40

Conscious and Unconscious Memory

John F. Kihlstrom, Jennifer Dorfman, and Lillian Park

We speak of "memory" but in fact there appear to be many memories. The "modal" multistore model of memory postulates a number of distinct storage structures (or systems) in the mind. Short-term or working memory is often identified with consciousness, and applies while our attention is focused on something; long-term memory applies after our attention has turned elsewhere. For most people, though, "memory" means long-term memory. As James put it in the *Principles*, "[m]emory proper ... is the knowledge of a former state of mind after it has already once dropped from consciousness; or rather *it is the knowledge of an event, or fact,* of which meantime we have not been thinking, *with the additional consciousness that we have thought or experienced it before.*"

The knowledge stored in long-term memory comes in two broad forms (Anderson 1976). *Declarative knowledge* constitutes our fund of factual knowledge, while *procedural knowledge* consists of our cognitive repertoire of rules and skills. Within the domain of declarative knowledge, we can distinguish *episodic* memory, or autobiographical memory for events that have occurred in our personal past, from *semantic* memory, a sort of impersonal mental dictionary (Tulving 1972). Procedural knowledge can be further classified into motoric and perceptual-cognitive skills. The declarative-procedural distinction has its immediate origins in artificial intelligence, but can be traced back to Ryle's distinction between "knowing that" and "knowing how," and Bergson's assertion that "the past survives" as both recollections and as habits. Conceptually, an episodic memory trace contains a description of some event, the unique spatiotemporal context in which that event occurred, and reference to the self as the agent or patient, stimulus or experiencer, of that event (Kihlstrom 1997).

A popular framework for memory research is *stage analysis*: mental representations of events are *encoded* as memory traces, retained in memory *storage*, and subject to *retrieval*. Encoded memories, available in memory storage, may not be accessible when retrieval is attempted. On the other hand, they may operate unconsciously, even when conscious remembering fails.

The Blackwell Companion to Consciousness, Second Edition. Edited by Susan Schneider and Max Velmans.

Levi, D. M. (2008) Crowding – an essential bottleneck for object recognition: a mini-review. *Vision Research* 48: 5, 635–54. doi: 10.1016/j.visres.2007.12.009.

Loftus, E. F. and Klinger, M. R. (1992) Is the unconscious smart or dumb? *The American Psychologist* 47: 6, 761–5. doi: 10.1037/0003-066X.47.6.761.

Mack, A. and Rock, I. (1998) *Inattentional Blindness.* Cambridge, MA: MIT Press.

Maniscalco, B, and H Lau. 2012. "A Signal Detection Theoretic Approach for Estimating Metacognitive Sensitivity from Confidence Ratings." *Consciousness and Cognition* 21: 422–30.

Marcel, A J. (1983) Conscious and unconscious perception: experiments on visual masking and word recognition. *cognitive Psychology* 15: 2, 197–237. doi: 10.1016/0010-0285(83) 90009-9.

Merikle, P. M., and Daneman, M. (1998) Psychological investigations of unconscious perception. *Journal of Consciousness Studies* 5: 1, 5–18.

Mudrik, L. Faivre, N., and Koch, C. (2014) Information integration without awareness. *Trends in Cognitive Sciences* 18: 9, 488–96. doi: 10.1016/j.tics.2014.04.009.

Persaud, N., McLeod, P., and Cowey, A. (2007) Post-decision wagering objectively measures awareness. *Nature Neuroscience* 10: 2, 257–61. doi: 10.1038/nn1840.

Pierce, C. S. and Jastrow, J. (1884) On small differences of sensation. *Memoirs of the National Academy of Science* 3, 75–83.

Raymond, J. E., Shapiro, K. L., and Arnell, K. M. (1992) Temporary suppression of visual processing in an RSVP task: an attentional blink? *Journal of Experimental Psychology. Human Perception and Performance* 18: 3, 849–60. doi: 10.1037/0096-1523.18.3.849.

Soto, D. and Silvanto, J. (2014) Reappraising the relationship between working memory and conscious awareness. *Trends in Cognitive Sciences* 18: 10, 520–5. doi: 10.1016/j.tics.2014.06.005.

Tsuchiya, N. and Koch, C. (2005) Continuous flash suppression reduces negative afterimages. *Nature Neuroscience* 8: 8, 1096–101. doi: 10.1038/nn1500.

Van Gaal, S., Ridderinkhof, K. R., Scholte, H. S., and Lamme, V. A. F. (2010) Unconscious activation of the prefrontal no-go network. *The Journal of Neuroscience : The Official Journal of the Society for Neuroscience* 30: 11, 4143–50. doi: 10.1523/JNEUROSCI.2992-09.2010.

Velmans, M. (1991) Is human information processing conscious? *Behavioral and Brain Sciences* 14: 04, 651–69.

Weiskrantz, L. (1996) Blindsight revisited. *Current Opinion in Neurobiology* 6: 2, 215–20.

