of some aspect of a prior experience. Familiarity, in contrast, is thought to be a subjective sensation that occurs when fluent processing of a stimulus is unconsciously attributed to past experience (e.g., Atkinson and Juola, 1974; Gardiner, 1988; Jacoby, 1983, 1991; Jacoby and Dallas, 1981; Mandler, 1980, 1991). It has been proposed that *recognition familiarity* primarily derives from the *perceptual fluency* that supports implicit perceptual memory. On implicit perceptual tests, fluent reprocessing of perceptual aspects of previously experienced stimuli yields perceptual priming (e.g., Jacoby and Dallas, 1981). On explicit recognition tests, the same perceptual fluency is thought to produce a sense of familiarity that can be used heuristically to discriminate studied from unstudied words (e.g., Gardiner, 1988; Gardiner and Java, 1990; Gardiner and Parkin, 1990; Jacoby, 1983, 1991; Jacoby and Dallas, 1981; Mandler, 1980; Rajaram, 1993; Yonelinas et al., 1995).

Support for the assertion that perceptual fluency mediates recognition familiarity comes from studies of recognition memory where fluency of test-item processing was systematically manipulated and the effects of these manipulations on recognition judgments was measured (e.g., Johnston et al., 1985, 1991; Kelley et al., 1989). Most studies in this vein have modulated fluency of test word processing by varying the density of visual noise masks (e.g., Whittlesea, 1993; Whittlesea et al., 1990) or by providing a brief masked priming presentation of a test word just prior to its occurrence (e.g., Forster, 1985; Jacoby and Whitehouse, 1989). Reductions in the density of a noise mask and presentation of test-item primes serve to increase participants' willingness to judge a test item as previously encountered, regardless of whether or not it actually had been studied, or to judge a test item as previously encountered for a longer than for a shorter duration, regardless of whether the study presentation was long or short. To the extent that these manipulations wield their effects by influencing fluency of test-item perceptual processing, then these results suggest that perceptual fluency is used as an attributional source for recognition. These results, however, do not inform us as to whether this process is the same as the long-term fluency process that supports perceptual priming.

Other evidence indicates that familiarity-based recognition is modulated by manipulations of test-item *conceptual* processing. For example, in a study by Whittlesea (1993), recognition test words were embedded at the end of conceptually related or unrelated sentence contexts. When the sentence context was conceptually predictive of the test word, participants were more likely to judge the word as having been previously encountered, regardless of whether or not the word had been studied.

Furthermore, these experiments reveal that such conceptual processing manipulations can have considerably larger effects on subsequent recognition compared to manipulations designed to modulate test-item perceptual fluency.

The influence of conceptual manipulations on recognition familiarity, manipulations that do not affect performance on implicit perceptual tests, is inconsistent with assertions that the familiarity process supporting recognition judgments derives entirely from the perceptual fluency that yields perceptual priming. As argued by Kelley and Jacoby (in press), it has been suggested that dissociations between familiarity-based explicit memory and implicit perceptual memory may indicate that familiarity is task specific: Depending on the retrieval context, familiarity-based memory performance may be more or less reliant on fluency of processing stimulus form and on fluency of processing stimulus meaning (see also, Jacoby, 1991; Jacoby et al., 1993; Jennings and Jacoby, 1993). While this is a possibility, such dissociations raise a fundamental question about the relationship between familiarity in explicit memory and fluency in implicit memory. Specifically, does a single perceptual fluency process support both recognition familiarity and perceptual priming or is the fluency mediating implicit perceptual memory distinct from the processes mediating recognition memory?

In this paper, we selectively review the literature with the goal of examining the relationship between implicit perceptual memory and familiarity in explicit recognition. An emphasis is placed on determining whether the perceptual fluency (*PF*) process that supports perceptual priming and the recognition familiarity (*RF*) process that supports recognition judgments can be reliably dissociated. Such dissociations would indicate that PF and RF do not reflect a common process. We first review the effects of conceptual encoding and study-test perceptual similarity manipulations on measures of PF and RF. We also review neuropsychological studies that have examined whether PF and RF are supported by the same neural substrates. We conclude this discussion by considering alternative possible relationships between familiarity in explicit memory and fluency in implicit memory.

