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Author(s): David C. Rubin

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The Basic-Systems Model of Episodic Memory

David C. Rubin

Duke University

ABSTRACT—*Behavior, neuropsychology, and neuroimaging suggest that episodic memories are constructed from interactions among the following basic systems: vision, audition, olfaction, other senses, spatial imagery, language, emotion, narrative, motor output, explicit memory, and search and retrieval. Each system has its own well-documented functions, neural substrates, processes, structures, and kinds of schemata. However, the systems have not been considered as interacting components of episodic memory, as is proposed here. Autobiographical memory and oral traditions are used to demonstrate the usefulness of the basic-systems model in accounting for existing data and predicting novel findings, and to argue that the model, or one similar to it, is the only way to understand episodic memory for complex stimuli routinely encountered outside the laboratory.*

My objective in this article is to outline a basic-systems model of episodic memory based on our current knowledge of brain and behavior. For decades, the digital computer provided a metaphor that allowed for major advances in our understanding of cognition. It did so in part by providing a more adequate metaphor than earlier mechanical devices; in part by allowing us to temporarily ignore several hard problems, such as motivation and emotion; and in part by switching the object of study from concepts such as images, energies, and dispositions, to the concept of information, which is easier to measure and describe. But the digital computer also introduced concepts that now need modification or replacement. We are in a position to better integrate the knowledge we have gained by abandoning the computer metaphor and adopting a model based on the brain.

Address correspondence to David C. Rubin, Duke University, Psychology and Neuroscience, Box 90086, Durham, NC 27708-0086, e-mail: david.rubin@duke.edu.

A DESCRIPTION OF THE MODEL

What form would a model of memory take if it were built on our most basic, most solid understanding of the mind and the brain, instead of starting with a model based on a 1960s computer? One basic observation is that the mind and brain are divided into basic systems, including separate systems for each of the senses, spatial imagery, language, emotion, narrative, and motor output. Each system has its own functions, neural substrate, processes, structures, kinds of schemata, and types of errors that have been studied individually. Each also has its own forms of memory, possibly including its own sensory information store, working memory buffer, and long-term memory. The scientists who study the mind and the brain have long assumed the division into such systems, and in many cases, their journals and societies are divided along the same lines. Each system can be further divided, and there are various mechanisms by which the systems interact in a coordinated fashion.

What needs replacing? The key concept from the computer metaphor that is now hindering progress is what I call the concept of *homogenized information*: information that either is the same for the whole mind or is used to integrate the output of more specialized modules, that is usually abstract and propositional, and that does not depend on the unique functions and properties of each basic system. In the case of memory, the main instantiations of the concept of homogenized information are in the modal model and mathematical variants of it, but what I write also applies to other models and computer simulations of cognition that do not take into account the specific properties of each basic system. My claim is that no homogenized information or abstract, propositional language of the mind exists. There is knowledge (i.e., schemata) within each basic system, including knowledge within the language system for each natural language an individual knows. Note that I am challenging an assumption of models of memory, not our basic empirical knowledge of episodic memory and its basic systems nor the utility of viewing each system as consisting of innate mechanisms that change with experience.

I am arguing for a change in our view of the basic architecture of episodic memory. I concentrate on episodic memory rather

than on memory or cognition in general because that is my area of expertise, but I briefly discuss the full scope of the model in the next section. My main thesis is that episodic memory, and by extension all of cognition, can be understood only if the properties of basic cognitive, behavioral, and neural systems are understood individually and in combination. On the one hand, this is a trivial claim that most everyone believes is true. On the other hand, it is a radical claim with implications that require a reformulation of our concept of memory.

My colleagues and I developed a basic-systems model of memory by combining our knowledge of neuropsychology, neuroanatomy, and behavior. We applied this model to oral traditions (Rubin, 1995a) and then to autobiographical memory (Greenberg & Rubin, 2003; Rubin, 1998, 2005; Rubin & Greenberg, 1998, 2003; Rubin, Schrauf, & Greenberg, 2003). We developed as simple a model as we could that accounted for the data. The basic systems included in the model are the following: explicit memory, search and retrieval, vision, audition, olfaction, taste, kinesthesia, somatosensation, pain, vestibular function, spatial imagery, language, emotion, narrative, and motor output. Whereas explicit memory systems based in the medial temporal lobe bind all aspects of a memory that are present at the same time in a fairly automatic way, the search-and-retrieval system selects the most relevant aspects of a network of activations and often operates in a more conscious, directed manner. Thus, the function of the explicit memory system corresponds more closely to one of the historical functions of short-term memory, in that it serves the function of increasing the probability that information from a single exposure will be transferred to long-term storage, whereas the search-and-retrieval system corresponds more closely to the central executive of working memory, which has its neural basis in the frontal lobes.

In cognitive psychology, it is common to invent exactly the components that a model needs to explain particular results. In contrast, each component system in the basic-systems model has a long intellectual and experimental history. Most of the components date back as far as the recorded history of speculation about the mind (e.g., the five or so senses, emotion). Three exceptions are the separate components for language and narrative, a division based on current neuropsychological data reviewed later; the explicit memory system, which has been a subject of study since at least the case of H.M. (Scoville & Milner, 1957, see Squire, 1987, for a review); and the search-and-retrieval system, a construct that dates back at least to Baddeley's (1986) central executive.

It would be exceedingly difficult to deny that any of the basic systems are useful scientific concepts that describe components of the mind. Each can be supported by results from all of the following sources: (a) neuroanatomy, (b) neuropsychology, (c) neuroimaging, (d) cognitive-experimental psychology, and (e) individual differences research (e.g., Carroll, 1993). Knowledge from all five sources sharpens and constrains predictions re-

garding memory functions of all the basic systems. Moreover, each system, with the possible exception of the explicit memory system, is used for tasks other than memory. Thus, each system would be the only system of its kind in a model that could be extended to explain cognition in general, and the considerable amount already known about each system from its nonmnemonic functions would further constrain its functioning as a component system of memory. What is novel about the approach I am advocating is that the differences among the systems and the implications of these differences for memory are taken seriously. According to the model, all episodic memories are formed by the interaction (coactivation in Damasio's, 1989, 1994, terms) of the basic systems. Each system is a separate network, with its own behavioral properties, storage, and neural substrates, and these networks interact to produce episodic memories. Episodic memories are constructed not from a general, abstract, propositional cognitive structure of homogenized information, but rather from sensory, language, emotion, and other systems, each of which uses fundamentally different structures and processes for fundamentally different kinds of information (i.e., variable embodiment in Barsalou's, 1999, terms).

In order to provide a direct phenomenological sense of the argument that aspects of memories are stored in different systems rather than in the same abstract format, I offer the following six questions as examples. The first question is linguistic in nature and thus provides a weak contrast to recall from a long-term memory containing homogenized information because natural languages seem to be close to what an abstract language of the mind must be like: *What is your name?* The second question is visual: *What is the color and shape of winter squash?* To me, this question has a very different feel from the first. The third question is spatial: *How many windows are in your home?* This question may appear to have a visual component, but it also seems to emphasize a layout or pathway. In answering this question, people often feel as if they are taking an imaginary walk. The fourth question, which has yet another feel to it, concerns audition: *Is the first note of your national anthem higher or lower than the second?* The fifth question involves kinesthesia and motor output: *Where is the letter "a" on your keyboard?* The answer often comes with bodily motions; when I ask this question during a lecture, I can often watch my students' motions. The sixth question is emotional: *How do your feelings when you have a manuscript accepted differ from your feelings when you have a manuscript rejected?* Note that most of these questions drew your attention to one system as much as possible. To do this, I asked about general semantic information; specific episodic encounters with, for example, winter squash, keyboards, and rejections usually involve many systems. To make my argument that all memories are not stored in the same abstract format, these six questions have relied on your intuitions, but the argument can also be supported by behavioral, neuropsychological, and neuroimaging data, as I discuss later.

Why Change the Model?

Why change models now, given that the modal model is working well in many situations? There are three main reasons. First, a new model could account for complex, real-world situations involving multiple senses, language, narrative, and emotion. Although the current model works well for many unimodal stimuli, it often fails for multimodal stimuli. To make this point, later in this article I use two domains as examples: autobiographical memory, because it is episodic memory for complex situations, and oral traditions, because I have analyzed this domain in detail (Rubin, 1995a). The second reason to change models is the renewed importance of the neural basis of memory systems that has accompanied advances in structural and functional neuroimaging. To better integrate the behavioral and neural data, we need a model that respects the basic divisions of both. The third reason to change models is that the assumptions of the approach we are currently using are too simple. With the computer metaphor, all information is viewed as bits and bytes; memory becomes memory regardless of whether what is remembered is linguistic or olfactory. Such general memory models are attractive and extremely efficient, if they are true. In the first half of the 20th century, researchers interested in animal learning pursued general learning models; in the second half of the century, they more fully acknowledged that different learning systems, such as eye blink conditioning and food avoidance, despite similarities, were fundamentally different and needed to be studied separately behaviorally (Garcia, 1981; Shettleworth, 1998). Such work often led to the description of different neural pathways for different kinds of learning. Perhaps it is time for the study of human cognition to catch up.

How should our basic view of cognition change, according to the basic-systems model? Instead of viewing the mind as a general-purpose computing machine, we should view it as a collection of more specialized systems or devices, each with properties tuned for the problems it is to process. This is certainly how many scientists view perception, if not the later memory of that perception (Purves & Lotto, 2003; Zeki, 1993). In evolutionary terms, we are a collection of devices that were first developed for other purposes in other organisms and that have subsequently been adapted for use in episodic memory. This is not a new view (Fodor, 1983; Paivio, 1971; Simon, 1969), but its full implications need to be considered. Because there are many systems that need to interact, and because the transformation of information in each system is different, memory becomes highly constructive, with the constructions being guided by specific schemata in the systems involved. Answering questions comparing the properties of systems requires careful analyses of the stimuli and conditions of presentation in each system individually, much as the work of ethologists studying different kinds of learning became more relevant to learning theory once the idea of a single form of learning was questioned.

Thus, taking the basic-systems approach would encourage a fuller description of stimuli and their structure. The current

emphasis on schemata would be modified as many systems, each with its own schemata, would be considered. The question of how information from different sources, processed in different ways, interacts to produce a memory would become central. Errors in memory would be seen as occurring within particular systems, perhaps drifting toward schemata in those systems, or as occurring between systems because the wrong information from one system has been accessed in constructing a memory.

Scope

The basic-systems model is intended for all declarative memory, that is, conscious remembering. However, here I concentrate on episodic memory. The theory put forth by Barsalou (1999, 2003; Goldstone & Barsalou, 1998; Solomon & Barsalou, 2001, 2004) provides much of what is needed to make parallel claims for semantic memory. Implicit memory would in some cases require different interactions among the systems outlined here; interactions in which the explicit memory and search-and-retrieval systems would often not be included, but the basic divisions into systems, each with its own memory, would remain. Taking the basic-systems approach for episodic memory, however, entails that this approach be used for all of cognition, including attention, categorization, concept formation, perception, and problem solving (see Fuster, 2003, for a related view). Moreover, these divisions of cognition and the traditional division of memory into kinds, such as short-term versus long-term memory, would undergo transition if the model proposed here were adopted. They would become less like scientific divisions and more like chapter headings used for the convenience of exposition. For instance, different forms of attention may be in different systems (Duncan, Martens, & Ward, 1997; Jonides, Lacey, & Nee, 2005; Segal & Fusella, 1970), the distinction between short- and long-term memory might vary with the relative contributions of the different systems, and a particular problem-solving task might require more or less visual imagery.

Modularity

The idea of dividing cognition into a set of basic systems is similar to Fodor's (1983) concept of modularity, according to which the mind consists of a set of modules and central systems. Modules operate on input in a close-to-reflex manner, handing their symbolic, abstract output to central systems. For Fodor, the border between modules and central systems is the border between perception and cognition. For Fodor, the separate sensory and language modules each produce a fairly veridical view of the world, and the more abstract language of thought in the central system combines and interprets the outputs using a representation that is not primarily a combination of perceptual and linguistic information.

In contrast, the present architecture keeps processing in the different modalities separate, but interacting, and there is neither a clear border between perception and cognition nor a

central system using an abstract language of thought (cf. Barsalou, 1999, 2003; Goldstone & Barsalou, 1998; Prinz, 2002). Fodor (1983) described properties of modules, but indicated that every module does not necessarily have all of these properties; he referred to the properties as operating “more or less” and “to an interesting extent” (p. 37). The properties that are fully embraced here are that modules are domain-specific, their operation is mandatory given an appropriate input, they are associated with fixed neural architecture and so exhibit specific patterns of breakdown in the event of neuropsychological damage, and they develop with a characteristic pace and sequence. The properties that are not fully embraced are that there is limited central access to the mental representations that modules compute, that modules are informationally encapsulated, that they have shallow outputs, and that they are fast. Although these properties need not be rejected outright, they come to mean something different in the basic-systems model because it lacks true central systems that interpret modular outputs. Thus, the output of modules is not interpreted by a general-purpose computing machine that is neither linguistic nor sensory, or that uses a module-independent language of the mind. It is hard to know what behavioral evidence would support a module-independent language of the mind. The trend in the development of our understanding of the neural basis of behavior has been in the opposite direction, with cortical association areas, which might use an abstract language of thought, disappearing from maps of the functions of areas of the brain as more of cortex is found to have specific functions. In the basic-systems model, the systems interact directly with each other, using a number of mechanisms to be specified throughout this article (and especially in the section on coordination among systems).