Seven (Plus or Minus Two) Principles of Conscious Recollection

For most of the century following Ebbinghaus, the psychology of memory was concerned with conscious recollection – our ability to recall or recognize events that occurred in the past. From this research emerged a small set of principles that largely govern how human memory operates:

1) **Elaboration**: memory is a function of the degree to which an event is related to preexisting knowledge.
2) **Organization**: memory is also a function of the degree to which individual events are related to each other.
3) **Time-dependency**: memory generally fades with time, due to decay, displacement, consolidation failure, or interference among competing memory traces. On the other hand, memory consolidation itself takes time.
4) **Cue-dependency**: successful remembering is a function of the informational value of the cues provided at retrieval.
5) **Encoding specificity**: remembering also depends on a match between the cues present at retrieval and those processed at encoding.
6) **Schematic processing**: events relevant to currently active beliefs, expectations, and attitudes are remembered better than those that are irrelevant; events which are incongruent with these mental schemata are remembered better than those which are congruent.
7) **Reconstruction**: memory reflects a mix of information contained in the memory trace and knowledge derived from other sources.

Different classes of memory may operate according to somewhat different principles. Although elaborative rehearsal seems to be necessary for encoding in long-term memory, for example, rote maintenance rehearsal will suffice to keep material active in short-term memory. Elaboration is critical for explicit memory, but less important for implicit memory. Forgetting from short-term memory is produced by decay and displacement, affecting availability, while forgetting from long-term memory appears to be a problem of proactive and retroactive interference, affecting accessibility.

Dissociating Explicit and Implicit Memory

For most of its history, the scientific study of episodic memory was concerned mostly with conscious recollection, and unconscious memory was relegated to a Freudian fantasyland. But beginning in the 1960s, research began to suggest that the notion of unconscious memories was valid after all – if not in the Freudian form. Of particular interest were studies of patients with the *amnesic syndrome* caused by damage to the hippocampus and related structures in the medial temporal lobe, or to the mammillary bodies and related structures in the diencephalon. In a pioneering study, Warrington and Weiskrantz (1970) asked amnesic patients to study a list of familiar words. Compared to control subjects, the patients performed very poorly on standard tests of recall and recognition. However, when they were presented with three-letter stems or fragments, and asked to guess the corresponding word, amnesics and controls were equally likely to complete the cues with items from the studied list.

This is a *priming effect*, in which the processing of one item (e.g., at the time of study) influences the processing of another item (e.g., at the time of test). Positive priming facilitates, while negative priming inhibits, processing of the target. Priming indicates that the studied items were encoded in memory and retained in storage. The fact that equivalent levels of priming occurred in neurologically intact subjects, who remembered the priming episode normally, and amnesic patients, who had very poor memory, indicates that priming can be dissociated from conscious recollection.

On the basis of evidence like this, Schacter (1987) distinguished between two expressions of episodic memory: explicit and implicit. Explicit memory refers to conscious recollection of a past event, as exemplified by performance on recall and recognition tests. By contrast, implicit memory refers to any effect of an event on subsequent experience, thought, or action. The dissociation between priming and recall in amnesic patients indicates that implicit memory can persist in the absence of explicit memory.

Subsequent research identified a number of different dissociations between explicit and implicit memory (for a comprehensive review, see Reder, Park, & Kieffaber 2009). Probably the most obvious and convincing of these involve various forms of memory disorder. By definition, these syndromes are marked by an impairment of explicit memory; but they also generally spare priming and other manifestations of implicit memory. These conditions include anterograde amnesia (covering "postmorbid" events, which occurred after the damage) associated with bilateral damage to the hippocampus and other structures in the medial temporal lobe; anterograde and retrograde amnesia (covering "premorbid" events, which occurred before the damage) secondary to electroconvulsive therapy (ECT) for depression; general anesthesia administered to surgical patients (see Kihlstrom & Cork, chapter 48); conscious sedation in outpatient surgery; dementia, including Alzheimer's disease; posthypnotic amnesia; and the "functional" or "psychogenic" amnesias encountered in genuine cases of dissociative disorder, including dissociative amnesia, dissociative fugue, and the inter-personality amnesia of dissociative identity disorder (also known as multiple personality disorder). Normal age-related declines in memory primarily affect explicit memory, leaving implicit memory intact. And neurologically intact subjects show significant savings in relearning for items that, because of the long retention interval involved, they can neither recall nor recognize. One of the most interesting of these dissociations is observed in source amnesia, where patients and subjects acquire new declarative and procedural knowledge, but have no conscious recollection of the learning episode.

Conceptually similar "functional" dissociations can even be observed in individuals with normal memory, where implicit memory is in some sense independent of explicit memory (Reder et al. 2009). A number of experimental manipulations have substantial effects on explicit memory, but little or no effect on implicit memory. These include depth of processing at the time of encoding; the generation effect (superior memory for items generated by subjects themselves, compared to those presented by the experimenter); repetitions; and exposure duration. Implicit memory is less vulnerable to variations in retention interval, and to interference effects. Still other manipulations affect implicit memory, but not explicit memory, including modality shift (e.g., between auditory presentation at study and visual presentation at test); changing the font of a visual stimulus; and changing the voice of an auditory stimulus.

Finally, neuroimaging studies indicate that performance of explicit and implicit memory tasks is associated with different patterns of brain activity (Reder et al. 2009; Spaniol et al. 2009). Visual word priming is associated with decreased activity in the fusiform area, frontal, and extrastriate cortex; cued recall is associated with increased activity in posterior cingulate cortex, precuneus, and inferior parietal lobe. While there is clear evidence of medial-temporal/hippocampal activation during episodic encoding and retrieval, studies of amnesic patients indicate that priming is dependent on the cerebral cortex.