2. Recognition familiarity and perceptual fluency

Behavioral and neuropsychological investigations have relied on encoding manipulations and on individuals with specific neural lesions to examine the separability of processes supporting implicit and explicit memory. We briefly review how a number of processing manipulations – levels of processing, picture naming or word reading, read or anagram study presentation, and study-test perceptual size congruency – and lesions of visual cortex affect indices of PF and RF. PF is indexed by priming on implicit perceptual tests (word-identification and word-stem completion) and inclusion/exclusion estimates of fluency in word-stem completion, and RF is indexed by inclusion/exclusion estimates of familiarity in recognition. The inclusion/exclusion (or process dissociation) procedure, developed by Jacoby and colleagues, is an analytic technique that is posited to decompose memory performance into the separate contributions of recollection and familiarity or fluency. The procedure depends on two conditions that make explicit or direct reference to the study episode: inclusion, where recollection and familiarity/fluency work in concert to support memory, and exclusion, where recollection and familiarity/fluency work in opposition (e.g., Jacoby, 1991; Jacoby et al., 1993; Jennings and Jacoby, 1993; for a discussion of the method see, Curran and Hintzman, 1995, 1997; Jacoby et al., 1997; Jacoby et al., in press; Yonelinas and Jacoby, 1996a).

2.1. Levels of processing

Levels-of-processing (LoP) manipulations vary how study stimuli are processed during encoding (Craik and Lockhart, 1972). An LoP manipulation, for example, may use orienting tasks that focus attention on the perceptual form (e.g., deciding the letter-case of a printed word) or the conceptual meaning (e.g., deciding whether a word represents an abstract or concrete concept) of study stimuli. Perceptual and conceptual orienting tasks are thought to engage different processes and yield different long-term representations of the encoding episode. Neuroimaging studies indicate that conceptual encoding engages regions in left inferior frontal and left middle temporal cortices not engaged during perceptual encoding (e.g., Kapur et al., 1994; Gabrieli et al., 1996; Wagner et al., 1997a).

Numerous studies have used LoP manipulations to examine the processes mediating explicit and implicit test performance, with most studies demonstrating dissociable effects on explicit recognition and implicit perceptual memory. Whereas recognition memory is usually superior following conceptual versus perceptual encoding (e.g., Craik and Lockhart, 1972; but see, Morris et al., 1977), LoP manipulations have little to no affect on perceptual priming (e.g., Graf and Mandler, 1984; Graf et al., 1982; Jacoby and Dallas, 1981). These null effects suggest that perceptual priming indexes a PF process that is insensitive to the processes and mnemonic representations arising from conceptual encoding. [1]

To further specify the nature of LoP influences on memory performance, a number of investigators have used the inclusion/exclusion procedure (Komatsu et al., 1995; Toth, 1996; Toth et al., 1994; Wagner et al., 1995b). Of particular interest for the present discussion, these studies provide indices of fluency-based word-stem completion and familiarity-based recognition performance, thus allowing compari-

[1] It should be noted, however, that there are reports of small but consistent LoP effects on word-stem completion priming, with priming increasing with conceptual encoding (for reviews see, Brown and Mitchell, 1994; Challis and Brodbeck, 1992). One interpretation of these modest effects is that performance on word-stem completion may sometimes reflect PF and contaminating contributions of explicit recollection (e.g., Toth et al., 1994). Alternatively, these effects may reflect differences in duration of study-phase perceptual processing. Typically, conceptual orienting tasks result in slower response latencies compared to perceptual orienting tasks, raising the possibility that participants spend more time processing stimulus form during conceptual encoding. Finally, Weldon (1991, 1993) has suggested that word-stem completion priming may index study-phase processing of stimulus form (i.e., PF) and study-phase access to the abstract lexical representation of a word. From this lexical access perspective, LoP may affect word-stem completion priming because conceptual orienting tasks typically demand greater lexical processing than do perceptual orienting tasks.

son of these measures to each other and to the PF indexed by perceptual priming. For example, Wagner et al. (1995b) examined LoP effects on RF using the inclusion/exclusion method and on PF using an implicit word-identification test. Three groups of participants studied visually presented words under conceptual (is the word tangible?) or perceptual (does the word have an 'A' in it?) orienting conditions. Participants then heard a second list of words. Finally, participants advanced to one of three test conditions: (a) recognition under inclusion instructions, where they were to respond "old" to both visually and auditorally presented items; (b) recognition under exclusion instructions, where they were to respond "old" to the auditorally presented items and were to exclude (respond "new") the visually presented items; or (c) implicit word-identification, consisting of the critical visually presented items and new (unstudied) items. As can be seen in Table 1, LoP had a dissociable effect on RF and PF. Whereas increased conceptual encoding enhanced RF (also see, Komatsu et al., 1995; Toth, 1996; for a related conceptual effect see Jacoby and Kelley, 1991), LoP had no effect on PF as indexed by perceptual priming.