The modules or systems incorporated in the model I present here are at a level that allows results from behavior, neuropsychology, and neuroimaging all to be used and integrated. Within each of these modules or systems, submodules or subsystems could be delineated. The clearest example is in the vision system, where at least motion, color, and form can be separated on behavioral and neural grounds. But for the other systems, the divisions are not always this clear. For instance, should the emotion system be divided into subsystems for a few basic emotions plus a subsystem for complex emotions (Ekman, 1992; Izard, 1992), or into one subsystem for positive emotions and another subsystem for negative emotions (Bradley, Greenwald, Petry, & Lang, 1992; Rolls, 2000)? In any case, the general idea that memory is best viewed as an interaction among separate systems, each with its own properties and neural basis, would remain.

Reductionism

This article and the basic-systems model use converging evidence from two independent levels of analysis: the brain and

the mind. Mind is inferred from behaviors, including verbal behavior and introspection. My goal here and in the future is to develop the model more rigorously using an iterative negotiation of the behavioral and neural data to define each system (Rubin, 1995a, 2005). The attempt to integrate two levels of analysis causes the basic-systems model to concentrate more on those aspects of mind that have known neural bases and less on the environment, including the social and cultural environment. However, this is done as a first step, only to take advantage of converging information; the model should account for behaviors that have no known neural localization and for those aspects of memory that are cued by or retrieved from the environment or organized using social and cultural schemata.

Schemata

Much research on human memory can be summarized by Bartlett's (1932) term *schema*, “an active organisation of past reactions, or of past experiences, which must always be supposed to be operating in any well-adapted organic response” (p. 201). In the modal model, schemata were often taken to refer only to abstract meaning, to gist or deep processing rather than to surface or shallow processing, but this was neither Bartlett's idea nor a reasonable summary of the data that emerged from testing his ideas (Blaxton, 1989; Bransford, McCarrell, Franks, & Nitsch, 1977; Rubin, 1995a). Rather, schemata can exist for any form of organization appreciated by the individual. For example, under this view, the good figures of Gestalt psychology are visual schemata. One way to view the thesis being put forward here is that each of the systems has its own schemata. How they operate individually and in combination is the key to understanding memory. I develop this idea further later in this article, when I consider oral traditions and autobiographical memory, but for now I provide an example of a complex event related to schemata in many systems.

Consider your memory for a particular birthday party for a preschool child. To have a full-blown episodic memory of the party that would let you write a convincing scene in a novel or entertain your friends, it would be helpful if you had schemata (i.e., abstract knowledge) in various basic systems to aid your understanding and memory of the event. Such schemata might include the following: visual schemata for the birthday cake, appropriate dress, party hats, and other decorations; auditory schemata for the birthday song and the chaotic sounds of many children playing; gustatory schemata for the standard birthday-party foods; olfactory schemata for blown-out candles; emotional schemata that could account for the likely emotions felt by children, parents, and the birthday child during events such as the arrival of guests, opening of presents, and singing a song for the birthday child; a narrative schema, probably described as a script, of the sequence of expected events; and a spatial schema for the layout of the location of the party.

Schemata in the different systems are based in different neural locations and work with fundamentally different kinds of information (e.g., odorants and temporal order). They evolved with the species and develop within the individual to serve different functions and thus to process and remember different aspects of stimuli. For instance, in the birthday-party example, the narrative and spatial schemata can be seen as working together to organize sensory and emotional information, but in different ways. A single birthday-party schema using homogenized, system-independent information would not take advantage of what we know about what the individual systems do and would not be adequate for anything but the most impoverished memories. A direct implication of this view is that schemata in each system interact with schemata in other systems, and thus accuracy and errors in memory can come both from within each system and from the interaction of systems (for examples, see Rubin & Kontis, 1983; Rubin, Stoltzfus, & Wall, 1991).

THE INDIVIDUAL SYSTEMS OF THE BASIC-SYSTEMS MODEL OF EPISODIC MEMORY

In this section, I present selective evidence to support the general argument that each of the various systems has its own functions, neural substrate, processes, structures, kinds of schemata, and types of errors that affect memory. Because the systems of the basic-systems model of memory are the basic neural and behavioral systems of much of cognition, a full review would include much of what we know about cognition and its neural basis. Instead, I note only a few key points. I concentrate on a few systems, such as vision, that are better understood than others; point out some systems, such as the motor system, about which more knowledge is needed; and ignore others completely to save space. In addition, I concentrate on behavior, because the neural bases of most of the systems discussed here are covered in textbooks. But two observations about the neural level are of note. First, the literature tends to concentrate on the cortical structures of each system, but the systems are circuits that often contain noncortical structures (e.g., Rubin, 1999). Second, neuroimaging is now clearly demonstrating that episodic memory involves the basic sensory systems relevant to the sensory content of what is remembered (e.g., Ishai, Ungerleider, & Haxby, 2000; Nyberg et al., 2000; O'Craven & Kanwisher, 2000; Rösler, Heil, & Hennighausen, 1995; M.E. Wheeler, Petersen, & Buckner, 2000), though neuropsychological evidence shows that the exact ways in which each system is involved can be complex (Mayes, 2000).

Vision

I start with vision because in cognitive psychology, cognitive science, and philosophy, there was a heated debate about whether visual imagery is needed as an explanatory concept separate from homogenized information in the form of propo-

sitions (Anderson, 1978; Block, 1981; Kosslyn, Pinker, Smith, & Shwartz, 1979; Tye, 1991). That this debate may seem a bit anachronistic a few decades later is encouraging for the view put forth here. In modeling behavior, a propositional representation can always work because it is possible to simulate an analog system of known properties, such as visual imagery, with a digital model whose properties are chosen to mimic it. However, once researchers considered neuropsychological and neuroimaging data showing that visual processing is performed in visual areas of the brain, the most parsimonious solution was to have a separate system for visual imagery (Farah, 1988).

The behavioral evidence mustered to argue that visual imagery is different from language-like propositions is consistent with the basic-system's assumption of modality-specific processing. One line of research showed that visual imagery is analog in the sense that an image shares some properties, such as shape and size, with the real object. Thus, for example, the image of an object would go through the same steps during rotation as the real object would if it were being rotated, and the size and distance of an object is reflected in its image (e.g., Cooper & Shepard, 1975; Paivio, 1975; Rumelhart & Norman, 1986; Shepard, 1978). Another line of research demonstrated that visual images have unique properties. For instance, though an image may take longer to form than a linguistic association, once formed it can be manipulated more rapidly, especially when many objects are associated in the image. Similarly, in a host of situations, sentences that can be imaged visually are faster to understand than sentences that do not lend themselves to visual imagery (see Paivio, 1971, 1986, 1991, and Rubin, 1995a, for reviews). The oldest line of evidence established that visual imagery is a great aid to memory. Most mnemonic devices from antiquity to the present have depended in part on visual imagery (Yates, 1966), and the experimental literature repeatedly demonstrated the advantage of using visual imagery (for reviews, see Paivio, 1971, 1986). Moreover, when processing that involves imagery is used, the items recalled are the ones that are easy to image, rather than the ones that have many associative links leading to them (Rubin, 1980, 1985).

Two empirical observations have been used to argue against visual images being special mnemonically. First, sentences that support visual images have more specific details than sentences that do not support such images, and so it could be that the added details, as opposed to visual imagery itself, aid recall (Chase & Ericsson, 1981; also see Hintzman, 1993, for a similar point about interactive relations in imagery). Thus, Chase and Ericsson (1981) argued that the sentence *Truth is good* has fewer specific details than *The cow kicked the ball*, and this could lead to memory differences between these sentences. For present purposes, this argument is that stimuli that involve more systems, such as the sensory and spatial systems in addition to the language system, are easier to recall than stimuli that involve fewer systems. Second, in most situations, the congenitally blind benefit from the mnemonic effects of visual imagery as much as

the sighted do, and show similar effects of visual imagery in general (De Beni & Cornoldi, 1988; Kerr, 1983). However, what is termed visual imagery may depend on tactile and other sensory input combined with spatial imagery, especially when vision is not available (Kennedy, 1993).

Spatial Imagery

There has been evidence for separate visual and spatial neural systems since the 1960s (Schneider, 1967; Trevarthen, 1968; Ungerleider & Mishkin, 1982). However, until cognitive psychologists began considering the neural substrate of imagery, visual imagery remained a unitary concept. Visual and spatial imagery can be separated on the basis of several kinds of evidence, including evidence from neuroimaging (Cabeza & Nyberg, 2000; Farah, 1988), studies of neuropsychological damage (D.N. Levine, Warach, & Farah, 1985), and dual-task behavioral paradigms (see Logie, 1995, for a review).

Spatial location has many effects on memory in people, and additional effects in animals. For many of these effects, spatial location need not be visual at all, but can be location known by auditory or tactile means. Studies have shown that spatial location is a cue to recall (H.P. Bahrick, 1974; Bellezza, 1983); that attributes of stimuli are easier to associate if paired in consistent locations (Geiselman & Crawley, 1983; Winograd & Church, 1988); that spatial location is an important attribute of memory (Underwood, 1969) that is automatically processed (Hasher & Zacks, 1979); that though spatial information typically does not help people sequence events, it can help when a known route is used to code the sequence (Paivio, 1971; Watson & Rubin, 1996), as is often the case in oral traditions; and that people have good recall for location, including the location of information on a page (Rothkopf, 1971; Zechmeister & McKillop, 1972). The information to be coded spatially need not be presented as a visual layout. When people read, they construct a spatial model for the information needed to understand the text, if they can, and they can change visual perspective within that spatial model (Johnson-Laird, 1983; Perrig & Kintsch, 1985; Taylor & Tversky, 1992). Moreover, the focus of attention can be moved linguistically within a remembered spatial layout, affecting the speed with which questions are answered (e.g., Morrow, Bower, & Greenspan, 1989).

Spatial ability and perception can be divided further at both the behavioral and the neural levels. The ability to rotate objects and the ability to navigate in the world do not seem to be the same ability, and the perception and manipulation of near (peripersonal) space and far (extrapersonal) space are different (Previc, 1998; Weiss, Marshal, Zilles, & Fink, 2003). The full implications of these differences for episodic memory have yet to be developed. For instance, it may be that near space is important mainly for particular forms of procedural memory, and that far space provides the context or setting that is a distinguishing characteristic of episodic memory.

Olfaction

Because more is known about vision than about the other senses, it is common in the literature on cognitive psychology and cognitive neuroscience to treat vision in great detail and relegate all other senses to a combined discussion, like this paragraph. Space limitations, the competence of the author, and the patience of the reader do preclude a full treatment of each sense. However, much is known about the role of other senses in episodic memory, and generalizations that hold for vision do not always hold for other senses. Different senses process information about different properties of the environment (e.g., electromagnetic radiation, vibration, pressure, chemicals that contact the sensory surface), using different transducer mechanisms and neural networks that have different short- and long-term relevance to different aspects of the individual's behavior. Thus, different senses provide very different contributions to episodic memory. Consider olfaction.

Olfaction has a strikingly different neural basis than vision. The cilia that contact odorants are one end of cells that terminate ipsilaterally in the olfactory bulb. Only one synapse must be crossed for information to reach entorhinal cortex. In contrast, information from one side of the visual field goes from the retina through many synapses before it reaches contralateral cortex, and must pass through still more synapses before it reaches areas near the hippocampus. We sense odors only when inhaling, not exhaling, so sniffing is the prototype case of active perception, one gated at the neural level. A sensory information store similar to iconic memory may not be needed for olfaction because the odorant itself remains in contact with the sense organs for a period of time. In contrast to visual and auditory stimuli, olfactory stimuli are difficult to locate without moving around in the environment, in part because people cannot tell in which nostril an odor is stronger, or is present, unless the odor has an irritant that excites trigeminal receptors. Finally, odor recognition is right lateralized in cortex (Jones-Gotman & Zatorre, 1993; Zatorre, Jones-Gotman, Evans, & Meyer, 1992).

Memory for olfactory stimuli differs from memory for simple visual, auditory, and linguistic stimuli in several ways (Engen, 1982; Herz & Eich, 1995; Herz & Engen, 1996; Schab & Crowder, 1995). Although odors seem to be associated easily with real-world events, they are associated to pictures and words in the laboratory with great difficulty (Cain, 1979). When memory for odors is tested by recognition, there is little or no effect of codability, familiarity, pleasantness, serial position, or even retention interval (for retention intervals of up to a year; Engen & Ross, 1973; Lawless & Cain, 1975). When odors are used as cues, there is no encoding specificity (J.E. Eich, 1978), and there is exaggerated proactive interference, with no observable retroactive interference (Lawless & Engen, 1977).

Olfaction also functions differently from vision at a phenomenological level. People are less successful at imaging or recalling even a strong, distinct odor (e.g., the smell of fresh-cut grass or a rose) than they are at imaging or recalling a visual

image of an object, though good recognition of olfactory stimuli implies that a memory ability is present. Experimental evidence for the lack of olfactory imagery with properties that parallel those of visual imagery supports more casual observations (Crowder & Schab, 1995). Although for a wide variety of objects it is easy to find pictures or drawings that undergraduates will label with the same word, it is difficult to find odors that produce high agreement (de Wijk, Schab, & Cain, 1995; Rubin, Groth, & Goldsmith, 1984). Although a visual image tends to represent an object, an odor tends to be a property of a class of objects. Although it is easy to describe a visual schema linguistically, it is difficult to describe an olfactory schema even with the jargon developed by specialists. Similar, though less dramatic, differences can be drawn among the other senses. If we are to extend our knowledge to include stimuli in many modalities, these differences cannot be ignored.