Some exceptions to these findings complicate the picture somewhat (Reder et al. 2009). Consider, for example, the functional dissociation involving depth of processing, which is so well accepted that it has almost become part of the operational definition of implicit memory. Two meta-analyses found that there was, indeed, an effect of depth of processing on priming, even if individual studies lacked the power to detect it. So, in this respect at least, implicit memory may not operate on different principles than explicit memory.

Dissociations between explicit and implicit memory come in several forms (Teuber 1955). Most often, they take the form of *single dissociations,* in which a single independent variable – amnesia, experimental manipulation, or brain region – affects one expression of memory, explicit or implicit, but not the other. Statistically, however, single dissociations take the form of statistical interactions (i.e., between some independent variable and dependent variables measuring explicit and implicit memory), which are often difficult to interpret. Spurious interactions can emerge as artifacts of differential item difficulty, while non-crossover interactions (which is what single dissociations are) may be "removable" if the variables are placed on the same scale of measurement. Differences between explicit and implicit memory are only meaningful if the cues presented at the time of test are matched for their informational value, as when stem-completion is pitted against stem-cued recall.

For these and other reasons, *double dissociations* are the "Holy Grail" of cognitive neuropsychology and cognitive neuroscience. These take the form of a crossover interaction, in which a single independent variable has opposite effects on two dependent variables, and they allow firm conclusions that performance of the two tasks is mediated by distinct processes, cognitive modules, or brain systems. Unfortunately, double dissociations are also exceedingly rare. Moreover, many ostensible double dissociations are more like *twin dissociations,* in which one independent variable affects explicit but not implicit memory, while another affects implicit but not explicit memory. As such, they are vulnerable to removability and the other problems discussed earlier.

Taxonomic Issues

Priming comes in a number of different forms. Most research on implicit memory has focused on *direct or repetition priming,* in which the target of the priming test is a recapitulation or token, in whole or in part, of the prime itself. In *stem- or fragment-completion* tests, subjects might study a word like *doctor* and then complete *doc-* or *d-c-o-* with the first word that comes to mind; in perceptual identification, they might try to identify the word *doctor* when presented against a noisy background; in lexical decision, they might decide whether the letter string *doctor* is a legal word. But *indirect or semantic priming* can be observed when subjects who have studied *doctor* are asked to give free associations to cues like *nurse,* or to generate instances of categories like *occupations* (e.g., McNamara 2005). Repetition priming can be mediated by a *perception-based representation* that is limited to the physical attributes of the prime and its configuration in space and time, but semantic priming requires a *meaning-based representation* that includes information about the semantic and conceptual features of the prime. Semantic priming can be studied with the same tasks normally used to measure repetition priming, such as perceptual identification and lexical decision, provided that the target and prime are linked by meaning rather than physical similarity. But it is more commonly studied with tasks such as free-association and category generation.

Explicit and implicit memory are sometimes referred to as "declarative" and "procedural" memory, or "declarative" and "nondeclarative" memory, respectively. The declarative-procedural usage was initially based on the view that preserved learning in amnesia was limited to procedural knowledge such as cognitive and motor skills, and an interpretation of priming and conditioning as procedural in nature. While some implicit expressions of memory may be mediated by procedural or nondeclarative knowledge, the declarative-nondeclarative distinction risks confusing the interpretation of explicit memories as representations that can be consciously "declared" with the propositional format in which declarative knowledge is represented. Amnesic patients can acquire new declarative knowledge as well, provided that they do not have to remember the circumstances in which they learned it (as in source amnesia). Furthermore, amnesia can also spare semantic priming, which is mediated by semantic memory – which in turn is an aspect of declarative knowledge. Unfortunately, dissociations involving semantic priming have been much less studied – with consequences for theories of implicit memory, as noted below.

Tests of explicit and implicit memory are sometimes referred to as "direct" and "indirect," or "intentional" and "incidental," respectively. This can cause confusion, as there is also a distinction between "direct" (repetitions) and "indirect" (semantic) forms of priming, raising the risk that repetition priming could be labeled as "direct-indirect" memory, and semantic priming as "indirect-indirect" memory. Subjects deliberately intend to consciously recall past events, while priming occurs incidentally when the subject is engaged with some other kind of task. It should be understood, though, that the direct-indirect distinction applies to memory tests and not to forms of memory. In principle, priming could be used to assess consciously accessible memories that the subject declines to report, much as psychophysiological measures are used in forensic lie-detection. Similarly, a conscious memory could emerge spontaneously in the course of a priming test – a situation that has been referred to as "involuntary explicit memory." Moreover, conscious recollection can occur incidentally, as in flashbacks of traumatic memory when some aspect of a task reminds the subject of a past event. In the final analysis, both the "direct-indirect" and "intentional-incidental" dichotomies fail to capture the essence of the explicit-implicit distinction – which is that explicit memory is conscious recollection, and implicit memory is unconscious memory, of the past.

Theories of Explicit and Implicit Memory

That explicit and implicit memory are dissociable – by various forms of amnesia, by experimental manipulations, and in neuroimaging studies – is now widely accepted. A variety of theoretical accounts have been offered to explain these dissociations, which come in two basic forms: multiple memory systems and multiple memory processes.