LoP manipulations also yield dissociations between RF and fluency-based word-stem completion, when performed under inclusion/exclusion instructions. As with perceptual priming, inclusion/exclusion measures of fluency-based word-stem completion appear unaffected by LoP manipulations (Toth et al., 1994). Thus, perceptual priming and inclusion/exclusion word-stem completion indices of PF (both insensitive to conceptual encoding) are dissociable from inclusion/exclusion recognition indices of RF (markedly affected by conceptual encoding).

2.2. Picture naming-word reading

Picture naming typically leads to superior explicit memory relative to word reading. One interpretation of this picture advantage is that pictures are represented both in a pictorial and a verbal code, whereas words are represented only in a verbal code (e.g., Paivio, 1986). Alternatively, picture naming may involve more extensive access to semantic representations than does word reading (e.g., Conway and Gathercole, 1990; Dewhurst and Conway, 1994; Nelson, 1979; Weldon and Roediger, 1987). Thus, as with LoP manipulations, having participants name pictures and read words may be another method of modulating the extent of conceptual processing during

Table 1
Effects of level of processing on recollection and familiarity in recognition and on word identification priming

	Recognition memory				Word identification	
	Probability "Old"		Process estimates		Probability of identification	Magnitude priming
Processing	Incl.	Excl.	R	F		
Conceptual	0.88	0.22	0.67	0.63	0.73	0.11
Perceptual	0.57	0.18	0.39	0.29	0.72	0.11
Heard	0.76	0.65	–	–	–	–
New	0.16	0.10	–	–	0.62	–

Note: Incl. = Inclusion; Excl. = Exclusion; R = Recollection; F = Familiarity.

encoding. Further, when test items are presented in a word form, picture-word manipulations inversely vary conceptual processing (greater for picture-studied items) and study-test perceptual similarity (greater for word-studied items).

Picture-word manipulations differentially affect performance on explicit word recognition and on implicit word identification and word-stem completion tests. Recognition of words studied as pictures is superior to that of words studied as words (e.g., Durso and Johnson, 1980; Madigan, 1983), with this *picture superiority effect* indicating that recognition is affected more by conceptual encoding than by study-test perceptual similarity. In contrast, word-identification (e.g., Weldon, 1991; Winnick and Daniel, 1970) and word-stem completion (e.g., Roediger et al., 1992; Weldon et al., 1989) priming are greater after word reading than after picture naming.

Further evidence for the separability of recognition and implicit perceptual processes comes from inclusion/exclusion experiments examining the effects of picture-word study on word recognition and word-stem completion. For example, Wagner et al. (1997b) used a picture-word study manipulation in conjunction with three indices of familiarity-based and fluency-based memory performance: word-identification priming, inclusion/exclusion word-stem completion, and inclusion/exclusion word recognition. As can be seen in Table 2, the picture-word study manipulation had dissociable effects on these measures of familiarity/fluency. RF was greater for picture-studied items, even though the perceptual similarity between study and test stimuli is greater for word-studied than for picture-studied test words. In contrast, PF in word-stem completion and implicit word-identification priming were greater for word-studied items. These double dissociations indicate that the PF mediating implicit perceptual memory is sensitive to study-phase perceptual representations, whereas the RF supporting recognition judgments is more sensitive to study-phase conceptual encoding.