Emotion

“Emotion is a short label for a very broad category of experiential, behavioral, sociodevelopmental and biological phenomena” (Cacioppo & Gardner, 1999, p. 194). The emotion system modulates other systems, by influencing perception and retrieval: Emotion is more than just nodes in a network of homogenized information (Bower, 1981). Emotion has many effects on episodic memory. For instance, my colleagues and I asked participants to rate the valence and intensity of emotions in recalled events, whether each recalled event seemed to have the same emotion as the original event, and whether the recalled event reinstated visceral reactions. Each of these measures tapped a different aspect of emotion and correlated with different properties of recall (Rubin, Schrauf, & Greenberg, 2003; Talarico, LaBar, & Rubin, 2004). In general, emotions modulate memory, often increasing memory for emotionally intense events (Cahill & McGaugh, 1998; LeDoux, 1995; McGaugh, 2004) and the feeling of recollecting those events (Ochsner, 2000; Sharot, Delgado, & Phelps, 2004; Talarico et al., 2004). Damage to neural areas involved in emotion does not affect memory in general in a catastrophic manner, but does affect the improvement to memory that emotion often adds (Greenberg & Rubin, 2003).

Language

Language is its own system in most respects, and yet, like memory, it relies on many other systems for its functioning. One can separate the sensory systems easily, saying they are modulated by a shared emotion system, are bound by a common explicit memory system, and rely on shared motor systems for their output. But when one considers the range of linguistic behavior, including auditory comprehension, reading, speaking, writing, gesturing (McNeill, 1992), and signing, one finds more overlap of the language system with other systems. Even in the case of understanding the meaning of words—a clear component of

language—there is the question of how much such understanding is based on linguistic knowledge and how much it is based in the senses and other systems (Barsalou, 1999; Pulvermuller, 1999; Solomon & Barsalou, 2004). A full analysis of language in the spirit of the basic-systems model would take the form of another article much like this one, but on language instead of episodic memory. Such articles might also be written for problem solving or other tasks, but language is also a system in this model. The question, then, is what aspects of the full range of linguistic behavior are best considered central for the language system. One way to approach the problem would be to take the standard linguistic breakdown of language into phonetics, syntax, and semantics and look for these as core functions. A second way would be to study aphasia to find neural substrates that support language and little else. A third way would be through neuroimaging studies.

What aspects of language are important for episodic memory? One could easily claim that phonetics and syntax should have little effect. After all, phonetics and syntax might mainly help us decode and encode, for purposes of communication, ideas that are actually stored in nonlinguistic form. Yet according to many theoretical perspectives in philosophy and psychology, we often or always think in words, we talk to ourselves, and this inner speech is equated with consciousness (Carruthers, 1996; Damasio, 1989; Ericsson & Simon, 1993; Skinner, 1974). For such kinds of thought, to have conscious, episodic memory, we need phonetically and syntactically correct language. The argument that meaning has a role in memory is stronger. Semantics both at the level of words and syntax and at the level of phrases and sentences has traditionally been seen as a way of interpreting and storing information about the world, at both the personal and cultural levels, and different languages are viewed as fostering the formation of different realities (Boroditsky, 2001; Brown, 1965; Lucy, 1992; Whorf, 1956) and providing support for different memories (Schrauf & Rubin, 1998, 2000). In addition, in Pavlov’s terms (Popov & Rokhlin, n.d.), language is a “second signal system.” One can describe most of the activity of the other systems in linguistic terms, and such recoding into linguistic terms can have profound effects on memory. Thus, under various conditions, phonetics, syntax, and semantics are all important.

The recoding of visual or multimodal objects or scenes into language has been studied from many perspectives. All are consistent with the idea that storage occurs in both the language and the original sensory systems. Verbal recoding and rehearsal of a stimulus improves memory if the verbal label that is rehearsed leads to or counts as a correct response (Crowder, 1976; Kausler, 1974). However, if the verbal recoding does not lead to or is not counted as a correct response, verbal rehearsal can cause a decrement in performance (Pickel, 2004; Tversky & Marsh, 2000). In these cases, the verbal response does not appear to replace the sensory component that was recoded into language, but rather provides an alternative that can affect what

is retrieved (Brown & Lenneberg, 1954; Dudukovic, Marsh, & Tversky, 2004; Schooler & Engstler-Schooler, 1990). Separating the basic systems involved in retrieval provides a parsimonious view of the processing involved in these and other phenomena (D.A. Allport, 1985). Instead of asking questions about memory, we ask questions about memory in each system. For example, we examine how sensory experiences are recoded into language, and how the systems interact to provide a single retrieval. Interference within systems is analyzed separately from interference between systems.

Narrative

Narrative is “the mental representation of a series of temporally occurring events that are perceived as having a causal or thematic coherence” (Brewer, 1980, p. 223). It is a mode of thought (Bruner, 1986) used to describe particular incidents of goal-directed behavior by people and animate objects assumed to have humanlike motives. It can combine information from other systems (Bucci, 1995) and can be expressed in forms other than language, such as pictures, cartoons, silent films, dreams, and mime (Rubin & Greenberg, 2003). But when narrative is expressed in language, it makes use of structure above the level of the sentence, above the level at which most formal linguistic analyses and studies of aphasia stop. Narrative impairment has been measured in the neuropsychological literature by testing story comprehension, especially when goals or other structure has to be inferred; by testing appreciation of the goals, motives, and therefore mood or emotional tone of characters in a story; and by testing understanding of nonliteral statements, jokes, and metaphors.

Narrative is usually considered a part of language, so proposing a separate narrative component requires justification. This separation was forced by neuropsychological evidence revealing a double dissociation between language and narrative impairments. Language impairment, or aphasia, is a neuropsychologically defined syndrome, and its properties and neural basis have been well studied. In contrast, narrative loss is not a neurological syndrome, unless one equates it with dementia. However, several investigations of narrative impairments attribute problems with narrative tasks to frontal lobe or right-hemisphere damage, and not to the left-hemisphere damage typically associated with aphasia. Damage to the right hemisphere frequently results in a loss of ability to appreciate context, presuppositions, affective tone, and theme of a narrative (Goodglass, 1993; Hough, 1990; Huber & Gleber, 1982). Moreover, formal tests of aphasia do not include material with narrative structure, and when aphasics are tested on stories instead of sentences or words, their deficits are typically reduced (see Rubin & Greenberg, 2003, for a review). In the two areas of research I discuss later to support the model, the division is clear in behavioral measures as well. I show that in work on oral traditions, the claims for the effects of language and

narrative on memory are different (Rubin, 1995a), and in the existing literature on autobiographical memory, almost all claims made about the importance of language are actually claims about narrative, not claims about phonetics, syntax, or semantics (e.g., Barclay, 1996; Fitzgerald, 1992, 1996; Fivush & Haden, 2003; Habermas & Bluck, 2000; McAdams, 2001; K. Nelson & Fivush, 2004; Robinson, 1996; Rubin, 1995b, 1998; Rubin & Greenberg, 2003; Schank & Abelson, 1995).

Explicit Memory and Search and Retrieval

This section on the explicit memory and the search-and-retrieval systems is short because these systems are normally considered the behavioral and neural basis of episodic memory, and much is already known and has been written about them in this regard. In the 1950s, bilateral removal of the hippocampus and surrounding areas was shown to result in catastrophic damage to explicit memory, with relative sparing of other cognitive functions (Penfield & Mathieson, 1974; Scoville & Milner, 1957). Thus, the medial temporal lobes became known as the site of explicit memory (for a review, see Squire, 1992). The consensus view is that areas in the medial temporal lobes, especially the hippocampus and surrounding structures, are necessary for binding information into events (Squire, Stark, & Clark, 2004). Without these areas, explicit memories of events that occur once cannot be encoded (Bayley & Squire, 2002). With the passage of time, it may be possible to retrieve events that occur once without hippocampal involvement (Squire, 1992, but see Nadel & Moscovitch, 1997). The functioning of the medial temporal lobes at encoding can be seen as an automatic, modular, and nonselective process in which all information in all sensory modalities of which a person is aware gets bound into a memory without effort (Moscovitch, 1992).

The search-and-retrieval system, based in the frontal lobes, provides the selective search needed to offset the lack of selectivity of the medial temporal lobes (M.A. Wheeler, Stuss, & Tulving, 1997). It does this for episodic memory retrieval as well as for other cognitive processes (Duncan & Owen, 2000). Like other systems, it consists of subcortical as well as cortical structures (Rubin, 1999). Whereas neural damage to the explicit memory system can be catastrophic for episodic memory, damage to the search-and-retrieval system is more subtle. Often it results in a lack of responding (e.g., Watson, Welsh-Bohmer, Hoffman, Lowe, & Rubin, 1999) and, more interestingly, in the formation of memories constructed in an implausible way from parts of memories that themselves may be plausible and accurate (Baddeley & Wilson, 1986; Moscovitch, 1989; Moscovitch & Melo, 1997; Schacter, Norman, & Koutstaal, 1998). In the basic-systems model, the search-and-retrieval system contains the processes needed to find and hold information temporarily while an episodic memory is being formed and maintained—processes that are usually considered central executive functions of working memory (Baddeley, 1986). The interaction

between the explicit memory and search-and-retrieval systems is beginning to get more research attention (Simons & Spiers, 2003); placing these two systems in the context of the other systems needed to produce episodic memories may be helpful to clarify this interaction.

Motor Output

Computers typically do not act or move on their own, and this has shaped models of human cognition based on the computer metaphor of memory. The computers used in the metaphor could have been robots, but were not. With the computer metaphor, the rich history of the study of sensory motor development and perceptual motor coordination became separate from the mainstream study of cognition. An examination of current cognitive psychology textbooks shows that the perceptual systems emphasized here usually have been reduced to one introductory chapter, and motor behavior is nearly completely missing (for an exception, see Willingham, 2001).

The nervous system from the spinal cord up is divided into afferent and efferent processes, but in modern-day views of episodic memory, efferent processes are typically neglected except in work on embodied cognition and the role of enactment in memory (Engelkamp, 2001; Glenberg, 1997; Koriat & Pearlman-Avni, 2003; Zimmer et al., 2001). This neglect of efferent processes is reasonable when the tie between memories and the way they are expressed motorically is arbitrary (e.g., expressing “yes” by pressing a button, speaking, writing, or nodding). The problem is that we are active organisms seeking information (Bartlett, 1932; Neisser, 1976), and we gain information needed to adapt and develop by moving through the environment and interacting with it (e.g., Gibson, 1966). Moreover, the physical requirement that motor output have a single coordinated response makes the motor system an ideal place to study interactions among systems. However, even the reduction of all the effects of motor behavior into one system with the computer-metaphor name of motor output is an admission of an inability to understand motor phenomena to the same degree as sensory phenomena.

There is a more optimistic view. Motor output rarely seems to reach the degree of conscious reexperiencing that vision, audition, emotion, narrative, and language do. Motor output remains procedural rather than declarative. In this view, we know a great deal about motor output; it is just that this knowledge is under a different heading than our knowledge of episodic memory. What remains is to more fully integrate that knowledge with how motor output influences episodic memory, a task started by the study of embodied cognition, enactment, and oral traditions. This view opens a wider speculation about the extent to which each of the basic systems contributes to episodic memory directly as a component of conscious memory versus indirectly in a procedural manner that facilitates the formation of memory.

COORDINATION AMONG SYSTEMS

Understanding coordination among basic systems is crucial for the approach taken here, but it is in this area that we have the least knowledge, in part because the issue of biologically plausible forms of coordination is not raised in a model based on homogenized information. Thus, it is in the study of coordination among systems that a change in approach can make its greatest contribution.

If each system provides a different analysis and memory of the world, then we can learn much more by studying memory in terms of these systems than by studying memory in terms of homogeneous information within one system. Psychologists familiar with experimental design often think in terms of orthogonal dimensions; each dimension is a variable that exists at all possible levels. The real world usually lacks this property, making coordination among systems an especially powerful way to cue memory. Consider the following example of the power of interactions among systems (Rubin & Wallace, 1989). The linguistic-meaning cue “building material” was found to cue the word *steel* with a probability of .00, and the auditory cue “rhymes with *eel*” also cued *steel* with a probability of .00. Thus, the expected combined probability that these supposedly independent cues would cue *steel* was .00, $p_a + p_b - (p_a \times p_b)$. However, the combined cue “a building material rhyming with *eel*” cued *steel* with a probability of 1.00, because there is simply no other alternative.

In theoretical terms, if single cues do not uniquely define a target, no single monotonic function can predict the strength of a dual cue formed from those single cues. Formulas like $p_a + p_b - (p_a \times p_b)$ do not apply, and what matters is the number of possible targets (Rubin & Wallace, 1989). In practical terms, this is one reason why rhyme cues have little effect on memory for words when used in isolation, but are very effective when used in conjunction with other cues—so much so that rhymes are one of the best and most commonly used mechanisms for increasing the ease of remembering of advertisements and songs. When rhymes are appreciated as schemata (Rubin, 1995a) that limit choices (Bower & Bolton, 1969), rather than considered the prototype for a shallow and mnemonically inefficient form of homogenized information, rhyme cues are extremely effective. When the differences in processing between rhyme and category cues are also taken into account, researchers can learn much more (D.L. Nelson, 1981). Thus, interactions among basic systems can illuminate our understanding of episodic memory of complex stimuli, but under current theories of memory, these interactions are generally ignored.

If we do not use Fodor’s (1983) division into modular and central systems, we need an alternative description of the coordination of the systems in the basic-systems model of episodic memory. Objects and events in the world are the stimuli for the individual systems. By definition, each stimulus has a single place in space and time. Thus, much of the problem of binding

the properties of stimuli processed in different systems can be handled by any mechanism that appreciates these spatial and temporal contiguities. Where might such integration occur in a real brain? For purposes of exposition, I discuss three classes of coordination among systems: *general coordination*, which involves all systems involved in the memory of an event; *specific coordination*, which involves a few systems or subsystems that are related to particular aspects of events; and *spatial coordination*, which can use not only the general setting, but also specific spatial contiguity.