Multiple Memory Systems

Based on the "modularity" view popular in cognitive neuroscience, a number of theorists have suggested that explicit and implicit memory reflect the performance of separate memory systems in the brain. For example, Squire (2004; see also Cohen & Squire 1980) has identified the neural substrate of the "declarative" memory system with the medial temporal lobe, including the hippocampus and related structures, and the diencephalon. Damage to the declarative system will impair explicit memory for facts and events but spare implicit memory, which is mediated by other, "nondeclarative," memory systems. There are at least five of these, mediating: procedural memory for skills and habits, located in the striatum; priming and perceptual learning, located in the neocortex; two types of simple classical conditioning, one located in the amygdala (for emotional responses) and the other in the cerebellum (for skeletal responses); and non-associative learning, located in various reflex pathways.

Schacter and his colleagues agree that the encoding and retrieval of explicit episodic memories is mediated by the medial temporal lobe system and the prefrontal cortex, while various forms of implicit memory are mediated by systems located in the cerebral cortex (Schacter, Wagner, & Buckner 2000; see also Schacter 1990). Repetition priming is mediated by a set of *perceptual representation subsystems* that store representations of the physical structure of the prime, but not its meaning. Semantic priming, as well as the explicit retrieval of semantic knowledge, is mediated by a separate semantic memory system tied to the prefrontal cortex; procedural knowledge is also cortical in nature. They also identify working memory with different cortical centers supporting each of its various components.

The *relational memory theory* of Eichenbaum and Cohen (e.g., Cohen & Eichenbaum 1993; Eichenbaum 2008) is an elaboration of Cohen and Squire's original distinction between declarative and procedural memory. On this account, declarative memory is not exactly synonymous with explicit memory; rather, the hippocampal system is critical for all forms of memory that relate arbitrary or accidental relations between the constituent features of an event – regardless of conscious awareness. By contrast, a hippocampus-independent procedural system supports the tuning or modification of processing modules engaged during initial learning. These processing modules are not dedicated to memory per se, but rather reflect plasticity within modules dedicated to perceptual, motor, and other functions.

A similar take on the multiple-systems view is provided by Bowers and Marsolek (2003). Instead of invoking multiple memory systems, they propose that implicit memory is a by-product of the plasticity of brain systems that are devoted to perceptual pattern recognition, conceptual processing, and motor behavior, rather than memory per se. These systems have individual memories, in that they are capable of encoding and recognizing information, but they are not memory systems. Bowers and Marsolek do not have much to say about explicit memory, which presumably *is* mediated by a dedicated brain system. Their approach has its roots in a proposal by Ewald Hering, the nineteenth-century sensory physiologist, who wrote that memory is "a universal function of all organized matter." Unconscious memory, on Hering's view, may be likened to the "memory" of a paper clip – which, when once bent, is easier to bend again in the same direction. Paper clips do not have memory systems, but they do have a physical structure which allows them to retain traces of their past structure.

The multiple memory systems view has been very attractive, not least because something like the doctrine of modularity lies at the heart of contemporary cognitive neuroscience. Dissociations, whether between explicit and implicit memory or any other measures, are readily explained by postulating separate brain modules underlying performance on each task. The downside, however, is that it can be tempting to invoke a new brain system whenever we encounter a new dissociation. Based on studies of verbal repetition priming, for example, some theorists postulated the existence of a *visual word form system*, associated with the extrastriate cortex, which mediates visual stem-completion, and an *auditory word-form system* mediating auditory perceptual identification. However, it is extremely unlikely that a word-form system actually exists in the brain, for the simple reason that writing is only about 5,000 years old – not enough time for the brain to have evolved such a system. More likely, the perceptual processing of words is mediated by a more generic system which mediates the identification and classification of familiar visual stimuli of all sorts – not just reading. For this reason, the challenge for multiple-systems theories is to develop a set of principles that would tell us when to stop making such inferences.

Unitary System Theories

By contrast with the multiple-systems view, other theories hold that explicit and implicit expressions of memory are the products of a single memory system. Perhaps the most intuitively appealing of these is the *activation view*, which has its roots in generic associative network models of memory (Rozin 1976). By analogy to a vacuum-tube radio, once a memory is encoded, corresponding nodes in the network retain some residual activation for a period of time – an amount sufficient to support priming, if not conscious recollection. A more elaborate version was proposed by Mandler (1980), who argued that priming in all its forms is mediated by the automatic activation and integration, at the time of encoding, of pre-existing knowledge structures corresponding to the prime; explicit memory, by contrast, requires effortful elaboration to establish new relations among activated structures. But activation, integration, and elaboration all take place within a single memory system.

Roediger's *transfer-appropriate processing* view (e.g., Roediger & McDermott 1993) holds that most implicit memory tasks, such as repetition priming, are "perceptually driven," in that they require access only to surface features of an object; by contrast, explicit memory tasks are typically "conceptually driven," in that they require access to semantic or contextual information associated with the studied item. In this view, dissociations occur because explicit memory depends on "top-down" or "symbolic" processing, while implicit memory depends on "bottom-up" or "data-driven" processing.