2.3. Read-anagram

Read-anagram encoding manipulations compare memory performance following word reading to performance following word generation from an anagram (e.g., SDNAT for STAND). Generation from an anagram is thought to require more extensive lexical, and perhaps conceptual, processing than does word reading (e.g., Roediger and McDermott, 1993). As with LoP and picture-word manipulations of conceptual encoding, word generation from an anagram produces superior recogni-

Table 2
Effects of picture naming and word reading on recollection and familiarity/fluency in recognition and word-stem completion and on word identification priming

	Memory test				
	Recognition		Word-stem completion		Word identification priming
Study form	R	F	R	F	
Pictures	0.71	0.77	0.30	0.28	0.06
Words	0.38	0.46	0.16	0.60	0.11

Note: R = Recollection; F = Familiarity/Fluency.

tion memory than does word reading (e.g., Allen and Jacoby, 1990). In contrast, word-identification priming is greater for read than for anagram-solved words (e.g., Allen and Jacoby, 1990; Schwartz, 1989; Weldon, 1991), again demonstrating that the PF indexed by word-identification priming is primarily sensitive to study-test perceptual similarity. Studies of read-anagram effects on word-stem completion priming, however, have either found that priming on this task is greater for read items (e.g., Jacoby et al., 1993) or is unaffected by this manipulation (e.g., Schwartz, 1989; Weldon, 1991). One possible explanation for these null effects is that recollection may sometimes contribute to word-stem completion performance (Jacoby et al., 1993; Toth et al., 1994). Alternatively, word-stem completion priming may reflect both fluent perceptual reprocessing of stimuli and more efficient access to lexical representations (e.g., Weldon, 1991, 1993). The greater lexical processing demanded by anagram solution may offset the greater PF for the read items.

Studies using the inclusion/exclusion method indicate that read-anagram manipulations yield dissociable effects on familiarity-based recognition and fluency-based word-stem completion. Whereas fluency in word-stem completion is greater for read than for anagram-solved items (Jacoby et al., 1993), RF is greater for anagram-solved than for read words (Jacoby, 1991; Verfaellie and Treadwell, 1993; but see, Jennings and Jacoby, 1993). Thus, as with picture-word manipulations, read-anagram manipulations yield a double dissociation between RF and PF: RF is enhanced more by conceptual encoding than by study-test perceptual similarity, but PF, as indexed by word-identification priming and inclusion/exclusion word-stem completion, is enhanced by perceptual similarity.

2.4. Size-congruency

The manipulations considered thus far either vary conceptual processing at encoding while holding similarity of study and test perceptual form constant (LoP) or inversely vary conceptual encoding and study-test perceptual similarity (picture-word and read-anagram). The latter two manipulations, by pitting the effects of perceptual similarity against those of conceptual processing, provide information about the relative effects of perceptual and conceptual processing on RF and PF. However, these manipulations do not directly address whether RF and PF are similarly influenced by study-test perceptual similarity. One manipulation that allows for consideration of the effects of study-test perceptual similarity is the more subtle manipulation of study-test size-congruency. In size-congruency manipulations, the match between the size of a stimulus at encoding and the size of the stimulus at test is varied.

Varying size-congruency dissociates performance on implicit perceptual and explicit recognition tests. Studies of implicit perceptual memory demonstrate equivalent magnitudes of perceptual priming for size-congruent and incongruent pictures (e.g., Cooper et al., 1992; but see, Srinivas, 1996; for a related perceptual match effect see, Snodgrass et al., 1996). These null effects indicate that the representations supporting this form of priming do not depend on an exact sensory match between study and test forms. Recognition memory, in contrast, is superior when study-test size is congruent (e.g., Cooper et al., 1992; Kolers et al., 1985; for a related perceptual match effect see, Snodgrass and Hirshman, 1994). One interpretation of this size-congruency effect is that the representations indexed by recognition tests include information about the distinctive spatial, temporal, and contextual details of an object (Cooper et al., 1992); study-test size incongruency may diminish the spatial similarity between study and test forms of an object.

Size-congruency manipulations have dissociable effects on PF and RF. Whereas size-congruency typically does not affect priming for objects, inclusion/exclusion studies of recognition demonstrate that RF is greater in size-congruent than in size-incongruent conditions (Yonelinas and Jacoby, 1995). These effects suggest that the episodic trace of the study event contains information about an object's distinctive spatial or perceptual attributes, information that is not needed for identification of stimulus form but that may support familiarity in explicit memory. Importantly, this pattern reflects yet another functional dissociation between RF in explicit recognition and PF in implicit perceptual memory.