General Coordination

I outline three types of systems for the general coordination of episodic memory: dumb, smart, and smarter. A dumb system would bind together everything that occurred at the same time into one event that could later be retrieved as a memory. Such a system would be very useful to have if one often did not know until later which events would need to be recalled, and we and the legal system often assume we have this kind of memory. A smart system might modulate the encoding of memories on the basis of the discrepancy between what was expected and what occurred (Rescorla & Holland, 1982), on the basis of surprise (Brown & Kulik, 1977) or interest (Bartlett, 1932), or on the basis of emotional arousal (Cahill & McGaugh, 1998; Dolcos, LaBar, & Cabeza, 2004; Talarico et al., 2004). A smarter system might have the ability to search for some components of a memory when cued by other components, while using inhibitory mechanisms to suppress dominant responses that do not fit all the criteria set by the known cues.

Substantial evidence indicates that we have all three kinds of general coordination systems. In the basic-systems model of memory, the dumb coordination is handled primarily by the explicit memory system, the smart coordination is subsumed under the emotion system, and the smarter coordination is a function primarily of the search-and-retrieval system. Depending on the situation, the three types of coordination are involved to differing degrees, resulting in differing memory strengths for differing retrieval cues and motivational states. Invoking such complexity is easy, but a specification of the details is needed. One reason to consider a new memory model is to take stock of the considerable knowledge we have and to point to areas of ignorance that need study.

Specific Coordination

There are many forms of coordination that might be local in that they involve only a few systems or subsystems. For instance, the visual, gustatory, olfactory, tactile, and emotion systems integrate in orbital frontal cortex to produce taste and regulate intake of nutrients relatively independently of other systems (Rolls, 2004). The specific integration of such processes might be reactivated more easily by a cue than by general coordination mechanisms.

Another well-studied domain in which specific coordination occurs is vision, which involves numerous subsystems, including those for motion and color (Felleman & Van Essen, 1991; Van Essen, Anderson, & Felleman, 1992). In theorizing on how these visual subsystems combine in perception, Zeki (1993) noted that specialization into motion and color subsystems requires integration, but that there appears to be no single anatomical area to which all specialized visual functions project, and that even when two specialized functions do project to the same anatomical structure, each maintains its own anatomical territory within that structure. Zeki proposed that output from the specialized processing areas for color and motion project back to primary visual cortex. Thus, unlike taste, for which the integration of sensory and emotional information occurs at the downstream end of cortical processing (Rolls, 2004), vision may be integrated at the upstream end. This reentry allows the outputs to be combined on the basis of their initial spatial location on the retina. Thus, visual perception is the result of ongoing activity in areas with reentrant connections to primary visual cortex. In the next section (on spatial coordination), I extend this reentrant hypothesis, which takes advantage of the spatial and temporal contiguity of objects and is well supported for vision, to other basic systems that code for location in the world.

Spatial Coordination

As a mechanism for the combination of information in episodic memory, reentry has many attractive properties, both for the organism and for the models used to describe episodic memory. First, the reentrant concept avoids a homunculus. Second, for vision, the idea can be made specific and testable, and the data support the existence of reentry (Zeki, 1993). For instance, reentry from higher visual cortical areas to primary visual cortex occurs during spatial attention (Noesselt et al., 2002; Woldorff et al., 2002), and reentry from motion areas to primary visual cortex is needed for conscious awareness of motion under some conditions (Pascual-Leone & Walsh, 2001). Third, objects and events exist at specific times and locations, so it would make a great deal of sense to maintain detailed spatial location as an organizing feature of memory by having reentry to neural structures that maintain spatial localization. At a behavioral level, such use of location within an object is the main way Barsalou (1999) solved the problem of combining features, often from different modalities, in semantic memory, and a similar approach could be used for events in episodic memory. Fourth, in the reentry view, conscious perception occurs when higher levels project back onto a lower spatiotopic area. By analogy, conscious recall would occur when neural activity similar to the original event is reinstated in a coordinated fashion on a spatiotopically mapped area.

To extend the idea of reentrant combination to the basic-systems model in a neurally plausible fashion, we need to

identify an area of the brain that has high spatiotopic resolution and that receives input from many senses. What could this area be? In current knowledge, no nonvisual sense has an area with resolution as high as that of primary visual cortex. Olfaction, gustation, and audition do not seem to have any high-resolution spatial mapping areas that preserve location in the world. In the case of touch, localization of external space is limited to areas within reach. There is a high-spatial-resolution homunculus map for touch, but it maps location on the body, not location in the world.

Perhaps primary visual cortex can serve as a general spatial mapping area. It has inputs that are not visual; touch and audition have inputs to primary visual cortex (Falchier, Clavagnier, Barone, & Kennedy, 2002; Kaas & Collins, 2004). Or maybe the ventral or object visual pathway is better viewed as a multi-sensory object pathway. For instance, functional magnetic resonance imaging (fMRI) studies have found that the lateral occipital complex, a region on the ventral visual stream that includes the occipital temporal junction, is more active in response to visually presented objects than in response to scrambled objects or textures. Many of the areas in the lateral occipital complex that are active during visual presentation of objects are also active during haptic presentation. The activity during haptic presentation is stronger than the activity observed when the objects are visually imagined, making it unlikely that the activity caused by tactile identification is due only to concurrent visual imagery (Amedi, Malach, Hendler, Peled, & Zohary, 2001). Visual exploration of novel objects produces activation in many of the same areas of the lateral occipital complex that haptic exploration produces, and viewing visually and haptically familiar objects produces more activity than viewing novel items (T.W. James et al., 2002). Thus, what are commonly considered visual processing areas have sufficient auditory inputs to affect visual processing and are also used by touch. Other sensory modalities that do not code for location in the world, such as olfaction and gustation, do not appear to send information to visual cortex or to take part in such general spatial mapping.

One problem with using primary visual cortex for reentry for episodic memory is that primary visual cortex maps location in terms of the retina, not the external world, but translating retinotopic and other body-based sensory information to world-based location is a standard problem for mobile organisms. The nervous system has evolved mechanisms to handle the difference between location in retinal coordinates and location in the world (e.g., Macaluso & Driver, 2004), and such normalization is a classic issue in behavioral studies of object and pattern recognition (e.g., Neisser, 1967). Moreover, for memory, there usually is no scene present, and if there is a competing scene present, averting gaze from it increases memory performance (Glenberg, Schroeder, & Robertson, 1998). Thus, a scene, event, or object can be remembered as existing as if the eyes were looking at the center of the visual field, making the retinotopic

mapping of primary visual cortex a mapping of the object or scene.

Summary of Forms of Coordination

Thus, communication among systems is not restricted to central systems that operate after all basic modular processing has taken place. The situation is more complicated than that. General coordination, specific coordination, and spatial coordination all contribute to episodic memory. The neurosciences have had a longer and more sophisticated discussion of coordination among systems than have the behavioral sciences (for reviews, see Calvert, Spence, & Stein, 2004), but a model like the one proposed here will require more behavioral studies of coordination.

An Example of Coordination: The Serial Nature of Recall in Oral Traditions

Having discussed memory for events in general, I turn now to memory for oral traditions. Within an oral tradition, recall is usually for a text heard, not for an event witnessed, and so there are specific forms of coordination that are organized by the serial nature of the encoding and recall. A brief outline of these forms of coordination and their implications for recall is provided here as an example of what can be done to study the coordination of systems under specific circumstances; more detailed analyses with tests of hypotheses are available elsewhere (Rubin, 1995a).

Recall in oral traditions is serial recall (Rubin, 1995a). What has been recalled provides cues for what is to be recalled next. Local, implicit, word-by-word or phrase-by-phrase cuing is the dominant form of cuing in oral traditions. The poetic devices of rhyme, alliteration, and assonance work locally within lines and between nearby lines (Hyman & Rubin, 1990; Rubin, 1977). Meaning, visual imagery, and spatial imagery also function in a local, serial fashion. Only rhythm is effective globally, because the specific rhythm used in the first line or stanza of an oral tradition is the same rhythm that is used in all lines or stanzas. For rhythm, the local organization is the global organization. Because the same rhythm repeats, it does not provide by itself a cue that discriminates among what is to be recalled. However, rhythm does combine with and accentuate other forms of organization to increase their effectiveness, and it does change the organization from one long list into a hierarchy of sublists.

Multiple cues make recall easier. They help discriminate the items to be recalled from all other items. Interference theory and later theories of memory view cue overload (Watkins, 1979, 1990) as a major cause of forgetting; when a cue leads to many items, cue-item discrimination is low, and a unique item cannot be retrieved. *Cue underload* is a property of oral traditions and accounts for much of their stability. Each item to be recalled is discriminated from others in memory by many different kinds of cues. Similarly, in the laboratory, multiple cues are much more effective than single cues (H.P. Bahrick, 1970; Mantyla, 1986; Mantyla & Nilsson, 1988; Solso & Biersdorff, 1975). As noted

earlier, weak rhyme and weak meaning cues can combine to discriminate a word from all words in the language without any learning occurring at all (Rubin & Wallace, 1989). The effectiveness of multiple cues is increased in oral traditions because the cues come from different systems. The different systems differ in their time courses and other properties, making the contribution of each system especially effective in particular situations. In addition, many of the multiple constraints in oral traditions reinforce each other. For example, the rhythm makes the rhyme clearer, and rhyme often marks the end of the line, making the rhythm clearer.

There is, however, a severe cost to basic systems working in serial recall, a cost that the basic-systems model makes clear and that is difficult to understand from any other perspective. When multiple cues come on-line in sequences and thereby cue the next word or phrase in many ways simultaneously, words or phrases often cannot be cued by just one cue alone. Thus, one cannot successfully start a song anywhere, but must start at the beginning or at least at the beginning of a rhythmic unit. One cannot directly recall what words in a ballad rhyme with *ee* or even what happens in the last stanza. Rather, one has to sing the ballad and listen for *ee* sounds and pay attention to the last stanza when one gets to it. That is, information in oral traditions is not content addressable. To get a sense of this idea informally, think of a story you know well, or a talk you heard recently, and try to summarize it or recall a part of it from the middle. In contrast, think of a poem, song, or prayer that you know well and that has a clear meaning. Try to summarize it without singing all the way through it, or try to start it from the middle of a line. The same serial processes that enable cuing in serial recall limit access except through serial recall. This is a novel observation for psychology, but it is not a new observation. Plato wanted to ban poets from the Republic because the content and form of their presentations made critical analysis difficult (Havelock, 1963), and the lack of content addressability is one of the standard criticisms of "rote learning," or memorization. Not all recall that involves many basic systems simultaneously is serial, and the problem of a lack of content addressability disappears when recall is no longer strictly serial, as is the case with autobiographical memory.

WHERE ARE THE MEMORIES?

Metaphors for Memory

There are two main metaphors of memory. The one most related to linguistic usage and most intuitive to nonpsychologists and to most psychologists is the storage metaphor, in which reified memories are things to be retrieved. The classic example is William James's (1890) attic. In more modern terms, the storage metaphor is the computer hard drive, where files are recorded, searched for, and retrieved, though many other analogies have been made (Roediger, 1980). Each memory has its own place, and no changes are possible, except for deterioration. The other

metaphor is that of learning, skill, tuning, or transfer-appropriate processing (Blaxton, 1989; Bransford et al., 1977; Gibson, 1966; Hyde & Jenkins, 1973; Jacoby, 1991; Kolers & Roediger, 1984; Kolers & Smythe, 1984; Rubin, 1988; Skinner, 1974; Toth & Hunt, 1999; Watkins, 1990). In this view, the organism is changed by its interaction with its environment so that it processes information differently the next time similar information or thoughts are encountered. For most people, the skill metaphor is much less intuitive than the storage metaphor. One advantage of the skill metaphor, however, is that it avoids positing a copy or representation of the world in the mind; rather, memory is viewed as the interaction of past experience with the present situation. Thus, for some systems, such as vision, much of a memory can remain in the world and be referred to when needed.

Either metaphor works for the basic-systems model, though the idea of processes fits more easily. What is crucial is that the storage or changed processes occur in the relevant systems. Under either metaphor, memories are constructed from information in the various systems. Under the storage metaphor, events in the world are transformed into neural impulses of various kinds. For example, light reflected from an object causes some cells in the retina to fire more rapidly than others, which causes electrical signals; these signals, in turn, cause more permanent chemical changes in the brain, which result in a visual memory of the object to be stored. Under the skill metaphor, the same stimulation in the same pathways results in changes in the strengths of connections among neurons that allow the organism to react differently later. Under either metaphor, the construction of an episodic memory requires interaction among all the relevant systems, the construction can be accurate or not, and a person can be cued by the environment or can cue him- or herself in the absence of external stimuli.

Two Notes on the Neural Basis of Memory

Two considerations provide boundary conditions for the neural basis of memory in the basic-systems model. First, every system discussed here has memory in that it can learn from experience. In fact, it is likely that every neuron in every system has the potential to learn from experience. It would be amazingly inefficient if all changes associated with experience in olfaction, vision, emotion, and language were kept in a separate memory area; rather, many of these changes should remain in their relevant systems. Interaction among systems is needed for conscious, episodic memory, but this does not imply that the content is stored in the coordinating connections.

Second, although the neurons in the brain are massively interconnected, not all neurons are connected to (innervate and are innervated by) all other neurons. There are about 2×10^{10} neurons in neocortex and about 1.5×10^{14} synapses, so that each neuron is highly connected to other cortical neurons—each having about 7,000 synapses (Pakkenberg et al., 2003). Nonetheless, at most, only about one in three million of the

potential connections among these neurons exist—that is, $(1.5 \times 10^{14}) / (2 \times 10^{10})^2$. The densest proportions of connections are within the systems; that is what makes them systems at the anatomical level. Thus, memory can occur everywhere in the human brain, and it has systems of highly, but selectively, connected neurons.