Yet a third single-systems view invokes Jacoby's (1991) *process dissociation framework*. In this view, explicit memory is largely a product of conscious, controlled, effortful, deliberate processing, while implicit memory is largely a product of unconscious, automatic, effortless, involuntary processing. Jacoby has further introduced a method, the *process dissociation procedure* (PDP), which measures the relative contributions of automatic and controlled processing to any task by pitting them against each other in the "method of opposition." Typically, the performance of normal subjects on a memory task is mediated by a mix of controlled and automatic processes, while the performance of amnesic patients is largely supported by automatic processes. One implication of Jacoby's theory is that explicit memory is largely a product of controlled processing while implicit memory is largely a product of automatic processing, both operating within the same memory system.

In some sense, it might seem that implicit memories are simply too weak to be consciously remembered, but strong enough to give rise to priming effects. Shanks and his colleagues (e.g., Berry, Shanks, and Henson 2008) hold that the same memory underlies both explicit and implicit performance, but the two tasks differ in terms of the distribution of noise in which the signal is embedded – greater for priming than for recognition. The model predicts that conditions that affect overall memory strength (like amnesia or deep processing) will be more likely to affect recognition than priming – thus yielding exactly the sort of dissociation that gave rise to the distinction between explicit and implicit memory in the first place.

Reder and her colleagues (Reder et al. 2009) have also argued that explicit and implicit memory draw on the same stored representation. In their view, explicit memory requires the formation of new associations, such as between a representation of the item and a representation of the episodic context in which it was presented. In most priming tasks, however, there is no such new association – the individual item, such as the word *doctor*, simply stands alone. Reder's argument is implemented in a general-purpose computational model of memory and cognition which predicts not only a wide variety of explicit-implicit dissociations, but also the circumstances under which they will *not* be observed. So, for example, the model predicts that hippocampal amnesia will impair not only explicit recollection but implicit memory for new associations, because all require the formation of associations between prime and target; however, hippocampal amnesia will not affect repetition priming, which involves only individual items. In Reder's view, the difference between explicit and implicit memory is not that one is conscious and the other unconscious, but that one is relational and the other one typically is not.

Hybrid Theories

Thesis, antithesis, synthesis: some theorists have proposed models that attempt to combine the virtues of the multiple- and unitary-memory theories. The easiest way to reconcile these two viewpoints is to agree that explicit and implicit memory reflect different processes, rather than different memory systems, but that these processes are themselves mediated by different brain systems. For example, Henke (2010) has proposed that separate brain systems support three different processing modes: rapid encoding of flexible associations (hippocampus and neocortex), slow encoding of rigid associations (basal ganglia, cerebellum, and neocortex), and rapid encoding of single or unitized items (parahippocampal cortex and neocortex). Although none of these systems is expressly identified with implicit memory, damage to the hippocampus but not to the parahippocampal cortex and neocortex will impair episodic memory but spare repetition priming – the very dissociation classically observed in the amnesic syndrome. On the other hand, hippocampal damage will also impair semantic priming, because it requires associating the prime with other information in memory.

Moscovitch and his colleagues (e.g., Cabeza & Moscovitch 2013) have suggested that memory is governed by a very large number of processing components, each associated with a different brain region. In their view, the hippocampus supports flexible relational processing involved in both conscious recollection and priming, so long as the priming involves semantic or other relations between representations; the ventral parietal cortex supports bottom-up attention involved in episodic memory retrieval. With such a proliferation of processing components, the component-process framework can account for virtually any pattern of task associations and dissociations that research might discover – an asset that is also a liability. Cabeza and Moscovitch agree that this approach lacks the appearance of parsimony, but also argue that it makes predictions that are both strong and falsifiable.

Testing the Theories

Each of these views has its strengths and weaknesses, not least because they evolved in different theoretical contexts. Multiple-systems theories bask in the reflected glory of cognitive neuroscience, but are bedeviled by the temptation to invoke a new memory system to explain every new dissociation revealed by research. The activation view gives a plausible account of priming results, but finds it difficult to explain how activation could persist for days or months – as it is sometimes observed to do. The transfer-appropriate processing view can explain dissociations not only between explicit and implicit memory, but also those that occur between two explicit or two implicit memory tasks (one perceptual, the other conceptual in nature); but it has some difficulty explaining dissociations between semantic priming and explicit memory, both of which are, in its terms, conceptually driven. A further question is whether it is appropriate to term explicit memory as conceptually driven in the first place.

The PDP view, for its part, offers a way to reconcile single-system and multiple-system views: on the assumption that automatic and controlled processes are mediated by separate processing modules that operate on a single memory store. At the very least, it has provided an increasingly popular technique for measuring the contributions of automatic and controlled processes to task performance. Like the hybrid theories just described, it offers a way to reconcile single-system and multiple-system views. However, the mathematics of the PDP requires the troubling assumption that these processes are independent of each other. An alternative view, also consistent with a single-system view of memory, describes automatic processes as embedded in, and thus redundant with, controlled ones.

One area where the various theories make competing predictions is with respect to implicit memory for novel, unfamiliar information. Activation theories would seem to suggest that this is not possible, because there is – by definition – no pre-existing knowledge structure stored in memory to be activated, or modified, by perceptual input. By contrast, the multiple-systems views are, at least in principle, open to the acquisition of new information. In fact, there is considerable evidence for priming of novel nonverbal items such as dot patterns and novel objects – though not, apparently, for line drawings of "impossible" objects that cannot exist in three-dimensional space (much like the drawings of the Swiss artist M. C. Escher). Although interpretation of these findings remains somewhat controversial, priming for novel stimuli would appear to support the multiple-systems view that repetition priming is the product of a perceptual representation system that encodes and preserves structural descriptions of stimulus events. Priming does not occur for impossible objects because the perceptual representation system cannot form a structural description of objects that cannot exist in three-dimensional space.