2.5. Neuropsychological evidence

Neuropsychological investigations of the mnemonic abilities of individuals with select neural damage have been an important source of evidence for theorizing about the relationship between the processes and neural substrates supporting implicit and explicit memory. Anatomic dissociations between explicit and implicit test performance support the assertion that functionally and anatomically distinct memory systems are indexed by implicit perceptual and explicit tests (e.g., Squire, 1992). Explicit test performance is thought to depend on mnemonic representations that require medial temporal and diencephalic structures for their formation. Implicit perceptual memory, in contrast, is thought to reflect experience induced changes in modality-specific sensory cortices, with these mnemonic representations arising without medial temporal and diencephalic input.

Neuropsychological investigations indicate that lesions to modality-specific visual cortex differentially affect implicit visual and recognition memory. For example, a patient (M.S.) with a right occipital-lobe lesion demonstrates impaired visual word-identification and word-stem completion priming but intact visual recognition and implicit conceptual memory (Fleischman et al., in press; Gabrieli et al., 1995; Vaidya et al., in press). A selective impairment of visual priming was also found in another patient with occipital-lobe lesions, L.H. (Keane et al., 1995). This pattern of impaired implicit perceptual memory and spared explicit recognition memory challenges assertions that the PF process mediating perceptual priming also supports recognition judgments.

Given that recognition memory abilities are preserved following lesions of visual cortex, it becomes theoretically critical to specify the bases for this intact performance. One possibility is that RF is impaired following sensory cortical lesions and that compensatory recollective processes are relied on for normal recognition memory. Alternatively, RF may not depend on the putative right-occipital memory system that subserves implicit perceptual memory for visual form. To directly test these two hypotheses, the contributions of recollection and familiarity to M.S.'s intact recognition memory were derived using the inclusion/exclusion procedure (Wagner et al., 1997c). In two experiments, M.S. and controls demonstrated similar contributions of recollection and familiarity to recognition. Further, familiarity contributions to M.S.'s recognition increased with conceptual processing rather than study-test perceptual similarity. Thus, M.S. demonstrates a neuroanatomic and functional dissociation between PF and RF.

2.6. Discussion

The aim of this review was to examine behavioral and neuropsychological evidence about the relationship between perceptual priming and familiarity-based recognition. Consideration of the effects of a number of encoding manipulations revealed multiple single and double dissociations between PF and RF. PF is sensitive to most manipulations of study-test perceptual similarity, but not to manipulations of conceptual encoding. RF, in contrast, is markedly affected by manipulations of conceptual processing, with the effects of picture-word and read-anagram manipulations indicating that RF is more reliant on mnemonic representations arising from conceptual than from perceptual encoding (Toth, 1996; Wagner et al., 1997b, c; Whittlesea, 1993). Even when RF appears sensitive to changes in study-test perceptual similarity, as demonstrated in experiments manipulating study-test size congruency, RF still dissociates from the PF indexed by perceptual priming. Finally, neuropsychological evidence reveals that right visual cortex supports implicit memory for visual form but not recognition memory. Collectively, these results indicate that the PF indexed by perceptual priming is functionally and anatomically distinct from the RF supporting recognition judgments.

Two aspects of the presently reviewed data suggest that PF makes little or no contribution to RF. First, as noted by Whittlesea (1993), conceptual encoding affects RF, with this familiarity being considerably more sensitive to modulations of conceptual encoding than of study-test perceptual similarity. Although this does not demonstrate that PF has no effect on recognition, it suggests that any effect is modest at best. Second, studies of individuals with lesions of visual cortex reveal an absence of PF as indexed by visual priming. To the extent that this PF process supports recognition memory, then recognition memory also should be affected by visual cortical insult. This is not the case. Furthermore, measures of RF revealed entirely normal contributions of familiarity following such lesions. These results indicate that the PF supporting perceptual priming does not support recognition memory.

The assertion that PF does not serve as a basis for recognition appears inconsistent with the implications of studies demonstrating that manipulations designed to vary test-item PF affect recognition judgments (e.g., Jacoby and Whitehouse, 1989; Johnston et al., 1985, 1991; Whittlesea et al., 1990). As discussed earlier, participants are more likely to embrace a test item as old, regardless of whether or not the item had been studied, when the test item is preceded by a prime or masked by low, as compared to high, density noise. These manipulations have been interpreted as wielding their effects by varying the PF of test-item processing, and, to the extent that this is the case, these results are difficult to integrate with the assertion that PF does not contribute to recognition memory. There are at least two possible interpretations for the conflicting results from studies that varied RF via a study-phase versus a test-phase manipulation. One possibility is that manipulations of test-item processing affect a familiarity process that is distinct from the RF indexed by inclusion/exclusion studies of recognition. Test-phase manipulations may affect a short-term familiarity process that is unrelated to long-term memory processes. This familiarity may make only modest contributions to recognition by biasing test-phase judgments of both studied and unstudied items, and may be most apparent when recollection-based memory performance is low (e.g., Johnston et al., 1985; Toth, 1996; Whittlesea, 1993). Alternatively, reports that manipulations of test-word conceptual processing also can influence recognition judgments (Whittlesea, 1993) raise the possibility that "perceptual" manipulations of test-item processing may conflate the effects of perceptual and *conceptual fluency* (*CF*), with the apparent PF effects truly reflecting the influence of CF on recognition memory.