A CONTRAST TO OTHER MODELS OF EPISODIC MEMORY

A Brief Description of the Modal Model

To provide an example of differences between the basic-systems model of memory and current models, I briefly review the modal model of memory, a model that has organized many observations about human memory, provided many insights, and suggested lines of productive research for about 40 years. I present a generally accepted consensus, a textbook account without full citations to the thousands of articles that contributed to it. I do not provide details of the many variants and computer instantiations of this model; the differences noted here generally hold for them all. Going back at least to Aristotle's wax tablet, human memory has long been modeled on the most advanced technology of the time, and Atkinson and Shiffrin's (1971) modal model of memory was no exception, being based on the hardware of the 1960s mainframe computer. The modal model of memory has a short-term memory that is the seat of consciousness and active processing and that holds verbally coded material; it also has a passive, unitary long-term memory that holds information that is not currently in consciousness. The short-term memory component was replaced by Baddeley's concept of working memory in the 1980s. Following Baddeley (1986, 2000, 2001), I omit discussion of the sensory buffers of Atkinson and Shiffrin's model, which transfer easily to the basic-systems model.

Historically, the modal model has been moving in the direction outlined in this article, as have other more computational approaches to cognition (Anderson, Bothell, & Byrne, 2004). In the model's earliest version, in the 1960s, short-term memory held verbally coded information. That is, the model was designed for linguistic material, such as word lists, or stimuli that could be verbally coded. Baddeley (1986) added two working memory buffers. The phonological loop maintains the linguistic basis of short-term memory, but is analog to the extent that it holds 1.9 s of linguistic information. The visuospatial sketchpad is an analog device that holds visual and spatial information. Recently, Baddeley (2000, 2001) added a multimodal episodic buffer. The episodic buffer temporarily binds information from multiple senses and long-term memory, a function carried out by the explicit memory and search-and-retrieval systems of the basic-systems model.

Two points should be emphasized. The first is the degree to which the modal model resembles the computer of the 1960s rather than what was known about the mind or brain at the time; the second is the extent to which modality-specific processing is

not considered. The 1960s computer had two kinds of memory. The very limited central processor that held the information being manipulated or transferred to long-term stores became the model for human short-term memory. The long-term storage devices that held information without change (except for passive degradation with age) unless the information was brought back to the central processor became the model for long-term memory. The direct parallels between the computer hardware and the modal model were apparent to researchers and commonly appear in textbooks on cognition.

Turning to the second point, the current modal model includes limited modality-specific processing, a later addition that occurred when Baddeley replaced short-term memory with working memory. Visual stimuli have their own working memory buffer; auditory stimuli do not. There is a working memory buffer specifically for linguistic sounds, but not sound in general; for musical, environmental, and other nonlinguistic sounds, there is no working memory buffer. Other senses have no working memory buffers, though within the working memory framework one could argue for them (e.g., Smyth & Waller, 1998). There is no differentiation of long-term memory into separate memory stores corresponding to the basic systems used here. Information in long-term memory is generally abstract, homogenized, and symbolic (see Barsalou, 1999, for a more detailed history). System-specific memory appears in the form of coding or attributes of memory (Underwood, 1969) and in arguments for specialized memory systems for visual imagery (Paivio, 1971, 1986; Shepard, 1978), olfaction (Schab & Crowder, 1995), and action (Glenberg, 1997; Zimmer et al., 2001), but these have not resulted in a general questioning of the role of homogenized information.

Thus, the computer metaphor brought with it the idea of abstract information rather than system-specific processing. The amount of information in a stimulus or memory could be measured and compared with the amount of information in another stimulus or memory, regardless of whether the information was primarily visual, auditory, olfactory, or emotional (Shannon & Weaver, 1949). All that mattered was the amount of information and how it was transformed. Similarly, theories could be expressed as executable computer programs that were independent of the initial modality of the information and of the detailed nature of the hardware on which they would be implemented and, by analogy, of the brains of the humans whose behavior was to be explained. Within cognitive science, there were exceptions to and arguments with this trend; the most notable exception was the consideration of biological plausibility in many of the neural net architectures that challenged the standard propositional programming languages used to model human memory (Rumelhart, McClelland, & the PDP Research Group, 1986).

Problems With the Modal Model

The modal model was developed in large part for verbal stimuli and works well for simple unimodal stimuli, such as words and pictures, when the stimuli are considered as symbols (Barsalou,

1999) or as homogenized information that is either remembered or forgotten. Along with many others researchers, I have used this model and continue to use it successfully with words, pictures, and nonsense strings (e.g., Rubin, Hinton, & Wenzel, 1999), but as I have shown, it cannot account for the memory of complex stimuli, a task for which it was not designed.

The use of homogenized information instead of system-specific information was caused in part by the distinction between surface and deep structure that was being developed in linguistics at the time the modal model was being formulated. Homogenized information is abstract; it captures the essence, meaning, or gist of the stimuli. In a model based on homogenized information, the sensory or surface details are not coded in long-term memory and cannot be remembered after a few seconds. Although this theoretical point was countered by many observations and common sense, it was supported by experiments in which the gist was the only easy-to-use form of organization and the only form of organization needed to perform the task at hand (Rubin, 1995a). The idea that abstract information is all that is retained remained part of the legacy of the homogenized information of the modal model, resurfacing in the depth-of-processing approach (Craik & Lockhart, 1972). In contrast, in the basic-systems model of memory, different systems have different mnemonic properties and organizational schemata to support memory; there are schemata for surface information, as well as for gist (Rubin & Kontis, 1983; Rubin et al., 1991).

One could attempt to solve the problems noted here by adding more working memory buffers and by differentiating long-term memory in the existing modal model. But the basic architecture would remain that of a 1960s computer, rather than being based on what we know about neuroanatomy, neuropsychology, and behavior. Such a revised model would still lack the special forms of processing that each system performs, and such a revised model would ignore questions about the different kinds of coordination among systems because they would be assumed to be handled by working memory. It is not that the modal model has ignored evidence at the neural level. In the 1960s, retrograde amnesia was examined as a way to find support for the difference between short- and long-term memory. Later neuropsychological and neuroimaging results were used to bolster, test, and improve the model. But this work always took the form of searches for particular kinds of patients or evidence to test issues within a well-established architecture based on 1960s computers. Researchers did not start with what we know about the organization of the nervous system to help frame the basic architecture.

A Contrast to Other Neural Models of Episodic Memory

The basic-systems model of memory is based heavily on what we know about the nervous system as well as behavior. Does this model also differ from existing neural-based models of memory? Because of the strong influence of theory from cognitive psy-

chology on neuropsychology and cognitive neuroscience, it does, though that is changing as work in neuroimaging advances (Buckner & Wheeler, 2001; Nyberg et al., 2000). For instance, in 1995, Fuster could write

This book is about the *memory of systems*, not about systems of memory. The distinction is crucial, for it clearly detaches the approach of this author from that of others Memory is a functional property, among others, of each and all of the areas of the cerebral cortex. (p. 1)

Most theories that make claims about the neural basis of episodic memory hold, as does the basic-systems model, that episodic memory requires an interaction among the medial temporal lobes, the frontal lobes, and the rest of the cortex. However, the implications of this claim have rarely been investigated. In particular, most major theories do not dissect memory storage into basic systems. Conway and Pleydell-Pearce (2000), for example, stated that memories are stored in an “undifferentiated pool” called “event-specific knowledge” (Fig. 1, p. 265). Kopelman’s model provides a detailed analysis of executive and emotional systems that play a role in memory, but only a single module is devoted to storage (Kopelman, 2000, Fig. 6, p. 608; Kopelman & Kapur, 2001, p. 1417). McClelland, McNaughton, and O’Reilly (1995, Fig. 14, p. 444); Squire (1992); Murre (1999, Fig. 1, p. 269); and Markowitsch (2000) all focused on medial temporal regions and devoted little attention to posterior neocortical sensory storage sites. McDonald, Ergis, and Winocur (1999) mentioned the hippocampus, the amygdala, the frontal lobes, the thalamus, and the basal ganglia—in fact, almost every region except the posterior neocortex sensory areas—as being involved in memory.

Even theories that do mention memory in the neocortex do not address the relative contributions of several different cortical areas to memory in general (with the exception of theories addressing anterior and lateral temporal regions). It is not that we are ignorant of the roles of these neocortical regions—in fact, the contrary is generally true—but rather that any such knowledge has rarely found its way into neurobiological theories of memory, and episodic memory specifically (Greenberg & Rubin, 2003). The major exceptions are found in more recent neuroimaging work (e.g., Nyberg et al., 2000). For instance, Buckner and Wheeler (2001) integrated the role of the explicit memory and search-and-retrieval systems (“retrieval attempt,” p. 624) with the role of sensory systems (“retrieval content,” p. 627).

Parallel Distributed Processing

Connectionist models based on parallel distributed processing of artificial neural networks are, in general, amenable to the approach taken here in that they often make biological plausibility a key feature (e.g., McClelland et al., 1995; Murre, Graham, & Hodges, 2001; Rumelhart et al., 1986; Schmajuk & DiCarlo, 1992). However, because the goals of these models vary

from the goals of my model, such models vary widely in the degree to which they implement the basic systems outlined here. Such models would be one way to implement in a more rigorous fashion the ideas put forth here.

EVALUATING THE BASIC-SYSTEMS MODEL

There are at least two levels at which the basic-systems model of memory can be evaluated. First, to evaluate the model as an approach, all we need to consider is whether the basic claims hold and whether they lead to novel predictions and research. Second, to evaluate the model as a full model, it is also necessary to specify mechanisms and test them. In the next sections, on autobiographical memory and oral traditions, I do more than show that the basic-systems approach is a good and useful one, but less than test a fully specified model. The latter would require more than one article and more knowledge than is currently available about the interaction of the various systems. In particular, issues of just how insulated the systems are from each other and exactly how they interact have not been studied in enough detail. The need for more study is greater for behavior than for the neural basis of behavior, in part because no behavioral model or framework has required this information.

The foundational claims of the basic-systems approach are that (a) the systems listed at the beginning of this article are a reasonable division of cognition, (b) the different systems have different properties that affect memory, and (c) interactions among the systems are important to memory. All these claims are supported by evidence and have been for a considerable time. Most of the divisions of cognition into basic systems date back to antiquity and are as close to fact as one gets in psychology. Similarly, the claim that the various systems have different properties that affect memory has considerable support and intellectual history. What has been lacking is the integration of these properties in one theoretical framework in which their interactions can be studied, and that is what is being proposed here. The basic-systems model adds to studies that consider one system at a time by providing a chance of obtaining a single coherent view of complex cognitive tasks that involve multiple systems. Ironically, accounting for a complex task is one of the same tests set by Newell (1973) for homogenized information: "to demonstrate that one has a sufficient theory of a genuine slab of human behavior" (p. 303). To demonstrate that the basic-systems model can contribute novel findings and theoretical integrations, I examine autobiographical memory and oral traditions.

A TEST AND APPLICATION TO AUTOBIOGRAPHICAL MEMORY

In terms of theory, from the perspective taken here, autobiographical memory is the same concept as episodic memory as developed by Tulving and his colleagues (Tulving, 1983, 1985;

M.A. Wheeler et al., 1997). However, autobiographical tasks differ from classic laboratory episodic memory tasks in ways that lead to more basic systems being important (Cabeza et al., 2004; Rubin, 1998, 2005).

Consider the prototypical episodic memory task of list learning and the prototypical autobiographical memory task of retrieving autobiographical memories in response to cue words (Crovitz & Schiffman, 1974; Galton, 1879; Robinson, 1976; Rubin, 1982). Differences include the following:

- What is recalled in the episodic memory task is usually a list of unimodal stimuli, either visual or auditory, whereas in the autobiographical memory task, multimodal events are recalled.
- The items in the episodic memory task usually share no narrative coherence relative to the learning episode or to events before or after it, whereas the autobiographical memory task usually involves coherent events that are important to the person and his or her self-concept or life story, thus increasing the role of narrative.
- In the episodic memory task, the items are usually learned in the same context and in temporal proximity, whereas in the autobiographical memory task, the items are usually not learned in this way, so that the importance of spatial imagery and narrative is greater.
- The episodic memory task tends to have minimal emotional involvement compared with the autobiographical memory task.
- In the episodic memory task, the retention interval is usually less than 1 hr, whereas in the autobiographical memory task, the retention interval is often a lifetime, thus allowing differences in the various processes over longer time intervals to be measured.
- The time to recall is typically on the order of 1 s in the episodic memory task and on the order of 10 s in the cue-word autobiographical memory task. On a cognitive modeling level, cyclical retrieval (Conway & Pleydell-Pearce, 2000; Conway & Rubin, 1993; Norman & Bobrow, 1979; D.M. Williams & Hollan, 1981), in which each successive partial retrieval serves as the cue for the next search, might produce such a 10-s delay; at a neural level, such a delay is consistent with a nervous system in which the components of a memory are distributed across basic systems in a way that requires a relatively long time to produce coactivation.

In sum, autobiographical memory is like classic laboratory episodic memory in theoretical terms, but autobiographical memory tasks should typically involve more of the systems of the basic-systems model and their interaction.

Another way in which episodic and autobiographical memory tasks differ is in the importance of the self. Some approaches to autobiographical memory emphasize the self in such a way that it would amount to a separate system in the basic-systems model. The self as an enduring essence that maintains a

fixed set of goals and values and is stable through minor and major life changes often does the work in psychology that the soul once did in earlier attempts to understand human nature—and that is much more work than a single scientific concept should have to bear. In the basic-systems model, the self is a collection of highly developed schemata, in several of the basic systems, that maintain the relatively stable characteristics of the individual, a view that borrows from an earlier proposal of Neisser's (1988). The self's neural location is thus highly distributed.