The situation with respect to priming for verbal materials, such as words, is more complicated. Early results, which showed priming for words like *candy* and *number* (which have pre-existing representations in semantic memory) but not for pseudowords like *canber* and *numdy* (which do not) are consistent with the activation view of implicit memory (Diamond and Rozin 1984). Bowers found priming for words (like *kite*), nonwords that followed the rules of English orthography (like *kers*) and for illegal nonwords (like *xyks*), again contradicting the activation view (Bowers 1994). On the other hand, Dorfman (1994, 1999) found priming for pseudowords made up of familiar morphemes (like *genvive*) and familiar syllables (like *fasney*), but not for pseudosyllabic pseudowords (like *erktofe*) made up of elements that are neither morphemes nor syllables in English. Her results are consistent with Mandler's view that priming of novel words results from the activation and integration of pre-existing sublexical components stored in memory: priming is less likely to occur where there are no such functional units to be activated.

The failure to find priming for impossible objects suggests that activation of prior knowledge contributes to priming of a novel stimulus. Indeed, in the verbal domain, Stark and McClelland (2000) found a strong repetition effect for words (e.g., *wave*) and pseudowords that followed the rules of English orthography (e.g., *bave*); priming of nonwords composed of random consonants (e.g., *bdxj*) yielded much weaker priming. This study is noteworthy because the paradigm permitted assessment of priming in the absence of conscious recognition under conditions that prevent contamination by explicit memory. Further adjudication between activation and acquisition theories may come from neuroimaging studies, as a decrease in neural activity: a decrease in activation during retrieval may reflect activation of pre-existing knowledge, whereas an increase would seem to implicate the acquisition of new knowledge (Henson 2003).

The theoretical debate continues back-and-forth, but theoretical development is hampered by the fact that experimental research on implicit memory is almost exclusively focused on a single experimental paradigm – namely, repetition priming. Viewed in this light, it is not surprising to find theorists proposing that implicit memory is the product of a perceptual representation systems, or of perceptually based processing. But if implicit memory extends to semantic priming, as indeed it does, such theories are too limited to account for the phenomenon. Repetition priming may be independent of depth of processing – though a more accurate statement would be that it is only *relatively* independent); but this is unlikely to be the case for semantic priming. Repetition priming may be modality specific – though not *hyperspecific*; but again, this is unlikely to be the case for semantic priming. Research on implicit memory must move beyond repetition priming if we are ever to determine its true nature.

Interactions between Explicit and Implicit Memory

Owing largely to the hegemony of cognitive neuroscience and the doctrine of modularity, the most popular theory of implicit memory remains some version of the multiple-systems view. Even so, claims for a strict separation of these memory systems should not be made too strongly. If these various memory modules were truly independent of each other, we would expect to see neurological cases where explicit memory is spared and implicit memory impaired. The reverse, of course, is what is commonly observed in amnesia. In fact, only one such case has been reported. The patient in question, known as M.S., had a scotoma (blind spot) secondary to brain surgery. He performed normally on a recognition test but poorly on a visual test of repetition priming. However, he showed normal performance on a test of conceptual priming, so it can hardly be said that he lacked implicit memory.

Whatever their underlying basis, the interaction between explicit and implicit memory can be observed in various ways. Subjects who consciously recognize the items on a perceptual-identification test (for example) may develop a mental set that actually enhances their priming performance – which is why researchers in this area take care to assess "test awareness" in their subjects, and why Jacoby's PDP has become so popular (Yonelinas & Jacoby 2012). Densely amnesic patients are not able to take advantage of explicit memory, but that does not mean that conscious recollection cannot influence priming in other circumstances.

Moreover, there is considerable evidence that subjects can take strategic advantage of implicit memory to enhance their performance on tests of explicit memory. Although free recall epitomizes conscious recollection, recognition judgments can be mediated by either conscious recollection of the test item, or by a feeling of familiarity that might be based on priming. If so, subjects can strategically capitalize on the priming-based feeling of familiarity to enhance their performance on recognition tests (Mandler, Hamson, & Dorfman 1990; Yonelinas et al. 2010). We know that, as a rule, recognition is superior to recall in normal subjects and this is also true for neurological patients with the amnesic syndrome, depressed patients receiving ECT, demented patients suffering from Alzheimer's disease, and normal subjects with posthypnotic amnesia. In addition, studies of recollective experience indicate that amnesic recognition is typically accompanied by intuitive feelings of familiarity, rather than full-fledged remembering.

Accordingly, it seems reasonable to suggest that successful recognition in amnesia can be mediated by spared implicit memory. This claim has been vigorously debated by some who insist that priming is inaccessible to conscious awareness, and so cannot serve as a basis for recognition. Despite methodological issues cutting this way and that, studies employing the PDP clearly indicate that, even among amnesic patients, recognition can be mediated by a priming-based feeling of familiarity. It may be that recollection and familiarity are governed by separate memory systems; but against a further proliferation of memory systems, it may be more parsimonious to conclude that explicit and implicit memory interact after all.