n addition to demonstrating that PF and RF index distinct mnemonic processes, the present review allows for a comparison of implicit perceptual and inclusion/exclusion indices of PF. In particular, both perceptual priming and inclusion/exclusion word-stem completion studies provide measures of PF. Studies of implicit perceptual memory demonstrate that modest magnitudes of perceptual priming occur when study-test stimulus form is varied (e.g., priming from picture to word forms; Wagner et al., 1997b). Inclusion/exclusion studies of word-stem completion, however, demonstrate no study-induced increments in PF when study-test perceptual form is varied (e.g., Jacoby et al., 1993; Wagner et al., 1997b). Manipulations of the match between study and test stimulus modality also results in a similar dissociation between these two indices of PF (Blaxton, 1989; Jacoby et al., 1993; Keane et al., 1991; Kelley et al., 1989).

One interpretation of these dissociations is that priming on implicit perceptual tests may be contaminated by contributions of recollection, with cross-form and cross-modality priming effects reflecting contributions of recollection, whereas inclusion/exclusion measures provide a pure index of PF (Jacoby et al., 1993). Arguing against this interpretation, however, are findings of normal cross-modality priming in amnesia (e.g., Graf et al., 1985; Vaidya et al., 1995). In addition, conceptual encoding, which enhances recollection and thus should increase the contaminating contributions of recollection to priming, does not influence the magnitudes of cross-modality priming (Craik et al., 1994). Alternatively, cross-form and cross-modality priming may reflect more efficient access to abstract lexical representations (e.g., Weldon, 1991, 1993). To the extent that this is the case, then the absence of cross-form and cross-modality effects on inclusion/exclusion word-stem completion indices of PF suggest that the processes engaged under explicit inclusion and exclusion instructions differ from the processes typically engaged during performance of implicit perceptual tests.

3. Recognition familiarity and fluency in implicit memory: alternative relationships

The present discussion reveals considerable evidence for the separability of implicit perceptual memory and familiarity-based recognition memory. This evidence is inconsistent with the initial assertions of some dual-process models that a single PF process mediates both implicit and explicit memory. However, these data do not rule out the possibility that implicit and explicit test performance depend on a shared fluency process. Indeed, studies of implicit conceptual memory reveal that the effects of conceptual and perceptual encoding manipulations on conceptual priming parallel the effects of these manipulations on RF (Table 3). For example, as with RF, priming on the category-exemplar generation task is greater following conceptual versus perceptual encoding (e.g., Hamann, 1990), following picture naming versus word reading (Vaidya and Gabrieli, 1996; but see Weldon and Coyote, 1996), and following word generation versus word reading (e.g., Srinivas and Roediger, 1990). Further, conceptual priming is spared following lesions of visual cortex (Fleischman et al., 1995, in press; Gabrieli et al., 1995). Thus, it remains possible that performance on implicit conceptual and explicit recognition tests depends on a shared CF process (e.g., Toth, 1996; Wagner et al., 1997b).

Alternatively, RF may reflect functionally and anatomically distinct processes from those supporting implicit conceptual and implicit perceptual memory. From this perspective, familiarity and recollection in recognition represents a functional and anatomic distinction within explicit or declarative memory (e.g., Haist et al., 1992; Knowlton and Squire, 1995; Reed et al., 1997; Wilding and Rugg, 1996). Familiarity-based recognition may reflect memory of context-free item information, whereas recollection-based recognition may reflect memory of item information associated with a specific learning context. Consistent with this interpretation, it has been noted that the inclusion/exclusion procedure partially hinges on participants' judgements of the context or source in which an item was encountered, raising the possibility that inclusion/exclusion indices of recollection and familiarity reflect memory for the context of an experience and memory for the content of an experience, respectively (Dodson and Johnson, 1996; Gruppuso et al., 1997; Mulligan and Hirshman, 1997; Yonelinas and Jacoby, 1996b).