The Neural Basis of Autobiographical Memory

Neuroimaging

The purpose of this section is not to definitively show what regions of the brain are active during the retrieval of an autobiographical memory and how they interact. This area of research is growing too rapidly, and there is not enough agreement among different neuroimaging laboratories on what constitutes an autobiographical memory (and on what, if any, subtraction tasks should be used to isolate it) for this ambitious goal to be met. Rather, my goal is to show that data at hand can best be understood in terms of the basic-systems model.

In particular, neuroimaging studies of autobiographical memory reveal activation not in one autobiographical memory area, but rather in several basic systems. Studies have shown that during recall of autobiographical memories, there is activation in the explicit memory system (e.g., Addis, McIntosh, Moscovitch, Crawley, & McAndrews, 2004; Cabeza et al., 2004; Fink et al., 1996; Gilboa, Winocur, Grady, Hevenor, & Moscovitch, 2004; Greenberg, Rice, et al., 2005; Piefke, Weiss, Zilles, Markowitsch, & Fink, 2003; Piolino et al., 2004; Ryan et al., 2001), in the search-and-retrieval system (e.g., Conway et al., 1999; Fink et al., 1996; Gilboa et al., 2004; Greenberg, Rice, et al., 2005; Piefke et al., 2003; Piolino et al., 2004), in the visual system (e.g., Addis et al., 2004; Cabeza et al., 2004; Conway et al., 1999; Gilboa et al., 2004; Piefke et al., 2003; Piolino et al., 2004), in the spatial system (e.g., Addis et al., 2004; Cabeza et al., 2004; Piolino et al., 2004), and in the emotion system (e.g., Greenberg, Rice, et al., 2005; Piefke et al., 2003; Piolino et al., 2004). Currently, most researchers using fMRI and positron emission tomography (PET) to study autobiographical memory describe their results in terms of networks of interacting areas corresponding to the basic systems outlined here.

Not only are a number of systems involved, but each has a particular role and time course when people are asked to retrieve and hold autobiographical memories. My colleagues and I used fMRI to track brain activity in various areas while 17 young adults retrieved autobiographical memories in response to 80 cue words (Daselaar et al., 2005; LaBar et al., 2005). When participants retrieved a memory, they pressed a button and maintained the memory until they were signaled to rate it for intensity of emotion and the extent to which they relived the

memory. Figure 1 plots activity in three regions of interest, with time measured from peak activity in the motor cortex, corresponding to the button press. Some areas associated with the explicit memory and search-and-retrieval systems—in particular, the hippocampus (results shown in Fig. 1), along with retrosplenial cortex and areas in right inferior prefrontal cortex—followed a time course consistent with retrieval in that activity in these areas increased from baseline after the stimulus word was heard and decreased once the memory was formed. Other areas followed a time course suggesting they were involved with the decision that a memory was formed, because their time course was similar to that of the areas of motor cortex responsible for the button press. These included areas in the search-and-retrieval system—in particular, left prefrontal cortex (results shown in Fig. 1) and left parietal cortex in a region slightly inferior to that usually associated with retrieval success in laboratory episodic memory studies (Buckner & Wheeler, 2001). A third set of areas followed a time course suggesting they were involved in maintenance of the memory; activation in these areas increased after the memory was found. These areas included visual cortex (results shown in Fig. 1); the precuneus, an area associated with the visual system; and areas in the left parietal and left dorsolateral prefrontal cortex associated with search and retrieval. Activity in the amygdala before the button press correlated with the rated intensity of the emotion, whereas activity in visual cortex after the button press correlated with rated reliving of the memory. Thus, the emotional ratings were foreshadowed by activity in the amygdala before the memories were judged as well formed.

Neuropsychology

If autobiographical memory is supported by the systems of the basic-systems model of memory, a logical first question for

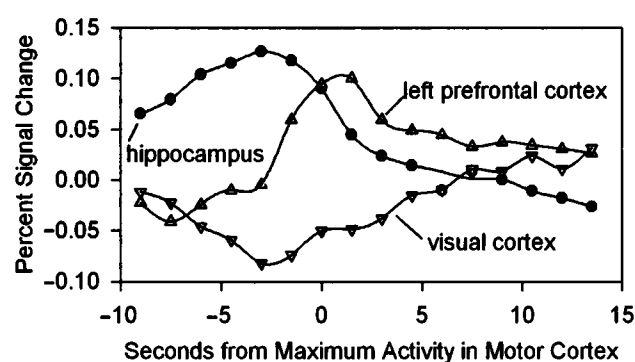


Fig. 1. The time course of brain activity during autobiographical memory. The graph shows the percentage signal change for three areas representing three different processes: Recovery or retrieval of the memory is indicated by activity in the hippocampus, decision that a memory was retrieved is indicated by activity in left prefrontal cortex, and reexperiencing or maintenance of the memory is indicated by activity in visual cortex. The timing is from the time of maximum activity in motor cortex, corresponding to the button press indicating that a memory was formed, which is given a value of zero.

neuropsychology to investigate would be what would happen if individual systems were damaged (Greenberg & Rubin, 2003; Rubin & Greenberg, 1998). If a system is damaged so that all memory in that system (or some particular aspect of it) is lost, then we would, of course, expect that loss to be evident in autobiographical memories. But can we find cases in which there are additional losses? We know a great deal about what occurs with damage to the two core memory systems used for binding and retrieving information from different systems: explicit memory and search and retrieval. As the effects of damage to these areas on autobiographical memory have long been studied, little can be added by the basic-systems model of memory, and so I review those effects quickly. However, little systematic work has examined how damage to the rest of the brain affects autobiographical memory, and so I review these effects in more detail as an example of what can be gained by using the basic-systems model of memory.

When the explicit memory system (i.e., the medial temporal lobes that include the hippocampus and surrounding areas) is damaged, classical cases of amnesia occur. Typically the loss of memory is greater for the time after than before the damage, and there is a reverse of normal forgetting in that memories from earlier in life are more likely to be spared than more recent memories (Ribot, 1882; Squire, 1987, 1992). Damage to the frontal lobes, especially the right frontal lobes, affects the search-and-retrieval system and produces confabulations (Baddeley, 1986; Moscovitch, 1989), that is, autobiographical memories that are inaccurate and often implausible but that appear to be the result of combining aspects of actual events or thoughts from several different events. The person who confabulates does so without awareness of the problem. Thus, damage to the explicit memory and search-and-retrieval systems has clear, well-known effects on autobiographical memory. What about damage to other systems?

There are many reasons to suspect that the language system should be important in autobiographical memory and that damage to it should have major effects. Moreover, language impairments, or aphasias, are commonly caused by brain injury (Goodglass, 1993), so there are many cases to examine. However, with the exception of semantic dementia, language impairments do not cause major impairments of autobiographical memory. Indeed, Broca's aphasics have written autobiographies (Luria, 1972; Wulf, 1979). Even conduction aphasics, who may lose inner speech, do not typically manifest any major deficits in autobiographical memory (e.g., D.N. Levine, Calvanio, & Popovics, 1982). Although aphasia can cause severe, obvious, and extensive changes to affected patients' speech and comprehension, it does not necessarily prevent these patients from producing well-structured autobiographical memories if they are given enough time and a choice of modalities in which to record their memories. Thus, except in the case of semantic dementias, language loss does not result in amnesia. Similarly, effects of damage to the amygdala and thus the emotion system

appear not to extend beyond changes in processing emotional stimuli (see Greenberg & Rubin, 2003, for a review).

But what about the sensory systems that process and, according to the basic-systems model of memory, store modality-specific aspects of memories? If stored sensory information in one system is lost, it should be absent from autobiographical memory. But if this information is central enough to memory, its loss could result in the loss of autobiographical memory as a whole, producing a global amnesia. That is, in neural net terms or in terms of Damasio's (1994) ideas of coactivation, if a significant sensory component of an autobiographical memory is lost, it may not be possible to activate the rest of the memory. Because sensory systems are not organized temporally, there is no reason to expect any temporal gradients in the loss, and so one might see either total loss of autobiographical memory involving stored information or a normal type of forgetting curve, which would be the opposite of the forgetting curve observed in medial-temporal amnesia. Autobiographical memory for events that took place after the damage should be relatively normal, except for details in the damaged sensory modality, as the explicit memory system would still store autobiographical memories using other sensory information. In contrast to central cortical damage to a sensory system, which results in loss of stored information in that system, peripheral damage should eliminate input in that system, but not access to information that has already been stored.

Consider the visual system. Optic blindness, whether congenital or acquired, does not produce any significant memory impairment outside of visual information. In fact, studies of visual imagery in the congenitally blind find that it is difficult to show any deficit on tasks involving visual imagery when tactile or verbal input is used (De Beni & Cornoldi, 1988; Kerr, 1983). The loss in autobiographical memory is the loss of visual information that occurred after the blindness (Ogden & Barker, 2001). But how does the loss of visual memories that were stored before neurological damage affect autobiographical memory? If vision is as important to autobiographical memory as reviewed in the next section (on the behavioral basis of autobiographical memory), then there should be profound effects; the loss of visual memory should prevent the construction of autobiographical memory. On the basis of Kosslyn's (1980) theory of visual imagery, Farah (1984) proposed that patients must meet three criteria in order to be considered to have lost visual memory. First, they must be able to copy line drawings, which indicates that their perceptual abilities are intact. Second, they must be unable to recognize objects by sight (i.e., unable to indicate their names and functions). Third, they must be unable to draw objects from memory, describe objects' visual properties from memory, or have a visual image of objects upon introspection. The first two criteria identify patients with visual agnosia; the third criterion demonstrates that the deficit arises from impaired access to long-term visual memory rather than difficulty generating, manipulating, or interpreting images.

In a review of the literature, Greenberg and I (Greenberg & Rubin, 2003; Rubin & Greenberg, 1998) found 11 patients who met these three criteria. Our analysis of their reported abilities and deficits produced striking results. All 11 had a general amnesia that extended beyond a visual deficit to include all aspects of autobiographical memory and that, to the extent described in the case studies in the literature, fit our expectations regarding the effects of the loss of stored visual information. Because their amnesia resulted from a deficit of visual memory, we labeled it *visual memory deficit amnesia*. Of the 7 patients for whom both anterograde and retrograde amnesia were reported, 5 had severe retrograde amnesia with more moderate anterograde deficits. Moreover, there was no temporal gradient in 4 of the 5 patients for whom the retrograde amnesia was reported in sufficient detail to judge which temporal periods were lost.

Thus, visual memory deficit amnesia had the properties that would be predicted if important stored information was lost but the explicit memory system used for encoding remained intact—properties that differ from those of the more common amnesias caused by damage to the medial temporal lobes. Although medial temporal damage might account for some of the memory loss in some of these cases (5 of the 11 patients had some sign of medial temporal damage), the patterns of the deficits suggest otherwise. In-depth testing of 1 of these 11 patients confirmed our general observations (Greenberg, Eacott, Brechin, & Rubin, 2005). The findings are consistent with most neuropsychological and neural net theories of memories (e.g., McClelland et al., 1995; Schmajuk & DiCarlo, 1992), and aspects of our explanation of visual memory deficit amnesia were considered in 2 of the case studies we reviewed (Hunkin et al., 1995; Ogden, 1993). Thus, our approach led to identification of a new type of amnesia, one that now seems to be tentatively accepted (Kopelman & Kapur, 2001; Westmacott, Leach, Freedman, & Moscovitch, 2001; M.A. Wheeler & McMillan, 2001).

We searched for similar modality-specific memory loss involving senses other than vision. It was difficult to find cases of spatial memory loss, and many cases of spatial deficits involve the right hippocampus and thus overlap with cases of deficits in the explicit memory system. We could assemble a reasonable set of cases only for auditory memory loss (Greenberg & Rubin, 2003). These patients did not exhibit a loss of autobiographical memory beyond the auditory components of the memories. We are not sure whether this difference from visual memory loss is due to the importance of vision in autobiographical memory, to other aspects of vision, or to areas involved in the neural basis of vision also being involved in tactile and auditory processing and thus being object areas rather than just visual areas, as suggested in the section on spatial coordination.

The Behavioral Basis of Autobiographical Memory

I begin this section by reviewing what is known about the role of four systems that are central to recalling autobiographical

memories: visual imagery, language, narrative, and emotions. The differences in the effects of these systems indicate that a model based on homogenized information will not be sufficient to account for autobiographical memory. Finally, I examine how these and other systems combine to produce autobiographical memories and especially two key phenomenological properties of autobiographical memory: a sense of recollection and the belief that a memory is accurate.

Contributions of Visual and Spatial Imagery

The behavioral literature often confounds visual and spatial imagery, and so I combine them in this section, but later in discussing their effects on a sense of recollection and the belief that a memory is accurate, I examine them separately. Even when cues are verbal and retrieved memories are reported verbally, visual imagery and spatial imagery play an important part in the retrieval of autobiographical memories (Schrauf, 2003). Visual and spatial imagery are central to three lines of research on autobiographical memory. The first is work on flashbulb memories. The term *flashbulb memories*, coined by Brown and Kulik (1977), denotes memories for which one's mind seems to take a picture of important events. The picture metaphor here reflects not only the assumed accuracy, but also the vivid visual imagery (Rubin & Kozin, 1984; Talarico & Rubin, 2003). Visual and especially spatial imagery are also important to the distinction between *field* and *observer* points of view, that is, whether one sees oneself in the memory or sees the memory from the original observer's viewpoint (this distinction dates back at least to Freud; see Robinson & Swanson, 1993, for a review). One can change perspective by manipulating the image of an autobiographical memory to take a different view. For instance, one can distance oneself from the memory. The third line of research in which visual and spatial imagery play a central role is work on demonstrating that specific, concrete details make a memory seem more accurate, thoughtful, and believable (Pillemer, 1998; Pillemer, Desrochers, & Ebanks, 1998). An eyewitness's testimony is more effective if details are included, even if they are irrelevant (Bell & Loftus, 1989), and remembering sensory details makes people likely to judge that they performed an action rather than just thought about it, though the spatial imagery may be more important than the visual image itself (Johnson, Hashtroudi, & Lindsay, 1993; Johnson & Raye, 1981). Thus, forming visual images of events that never occurred may be important in the creation of false memories (Gary, Manning, Loftus, & Sherman, 1996; Hyman & Pentland, 1996).