The Phenomenal Experience of Remembering

The role of familiarity in recognition brings us full circle, to the conscious experience of remembering. In a seminal paper, Tulving (1985) distinguished between two different recollective experiences: remembering, or one's concrete awareness of oneself in the past, and knowing, one's abstract knowledge of the past. For Tulving, the remember-know distinction maps onto the distinction between episodic and semantic memory. The remember-know distinction was further developed by Gardiner (1988) and others, who showed that "remember" judgments were significantly affected by depth of processing, while "know" judgments were not. This is not necessarily the functional dissociation we would expect between explicit episodic and semantic memory, both of which are the product of deep processing; but it is just the sort of functional dissociation we would expect to find between explicit memory and priming memory. In this way, the remember-know distinction maps onto the distinction between recollection and familiarity – closer, that is, to the distinction between explicit and implicit memory.

"Remembering" reflects the conscious retrieval of an episode, including a representation of the event, its spatiotemporal context, and the role of the self as agent or patient, stimulus or experiencer of that event. Viewed strictly, "knowing" reflects one's abstract, impersonal knowledge of the past.

The remember-know distinction has proved quite valuable in research on memory and amnesia. However, it now seems that we should make at least a tripartite distinction among three varieties of recollective experience: "remembering," or conscious retrieval from episodic memory; "knowing," or conscious retrieval from semantic memory; and "feeling," or an inference based on a priming-based feeling of familiarity. There may even be a fourth variety: "believing," or an inference concerning the past based on other world-knowledge. All of these may be dissociable, showing differential impairment in various forms of amnesia, different effects of experimental manipulations, and different patterns of neural activity. If so, amnesic patients and others with severely impaired autobiographical memory may be able to use these alternative routes to recollect the past.

The Implicit and the Unconscious

Together with the concept of automaticity, research on implicit memory constituted our first steps toward a revival of interest in unconscious mental life (Kihlstrom 2013). Although the psychological unconscious suffered much in the twentieth century from taint by Freudian psychoanalysis – one reason why theorists choose to speak of "implicit" memory rather than "unconscious" memory – the concepts and methods employed to study implicit learning and memory have now been extended to other domains, such as perception and even thinking – and beyond cognition to emotion and motivation. In this way, the study of implicit learning and memory offers a new, non-Freudian perspective on unconscious mental life – and, in turn, on consciousness itself.

See also 10 Affective consciousness; 38 Studying consciousness through inattentional blindness, change blindness, and the attentional blink; 39 Conscious and unconscious perception; 41 Consciousness of action.

Further Reading

Anderson, J. R. (2000) *Learning and Memory*, 2nd edn. New York: John Wiley & Sons.
Crowder, R. H. (1976) *Principles of Learning and Memory*. Hillsdale, N.J.: Erlbaum.
McConkey, J. (ed.) (1996) *The Anatomy of Memory*. Oxford: Oxford University Press.
Reder, L. M. (ed.) (1996) *Implicit Memory and Metacognition*. Hillsdale, NJ: Erlbaum.
Tulving, E. and Craik, F. I. M. (eds.) (2000) *Oxford Handbook of Memory*. Oxford: Oxford University Press.

References

Anderson, J. R. (1976) *Language, Memory, and Thought*. Hillsdale, NJ: Lawrence Erlbaum.
Berry, C. J., Shanks, D. R., and Henson, R. N. A. (2008) A unitary signal-detection model of implicit and explicit memory. *Trends in Cognitive Sciences* 12, 367–73.

Bowers, J. S. (1994) Does implicit memory extend to legal and illegal nonwords? *Journal of Experimental Psychology: Learning, Memory, & Cognition* 20, 534–49.

Bowers, J. S. and Marsolek, C. J. (eds.) (2003) *Rethinking Implicit Memory*. Oxford: Oxford University Press.

Cabeza, R. and Moscovitch, M. (2013) Memory systems, processing modes, and components: Functional neuroimaging evidence. *Perspectives on Psychological Science* 8: 1, 49–55.

Cohen, N. J. and Eichenbaum, H. (1993) *Memory, Amnesia, and the Hippocampal System*. Cambridge, MA: MIT Press.

Cohen, N. J. and Squire, L. R. (1980) Preserved learning and retention of pattern analyzing skill in amnesia: dissociation of knowing how and knowing that. *Science* 210, 207–10.

Diamond, R. and Rozin, P. (1984) Activation of existing memories in anterograde amnesia. *Journal of Abnormal Psychology* 93, 98–105.

Dorfman, J. (1994) Sublexical components in implicit memory for novel words. *Journal of Experimental Psychology: Learning, Memory, & Cognition* 20, 1108–25.

Dorfman, J. (1999) Unitization of sublexical components in implicit memory for novel words. *Psychological Science* 10: 5, 387–92.

Eichenbaum, H. (ed.) (2008) *Memory Systems*, Vol. 3. New York: Elsevier.

Gardiner, J. M. (1988) Functional aspects of recollective experience. *Memory & Cognition* 16, 309–13.

Henke, K. (2010) A model for memory systems based on processing modes rather than consciousness. *Nature Reviews Neuroscience* 11, 523–32.