Neuroanatomically, familiarity and recollection may both index representations that are dependent on medial temporal/diencephalic structures for their formation, with recollection being additionally dependent on frontal-lobe regions. Frontal lesions can result in impaired source memory with spared recognition memory, indicating that prefrontal cortex is critical for context memory but not item memory (e.g., Janowsky et al., 1989; Schacter et al., 1984). Neuroimaging studies suggest that right prefrontal regions may contribute to the retrieval, evaluation, and integration of context infor-

Table 3
Comparisons across multiple indices of familiarity/fluency

Encoding manipulation or group	Implicit perceptual memory	Implicit conceptual memory	Familiarity-based recognition
Conceptual vs. perceptual encoding	=	+	+
Word generation vs. word reading	−	+	+
Picture naming vs. word reading	−	+	+
Size-congruent vs. size-incongruent	=	?	+
Amnesics vs. controls	=	=	= or −
Patient with visual cortex lesion vs. controls	−	=	=

Note: (+) indicates "increases familiarity/fluency"; (−) indicates "decreases familiarity/fluency"; (=) indicates "invariant familiarity/fluency".

mation with item information (e.g., Buckner et al., 1995; Kapur et al., 1995; Rugg et al., 1996; Squire et al., 1992; Schacter et al., 1996; Wagner et al., 1996).

Consideration of the status of RF in global amnesia may serve to clarify whether a putative CF process mediates both explicit recognition and implicit conceptual memory or whether RF reflects mnemonic processes distinct from those mediating implicit memory. Global amnesia, which results from medial temporal/diencephalic damage, is a memory deficit characterized by the loss of declarative memory for item and context information, and the sparing of conceptual and perceptual implicit memory (e.g., Cermak et al., 1995; Graf et al., 1984; Vaidya et al., 1995; Warrington and Weiskrantz, 1970). To the extent that medial temporal damage does not impair the processes necessary for attributing fluency to the past, which is posited to be the mechanism by which fluency is subjectively experienced as familiarity, then examination of recognition memory in amnesia may provide insight into the relationship between CF and RF. If RF and conceptual priming reflect a common CF process, then dual-process models predict that (a) RF should be intact in amnesia and (b) recognition performance should be spared relative to recall performance because only recognition is thought to be supported by familiarity (e.g., Hirst et al., 1986; Hirst et al., 1988; Verfaellie and Treadwell, 1993). In contrast, the context/item perspective predicts that medial temporal/diencephalic damage should result in (a) impaired RF and (b) equivalent impairments of recognition and recall.

There are conflicting results regarding the status of RF in amnesia, with one study demonstrating preserved and other studies demonstrating impaired familiarity (Knowlton and Squire, 1995; Verfaellie and Treadwell, 1993; Yonelinas et al., 1997). Using the inclusion/exclusion method, Verfaellie and Treadwell (1993) found that amnesic and control participants demonstrate comparable magnitudes of RF. Interpretation of these results, however, is complicated by group differences in baseline false-alarm rates (Roediger and McDermott, 1994; Verfaellie, 1994). Knowlton and Squire (1995) used the remember/know method to index familiarity-based recognition, with this method assessing the phenomenological nature of memory via subjective reports (Gardiner, 1988; Tulving, 1985). [2] Results from this study

[2]The remember/know procedure requires that participants describe the subjective experience accompanying a recognition judgment. "Remembering" indicates recognition associated with conscious remembrance of some aspect of the study episode, whereas "knowing" indicates recognition associated with a feeling of familiarity without conscious remembrance (e.g., Gardiner, 1988; Gardiner and Parkin, 1990). These subjective states are thought to be mutually exclusive such that memory judgments are associated with either remembering or knowing, but not both (e.g., Richardson-Klavehn et al., 1996). Further, it has been emphasized that this procedure indexes states of awareness associated with memory performance, rather than processes supporting performance (e.g., Richardson-Klavehn et al., 1996). Indeed, when "know" judgments are treated as a measure of RF, it becomes apparent that this measure, at least when computed under an exclusivity assumption, can be functionally and anatomically dissociated from perceptual priming measures of PF and inclusion/exclusion measures of RF (e.g., Richardson-Klavehn et al., 1996; Wagner et al., 1997b; Wagner et al., 1995a; Yonelinas and Jacoby, 1995). However, if it is assumed that the processes underlying "remembering" and "knowing" are independent, then "know" estimates tend to correspond closely with RF as indexed by the inclusion/exclusion procedure (Jacoby et al., in press), although convergence does not always occur (Richardson-Klavehn et al., 1996).