Underlying these three uses of visual and spatial imagery are two conflicting metaphors: Flashbulb memory seems to imply that imagery is a static, accurate picture, but the other two uses suggest that imagery is a fluid mental model that is created at will and can be seen from different points of view (both literally and figuratively). What is important here, though, is that the visual and spatial properties of memory, not the linguistic medium used to express it, are what matters.

An interesting asymmetry in the model is that spatial context has its own, separate system of spatial imagery, but temporal context is only one part of the narrative system. If this asymmetry is a historical accident of the neural basis of spatial context being better understood than the neural basis of temporal context, this is a flaw that will need correction. However, the asymmetry is a strength if spatial context is an integrated aspect of individual autobiographical memories and temporal context is not, but is arrived at through various strategies (Brewer, 1996; Friedman, 1993).

Contributions of Language

One way to look at the behavioral effect of language on autobiographical memory is to obtain autobiographical memories from people who know two languages, because bilinguals can provide information on how their different languages affect their memory. A particular memory of a bilingual can come in a particular language, much the way a dream can come in a particular language (Marian & Neisser, 2000; Schrauf, 2000, 2003; Schrauf, Pavlenko, & Dewaele, 2003; Schrauf & Rubin, 1998, 2000). The language of the memory is often not the language in which the memory testing is done, but is instead likely to be the language that was being used at the time of the event. Phonemic content that is part of a cue or a memory (e.g., a Japanese /r/ vs. a Spanish /r/ vs. an English /r/), syntactic structure (see Bock, 1986, and Rubin, 1995a, for examples), and the culturally laden semantic content of words can all keep a memory in a language by cuing similar content or structure (Schrauf et al., 2003). But unlike the more traditional theoretical approaches to bilingualism, in which there is memory for each language and for a homogenized and abstract *conceptual store* (e.g., Kroll & de Groot, 1997), the basic-systems model does not include a homogenized conceptual-store system. All memory is in one of the systems outlined, and thus not in the language of mind of a homogenized conceptual store.

Contributions of Narrative

Most researchers who have examined the form and content of autobiographical memory have focused on narrative structure, and most claims for the importance of language in autobiographical memory have actually been claims for the importance of narrative. Narrative establishes a major form of organization in autobiographical memory, providing temporal and goal structure. Autobiographical memories are usually recoded as narrative; they are told to another person and to oneself. Inclusions and exclusions depend in part on the narrative structures used. Information that is not central to the narrative structure of the schema being used is less likely to be remembered than information that is more central. For example, Brown and Kulik (1977) observed that reports of flashbulb memories tend to include canonical categories of information, such as the place, the ongoing event that was interrupted by the news,

the source of the news, affect in others, affect in self, and the aftermath. Neisser (1982) countered that these categories may be properties of the narrative genre used to report any news, rather than properties of flashbulb memories per se.

There has been considerable research on the role of narrative in autobiographical memory (Fivush & Haden, 2003; K. Nelson & Fivush, 2004). For example, Barclay (1996; Barclay & Smith, 1992) framed autobiographical memory in terms of the conversational nature of autobiographical remembering. Conway and Pleydell-Pearce (2000) viewed narrative structure, especially goals, as central to the formation of autobiographical memories, and Conway (2004) organized all knowledge structures in people's autobiographical memory under their life stories. Fitzgerald (1992, 1996) used concepts like *narrative thought* and *self-narratives* to account for autobiographical memory and its changes with mood and age. Habermas and Bluck (2000) used *autobiographical reasoning* to understand the process by which autobiographical memories are combined into a coherent life story and related to the current self. Schank and Abelson (1995) claimed that "the content of story memories depends on whether and how they are told to others, and these reconstituted memories form the basis of the individual's *remembered self*" (p. 1). Pasupathi (2001) described the narrative-based social construction of autobiographical memory and its development. Using a psychoanalytic framework, Schafer (1981) and Spence (1982) noted the importance of narrative for autobiographical memory.

Freeman (1993) took a more humanistic approach to tie narrative to autobiographical memory, and Gergen and Gergen (1988) used narrative structure to emphasize the social nature of remembering and the self. Narrative structure is central to recollection in groups (Hirst & Manier, 1996) and to the shared memories that define them (Bruner & Feldman, 1996). Children must have the ability to create narrative structure in recollection before they develop autobiographical memory (Fivush, Haden, & Reese, 1996; K. Nelson, 1993; K. Nelson & Fivush, 2004). Narrative coherence is often claimed to be reduced in individuals with posttraumatic stress disorder (van der Kolk & Fislser, 1995), but the evidence for this claim can be questioned (Berntsen, Willert, & Rubin, 2003; Rubin, Feldman, & Beckham, 2003).

Thus, narrative has functions and schemata in autobiographical memory that are different from those of visual and spatial imagery and language. But narrative imperialism (e.g., Schank & Abelson, 1995) needs to be avoided (Rubin, 1995b). Narrative may be especially important for the development of autobiographical memory, as emphasized by K. Nelson and Fivush (2004), only because it is the slowest system to develop (Habermas & Bluck, 2000) and thus is the limiting factor. Moreover, narrative is often important because it is used to communicate to other people the information that is in other systems, such as visual imagery, rather than because of its intrinsic value. The experience of having an image is linguistically

marked in narrative (Chafe, 1982, 1990; Pillemer et al., 1998) and has been at least from the time of Homer (Bakker, 1993). For instance, Chafe (1990) noted that the linguistic dimension of *involvement* is marked by the use of first person and dialogue, and we use these same properties to infer that other people are reliving an experience or seeing it in their mind's eye (Pillemer et al., 1998).

Contributions of Emotion

Although there is some research on the effects of individual emotions on episodic memory (see L.J. Levine & Pizzaro, 2004, for a review), most research on the relation between emotion and memory has investigated the dimensions of emotional intensity and valence (see Berntsen, 2002, and Talarico et al., 2004, for reviews). The intensity of emotions at the time of recall increases the intensity of most phenomenological reports, whereas the effects of valence are more limited (Talarico, 2002; Talarico et al., 2004). Both the valence and the intensity of emotions at the time of recall affect tunnel memory; people focus on the central details of their memories more for negative and for intense emotional events than for positive and less arousing events (Berntsen, 2002; Christiansen, 1992; Christianson & Safer, 1996). Although positive memories are more frequent than negative memories among involuntary memories, extremely negative memories continue to return unbidden for longer periods of time than extremely positive memories do (Berntsen, 2001). Valence also affects the distribution of memories over the life span. Older adults show a bump, or increase, in memories from adolescence and early adulthood (relative to other life stages) when asked for their most positive memories, but not their most negative memories. Because a similar difference does not occur when memories are cued by words, this effect may be driven by differences in the search for memories related to positive emotions, rather than by the negative emotional content of the memories. A typical life script contains many positive events in adolescence and early adulthood (Berntsen & Rubin, 2002, 2004; Rubin & Berntsen, 2003).

Emotions associated with autobiographical memories can be categorized not only in terms of intensity and valence, but also in terms of higher-level cognitive evaluations, such as whether the emotion recalled is the same as that originally experienced, and direct reports of current visceral reactions, such as whether the person's heart is racing. In a study of undergraduate students' memory reports for a recent negative event, reported visceral reactions were better predictors of later symptoms of post-traumatic stress disorder than were more cognitive evaluations (Talarico & Rubin, 2003). Reports of visceral reactions also correlated more highly than more cognitive evaluations with symptoms of posttraumatic stress disorder in a sample of veterans diagnosed with posttraumatic stress disorder (Rubin, Feldman, & Beckham, 2003).

Many studies of the effects of mood and depression on autobiographical memory have been conducted. Mood at the time of

recall has clear effects on the recall of autobiographical memories: The emotion in recalled memories tends to match the current mood. The degree to which this effect reflects a match to the memory as originally encoded is less clear (Christianson & Safer, 1996; E. Eich, 1995; E. Eich, Macaulay, & Ryan, 1994). Depression makes autobiographical memories less specific and more likely to reflect a merger of many events of a similar type—"times that I did X," rather than "one time that I did X." This effect appears to be mediated by changes in the search process that extend to other tasks (M.J.G. Williams, 1996). If this interpretation is correct, the emotion effects are mediated by changes in the search-and-retrieval system.

In general, the effects of emotion are consistent with the view that emotion modulates memory encoding and recall. Emotion interacts with the spatial, narrative, and search-and-retrieval systems, as reviewed here and in the section on the contributions of visual and spatial imagery to autobiographical memory. Viewing emotion as a separate system that contributes to autobiographical memory may help to untangle these effects. It is hard to imagine how to increase our understanding of autobiographical memory without viewing emotion as a separate system that has its own properties and modulates visual and spatial imagery, narrative, and language.

Recollection and Belief

The degree to which a person recollects or relives an autobiographical memory is a basic property of, and in some systems a defining feature of, episodic memory (Rubin, Schrauf, & Greenberg, 2003; Tulving, 1983, 1985; M.A. Wheeler, Stuss, & Tulving, 1997). In the list-learning literature on episodic memory, there are many studies about recollection as measured by the remember/know distinction (Gardiner, Ramponi, & Richardson-Klavehn, 1998; Yonelinas, 2002). The degree to which a person believes that an event really happened the way he or she recalls it is of great practical and theoretical importance (Johnson & Raye, 1981; Loftus, 1979). Both recollection and belief are phenomenological reports. One can assess them by how a person acts, but unless deception is suspected, the ultimate measure of recollection and belief in a memory is a verbal report of a phenomenological state. In the basic-systems model, recollection and belief are considered metacognitive judgments based on processing in basic systems. At the behavioral and neural levels, they are analyzed in terms of activity in those systems (Rubin, 1998).

In several experiments (e.g., Rubin, Burt, & Fifield, 2003; Rubin, Schrauf, & Greenberg, 2003; Rubin & Siegler, 2004), my colleagues and I measured participants' degree of recollection, asking them to rate the extent to which they felt that they were reliving the original event and the extent to which they felt they had traveled back to the time when it happened. We measured belief in the accuracy of memory by asking participants to rate the extent to which they believed the event in their memory really occurred in the way they remembered it (i.e., that they had

not imagined or fabricated anything that did not occur); whether they were confident enough to testify in a court of law; whether they could be persuaded that their memory was wrong; and whether the memory was distorted by beliefs, motives, and expectations rather than being an accurate reflection of the event. We measured the reported activity of the basic systems, such as the visual, auditory, spatial-imagery, and emotion systems, by using rating scales as well. Each participant retrieved and rated 15 to 30 memories, so we could conduct correlational analyses within participants and average the resulting correlations over all participants. The degree of recollection was predicted by visual and auditory imagery, the degree to which the memory was a coherent story, and emotions. In contrast, the degree of belief in the accuracy of the memory was positively predicted by how well the setting was remembered and by coherence of the story, and was negatively predicted by how long ago the event occurred. R^2 values were generally between .50 and .75. The finding that vivid imagery predicted reliving and spatial layout or setting predicted belief is consistent with earlier work (Johnson, Foley, Suengas, & Raye, 1988).

We also averaged the ratings over all memories for each participant and then correlated the means for each person's rating scales. Thus, the theoretical issue changed from the standard cognitive psychology question of how processes within a person affect each other to the individual differences question of how individuals who vary in a particular ability differ in their average degree of belief in and recollection of their autobiographical memories. The magnitudes of the correlations were similar to those obtained within persons, described in the previous paragraph, except for two changes. First, people who tended to relive their emotions more tended to believe their memories less. Second, the R^2 values for predicting belief were about half as big as they were in the within-subjects analysis; individual differences in belief in the accuracy of memories could not be predicted well by overall imagery or other cognitive variables. However, individual differences in belief could be predicted by measures of depression, dissociation, and personality (Rubin, Schrauf, & Greenberg, 2003; Rubin & Siegler, 2004).

The measure of emotional processing used in these studies was the degree to which the emotions reexperienced were judged to be the same as the original emotions. Thus, it is not surprising that emotional reliving predicted recollection. We therefore tried to predict recollection, belief, and the ratings used to assess our basic systems with the two standard dimensions of emotion: intensity and valence (Talarico et al., 2004). Overall, valence was not a predictor of most of our measures, but it did predict recollection and belief, with more pleasant memories being rated higher on both variables. Intensity was a much stronger predictor of all measures than valence was, with one major exception: Belief was not predicted by the intensity of emotion, supporting our initial finding that the degree of emotional recall was not related to belief in the accuracy of the memory.

Summary of the Evidence on Autobiographical Memory

It is very difficult to make sense of the neuroimaging, neuropsychological, and behavioral data on autobiographical memory without using an approach very similar to the basic-systems model. Different systems each contribute in their own unique ways to the construction of autobiographical memories. At both the neural and the behavioral levels, visual memory and spatial memory play a central role. The contributions of other systems, including systems for language, narrative, emotion, and olfaction (Vermetten & Bremner, 2003), can also be demonstrated to be important. In sum, an examination of the data provides considerable support for the basic-systems model or something very much like it.