Henson, R. N. (2003) Neuroimaging studies of priming. *Progress in Neurobiology* 70, 53–81.

Jacoby, L. L. (1991) A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory & Language* 13, 513–41.

Kihlstrom, J. F. (1997) Consciousness and me-ness. In J. D. Cohen and J. W. Schooler (eds.), *Scientific Approaches to Consciousness*, 451–68. Mahwah, NJ: Erlbaum.

Kihlstrom, J. F. (2013) Unconscious processes. In D. Reisberg (ed.), *Oxford Handbook of Cognitive Psychology*, 176–86. Oxford: Oxford University Press.

Mandler, G. (1980) Recognizing: the judgment of previous occurrence. *Psychological Review* 87: 3, 252–71.

Mandler, G., Hamson, C. O., and Dorfman, J. (1990) Tests of dual process theory: word priming and recognition. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology* 42: 4, 713–39.

McNamara, T. P. (2005) *Semantic Priming: Perspectives from Memory and Word Recognition*. New York: Psychology Press.

Reder, L. M., Park, H., and Kieffaber, P. D. (2009) Memory systems do not divide on consciousness: Reinterpreting memory in terms of activation and binding. *Psychological Bulletin* 135, 23–49.

Roediger, H. L. and McDermott, K. B. (1993) Implicit memory in normal human subjects. In F. Boller and J. Grafman (eds.), *Handbook of Neuropsychology*, 63–131. Amsterdam: Elsevier Science Publishers.

Rozin, P. (1976) The psychobiological approach to human memory [with Postscript: The little man in the head]. In M. R. Rozenzweig and E. L. Bennett (eds.), *Neural Mechanisms of Learning and Memory*, 3–48. Cambridge, MA: MIT Press.

Schacter, D. L. (1987) Implicit memory: history and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 13, 501–18.

Schacter, D. L. (1990) Perceptual representation systems and implicit memory: Toward a resolution of the multiple memory systems debate. In A. Diamond (ed.), *Development and Neural Basis of Higher Cognitive Function. Annals of the New York Academy of Sciences* (Vol. 608, pp. 543–71)

Schacter, D. L., Wagner, A. D., and Buckner, R. L. (2000) Memory systems of 1999. In E. Tulving and F. I. M. Craik (eds.), *Oxford Handbook of Memory*, 627–43. Oxford: Oxford University Press.

Spaniol, J., Davidson, P. S. R., Kim, A. S., Han, H.-Y., Moscovitch, M., and Grady, C. L. (2009) Event-related fMRI studies of episodic encoding and retrieval: meta-analyses using activation likelihood estimation. *Neuropsychologia* 47: 8–9, 1765–79.

Squire, L. R. (2004) Memory systems of the brain: a brief history and current perspective. *Neurobiology of Learning & Memory* 82: 3, 171–77.

Stark, C. E. L. and McClelland, J. L. (2000) Repetition priming of words, pseudowords, and nonwords. *Journal of Experimental Psychology: Learning, Memory & Cognition* 26: 4, 945–72.

Teuber, H.-L. (1955) Physiological psychology. *Annual Review of Psychology* 6, 267–96.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving and W. Donaldson (eds.), *Organization and Memory*, 381–403. New York: Academic Press.

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

Warrington, E. K. and Weiskrantz, L. (1970) Amnesia: consolidation or retrieval? *Nature* 228, 628–30.

Yonelinas, A. P., Aly, M., Wang, W.-C., and Koen, J. D. (2010) Recollection and familiarity: examining controversial assumptions and new directions. *Hippocampus* 20, 1178–94.

Yonelinas, A. P. and Jacoby, L. L. (2012) The process-dissociation approach two decades later: convergence, boundary conditions, and new directions. *Memory & Cognition* 40, 663–80.

The Blackwell Companion to Consciousness

Second Edition

Edited by

Susan Schneider and Max Velmans

WILEY Blackwell

This edition first published 2017

Registered Office
John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Offices
350 Main Street, Malden, MA 02148-5020, USA
9600 Garsington Road, Oxford, OX4 2DQ, UK
The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

For details of our global editorial offices, for customer services, and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell.

Library of Congress Cataloging-in-Publication Data

Names: Schneider, Susan, 1968– editor. | Velmans, Max, 1942– editor.
Title: The Blackwell companion to consciousness / edited by Susan Schneider and Max Velmans.
Description: Second edition. | Hoboken : John Wiley & Sons Inc., 2017. |
Includes bibliographical references and index.
Identifiers: LCCN 2016059944 (print) | LCCN 2017000216 (ebook) | ISBN 9780470674062 (cloth) |
ISBN 9780470674079 (pbk.) | ISBN 9781119002239 (Adobe PDF) | ISBN 9781119002208 (ePub)
Subjects: LCSH: Consciousness.
Classification: LCC BF311 .B5348 2017 (print) | LCC BF311 (ebook) | DDC 153–dc23
LC record available at https://lccn.loc.gov/2016059944

A catalogue record for this book is available from the British Library.

Cover image: © Anikakodydkova/Gettyimages
Cover design by Wiley

Set in 10/12pt Warnock by SPi Global, Pondicherry, India

Printed in Singapore by C.O.S. Printers Pte Ltd

10 9 8 7 6 5 4 3 2 1