demonstrated a RF impairment in amnesia. Interpretation of these results, however, is complicated by the assumptions of the remember/know method. Whereas it seems likely that recollection and familiarity are not mutually exclusive, remember/know estimates of RF are based on an assumption that these two processes are mutually exclusive (Knowlton and Squire, 1995; Yonelinas and Jacoby, 1995). Re-analyses of the data from both studies, taking into account differences in false alarm rates and assuming process independence rather than mutual exclusivity, revealed moderate impairments in RF in amnesia (Verfaellie, 1994; Yonelinas et al., 1997). Further, Yonelinas et al. (1997), examining the status of RF in amnesia via the computation of receiver operating characteristic curves for amnesic and control participants, demonstrated that RF, while not as impaired as recollection, nevertheless was reduced in amnesia. Collectively, these studies suggest that RF is compromised following medial temporal/diencephalic damage. It is difficult to know, however, whether the remaining contributions of RF to amnesic recognition performance reflect residual declarative memory or CF processes.

Determining whether recognition in relatively spared compared to recall provides indirect evidence about whether CF mediates recognition. Evidence regarding the status of recognition relative to recall in amnesia is equivocal. Consistent with the idea that CF contributes to recognition, there have been reports of a relative sparing of recognition relative to recall in amnesia (Aggleton and Shaw, 1996; Hirst et al., 1986, 1988). Other studies, however, have revealed proportional impairments in recognition, recall, and cued recall (e.g., Haist et al., 1992; Shimamura and Squire, 1988), raising the possibility that demonstrations of disproportionately spared recognition reflect the differences in the measurement scales for recall and recognition and the contributions of residual declarative memory of recognition. Indeed, studies of a severely amnesic patient (E.P.) reveal that this patient differs from other patients with less severe amnesia, including H.M. (Freed et al., 1987), in that this patient fails to demonstrate enhanced recognition performance following extended exposure during encoding (Reed et al., 1997). Although E.P. has cortical damage beyond the medial-temporal region including frontal, insular, and inferior temporal regions, raising concerns that regions critical for CF may also be compromised in this patient, these results suggest that partially spared recognition abilities in amnesia may reflect partially spared declarative memory rather than influences of CF.

To the extent that spared declarative memory is the source of above-chance recognition performance in amnesia, there is some evidence that such declarative memory abilities may arise from preserved parahippocampal cortex. In contrast to E.P., H.M.'s lesion spared parahippocampal cortex (Corkin et al., 1997), and H.M. is able to demonstrate above chance recognition following extended study (Freed et al., 1987). Further, Aggleton and Shaw (1996) note that amnesic patients with lesions sparing parahippocampal cortex demonstrate a relative sparing of recognition. These results are consistent with neuroimaging evidence suggesting that distinct medial-temporal regions mediate recollection and familiarity (Gabrieli et al., 1997), with parahippocampal regions being important for RF.

Thus, most (but not all) neuropsychological studies support the view that recollection depends upon frontal and anterior medial-temporal regions, whereas RF depends upon posterior medial-temporal regions. By this view, there are no shared processes mediating performance on explicit and implicit memory tests.

4. Conclusion

The present review demonstrates that the perceptual fluency process that supports implicit perceptual memory is distinct from the familiarity process supporting explicit recognition memory. Further, implicit perceptual and inclusion/exclusion indices of perceptual fluency in word-stem completion diverge suggesting that changes in test instructions may fundamentally affect how participants perform a task. Finally, it remains to be seen whether implicit conceptual and explicit recognition memory rely on a common conceptual fluency process or whether implicit and explicit tests index entire separable processes.

Acknowledgements

The research reported herein was supported by a National Science Foundation Graduate Fellowship, and grants AG11121 from the National Institute on Aging and MH53673 from the National Institute of Mental Health.

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