A TEST AND APPLICATION TO ORAL TRADITIONS

Oral traditions provide the strongest behavioral evidence of why the basic-systems model, or something very similar to it, is needed to understand human memory. In oral traditions, such as ballads, epics, and children's counting-out rhymes (Rubin, 1995a), verbal material is transmitted through memory with little change for centuries. The products are elegant and considered some of the world's best literature. But oral traditions are more than an art form. When written records are uncommon, oral traditions are the only way of preserving and transmitting cultural knowledge that is coded in linguistic form.

Applying knowledge from cognitive psychology in conjunction with the basic-systems model of memory leads to an understanding of these genres that was not previously available. There is no way to understand the stability and change observed in oral traditions except by examining the structure and processing of the systems in this model, both separately and in interaction; analyses based on homogenized information fail. I present no neural data. Analysis of the systems at the neural level, however, does constrain the general properties of the systems involved and their interaction at the behavioral level.

Oral Traditions

Oral traditions are genres of literature transmitted for long periods of time with minimal use of external memory aids. Thus, oral traditions depend on human memory for their preservation. For a tradition to survive, it must be stored in one person's memory and told to another person who can retain and retell it. This must be repeated over many generations (Rubin, 1995a). The transmission of oral traditions must be different from the standard rumor procedure in psychology (G.W. Allport & Postman, 1947; Bartlett, 1932), or else the traditions would change radically or die out. To accomplish stability in memory, oral traditions have developed interacting schemata in basic systems, thereby decreasing the changes that human memory imposes on more casual transmission of verbal material. Thus, oral

traditions can provide a test of theories of memory on a grand, literally epic, scale.

Some oral traditions are rituals and are intended to be recalled verbatim. But the evidence indicates that recall is not, in fact, verbatim (Hunter, 1984); accuracy cannot even be measured without writing. Most students of oral traditions (including myself) claim that a specific variant of a tradition is not being memorized and transmitted (Foley, 1990; Havelock, 1978; Lord, 1960; Ong, 1982). Rather, what is being transmitted are the schemata in many of the systems of the basic-systems model. The schemata from different systems interact to drastically limit the number of possible solutions and thereby the number of possible changes that would be acceptable. Once schemata for the narrative, auditory-imagery, visual-imagery, spatial-imagery, kinesthesia, and perhaps other systems are satisfied, much of what can be recalled and still fit all the schemata is fixed, much as the rhyme cue "eel" and the category cue "building material" limit the possible responses to one word, *steel*, as discussed earlier. As discussed earlier, this added stability comes at a cost: A variant of a piece from an oral tradition can be produced only by starting at the beginning; each word provides cues in many systems for the words that follow.

It is reasonable to use oral traditions as a comparison to more traditional models of laboratory memory paradigms. Oral traditions are verbal material. They are presented as words and are recalled as words. Thus, they could be remembered completely in terms of language, and so finding a role for other systems and their interaction is noteworthy. In addition, the nearly perfect learning of verbal material in oral tradition is similar to, and thus can provide a contrast with, many kinds of verbal learning in the laboratory. It was my frustration with trying to understand the stability and change in oral traditions in terms of theories of memory that ignored the different schemata and processes in different systems that led me to begin formulating the basic-systems model of memory. In my study on memory in oral traditions (Rubin, 1995a), I provided information on oral traditions in general and on how memory operates in epic poetry, children's counting-out rhymes, and the genre included here (oral tradition ballads). I also discussed schemata in different systems and the need to consider them simultaneously in more detail than can be offered here.

An Example of One Genre: Ballads

A good argument can be made that oral-tradition ballads like those analyzed here existed "from the dawn of English history" (Kittredge, 1904, p. xiv), a claim consistent with scholarship in other European languages. For a portion of this time, a popular broadside, or printed, tradition and later a phonograph-recording tradition that did not need to rely on human memory existed. Nonetheless, the effects of such external memory aids appear to have been minimal in the North Carolina tradition I analyze here (Rubin, 1995a). In addition to being an oral tradition that still

exists today and that dates back to the Middle Ages, ballads have the advantage of an extensive scholarly literature that can be drawn on to describe their properties and transmission (Richmond, 1989), a literature that was formed independently of and thus can provide converging evidence for the basic-systems model.

The words and the music of ballads are remarkably stable. The following three variants of a stanza from "Lord Thomas and Fair Annet," spaced over 250 years and two continents, illustrate the stability, high visual imagery, and dramatic, objective narrative style of the ballad. They also illustrate how changes in wording are accompanied by stability in the narrative, visual, and auditory schemata (including the rhythm, rhyme, and alliteration).

This brown Bride had a little Penknife,
That was both long and sharp,
And betwixt the short Ribs and the long,
Prick'd fair Ellinor to the Heart.
(from *A Collection of Old Ballads*, 1723)

The brown girl she had a little pen-knife,
And it was keen as a dart;
And between the short ribs and the long
She pierced fair Eleanor's heart.
(from Mrs. R.D. Blacknall, Durham, NC, ca. 1812–1820; Belden & Hudson, 1952)

Well, the brown girl she had a little pen knife,
The blade were wonderful sharp,
Betwixt the long ribs and the short,
She pierc-ed fair Ellender's heart.
(from Bobby McMillon, Lenoir, NC, 1989, collected by Wanda T. Wallace)

Auditory Imagery

The central organizing property of ballads is the stanza. Thus, what a cognitive psychologist might consider to be a shallow depth of processing provides the unyielding rhythmic form to which schemata in all other systems have to fit. Stanzas of a ballad have either 14 (common meter) or 16 (long meter) stressed syllables. Once the first stanza is sung, the rhythm and music for the entire ballad are known. In contrast, the details of all other forms of organization are not known until they are nearly reached in the course of singing. Each stanza is a narrative unit and a visual-and-spatial-imagery unit; except for the core stanzas that carry the story, each stanza can be omitted or included at the singer's discretion. Idea units of narrative, visual scenes, and spatial locations do not run over the end of one stanza to the next. This chunking into rhythmic units (or lack of necessary enjambment in literary terms) is common in oral traditions, including the epic tradition, where it occurs on a line-by-line basis and makes composition at the level of rhythmic units easier. However, the singer has only 14 or 16 stressed

syllables in a stanza to express a complete idea, so that between 5 and 20 stanzas of these complete ideas make a story. This structure severely affects the choice of words. There is little room for “he said” and other clarifications in many ballads, and so confusions in the narrative can be introduced.

Auditory imagery in the form of rhyme, alliteration, and assonance are part of the ballad genre. A conservative measure indicates that there is a consistent pattern of end rhyme in 79% of the 29 most often cited popular ballads in the North Carolina tradition (Belden & Hudson, 1952). Because the rhymes used are often not exact (Zwicky, 1976), including both near rhyme and assonance would make the percentage higher, as would counting repeating words. Within-line poetics are also important. McCarthy (1990, pp. 146–147) provided examples, taken from “Johnie Scot,” of variation on the theme of reading a letter; although the words vary, the *l* alliteration is preserved: “long letter,” “first line of the letter,” “first line that Johnie looked on,” “first lang line that he looked to,” and “Johnie looked the letter upon.” Such variation suggests that alliteration in the ballad tradition is independent of the words used to express it. Because of alliteration, it is more likely that a ballad will refer to looking at a line in a long letter than that it will refer to reading a short message, but alliteration allows for variation on whether the letter or the line is described as long. Such line-internal poetics are important even to undergraduates who are not expert in the tradition. In one study, 24 words in “The Wreck of the Old 97” were changed to eliminate most cases of rhyme, alliteration, and assonance in words adjacent or one word away from each other (Wallace & Rubin, 1988b). The numbers of syllables, stress patterns, and meanings of the original words were preserved. A comparison of scores for verbatim recall among the 27 undergraduates who heard the original ballad and the 27 who heard the altered version showed that the former were twice as accurate (51% vs. 24%) in recalling these 24 words.

Auditory imagery in the form of music is central to ballads, but as many ballad scholars have noted, there have been few studies done by people interested and skilled in both the music and the words (Bronson, 1969; Richmond, 1989). There is a general agreement between the stresses in the text and the stresses in the music (Wallace & Rubin, 1991). In modern times, ballads are sung by a person who is also playing a guitar. Thus, kinesthesia, or finger memory, for the notes of the tune played provides another form of organization to stabilize recall (cf. Bronson, 1969).

Narrative

Ballads have highly restrictive narrative schemata that can aid in composition and recall. First, the tradition includes a limited number of narrative themes. These include train or ship wrecks, the murdered girl, and the criminal brought to justice (Laws, 1964). Each theme has its own scripted activities. For instance, the murdered-girl pattern includes the wooing of an innocent, trusting young woman by an artful man; the luring of the woman to a lonely spot; the murder of the woman, who offers little re-

sistance; abandonment of the body; occasionally regret by the lover-murderer; and a warning to women (Cohen, 1973).

Second, there are set phrases, or *commonplaces*, that allow singers to compose or recall ballads in units larger than the word. Such repeating phrases are a mark of oral traditions and are especially frequent in epic poetry, where there are strict metrical slots to fill (Foley, 1991; Lord, 1960; Parry, 1928/1971). These commonplaces are informative about the narrative to come, because the same commonplaces are used in the same location in the narrative progression in different ballads (Andersen, 1985). “Lord Thomas and Fair Annet,” the ballad from which the stanzas listed earlier were drawn, has many examples, including “She clad herself in satin fine, her ladies all in green,” which indicates that a change in scene is coming. When a woman dresses, it is usually to regain a lost love who is about to wed another, and the woman usually succeeds, as occurs in “Lord Thomas and Fair Annet.” Thus, the commonplace of dressing foreshadows much of what follows (Andersen, 1985, pp. 249–253).

Third, as do many oral traditions, ballads have a ring structure to the overall narrative. In computer terms, this first-in/last-out structure can be characterized as a push-down stack. Lord (1991) argued that although this pattern can be transformed into a technique of literary rhetoric, it is a natural way for an illiterate poet to compose orally; momentary continuity of thought is maintained by picking up the most recently dropped theme.

Fourth, unlike most stories, oral-tradition ballads usually are not introduced by explicit settings. This is especially true for ballads of Old World origin (Richmond, 1989; Rubin, Wallace, & Houston, 1993; Whiting, 1955).

Visual and Spatial Imagery

Like other oral traditions, ballads are high in visual and spatial imagery. Ballad scholars have long noted that ballads consist of rapidly advancing action, with little discussion of thought, feelings, and abstract concepts. If one divides the narrative within a ballad into *states* or *events* using Mandler and Johnson’s (1977) story grammar, there are few states; for example, the protagonist is not said to be angry, but that is inferred from the murder committed. To measure the amount of visual and spatial imagery in ballads, Wallace and I analyzed the 29 most often cited popular ballads in the North Carolina tradition, assigning each line to one of the following three categories:

- Visual: a line describing the people or objects in a scene without regard to location or motion (e.g., “She clad herself in satin fine”)
- Spatial: a line tracking the location of people and objects in the visual scene (the line could provide a vivid image, but it had to specify either a location or a motion that produced a change in location; e.g., “He rode and he rode till he came to the castle”)
- Abstract: a nonvisual line that did not describe a mental picture

On the average, 52% of the lines were visual, 28% were spatial, and 20% were abstract (Wallace & Rubin, 1991).

Examples of Schemata Limiting Change

The organization, or schemata, in each of the systems, alone and in combination, aids recall and helps keep ballads stable without being fixed. If a singer follows the narrative, visual-imagery, spatial-imagery, auditory-imagery, kinesthetic, and linguistic schemata of the genre and the particular ballad, then recall is highly cued, and the combination of all cues limits what can be recalled. The change-limiting effects of schemata can be seen in several ways.

One way to infer the effects of schemata is to examine the formation of ballads from actual events and check that the ballads come to follow these schemata (in literary terms, this is genre convergence). The clearest case for this purpose are the ballads sung about "Poor Pearl" (Cohen, 1973). The ballads generated to commemorate the murder of Pearl Bryan had traditional schemata in many systems, but the effects of the narrative expectations of the genre are most impressive because they demonstrate a change from accurate recall to schematic recall over a 70-year period. There are many possible epithets for Pearl Bryan, but few as poetically linked as the one used, "Poor Pearl." In 1896, her headless, pregnant body was found. Two men were arrested, tried, convicted of the murder, and hung on the same gallows. Bryan became pregnant either by one of them or by her cousin. The head was never found. The headless body, the two murderers, the double hanging, her affair with her cousin, and the missing head are highly distinctive and easy-to-image details with the potential to make a ballad very memorable. However, they do not fit the narrative schema of the murdered-girl theme, described earlier. With time, the schema won out over reality. The most popular ballad about Poor Pearl had 65 variants. A second murderer is mentioned in 29% of the ballads prior to 1928, in 14% of the ballads from 1928 through 1938, and in 0% after 1938 (thus leaving only one murderer). For the same three time periods, the body is headless in 46%, 28%, and 0% of the ballads.

The variation in recall that occurs in the singing of a ballad also follows schemata in the basic systems (Wallace & Rubin, 1988a, 1988b). For instance, in four ballads sung a second time by the same singer after a 5-month interval, 12 alliterative or rhyming words changed. Ten of these 12 changes resulted in a new rhyme or alliteration, and only 2 resulted in a loss of rhyme or alliteration. Similar effects have been noted by comparing different people's variants of the same traditional ballads (Buchan, 1972) and different undergraduates' recall of popular songs (Hyman & Rubin, 1990).

In order to see if schemata in basic systems can be learned easily and if such learning is accomplished by consciously observing regularities or by more implicit means, my colleagues and I had undergraduates learn five 10-stanza ballads (Rubin et al., 1993). Each ballad was learned in one session, and sessions

were spaced at intervals of 1 week. Compared with the undergraduates' recall of the first ballad, their recall of the fifth ballad contained about one and a half as many of the original words, about twice as many of the end rhymes, and about three times as much of the line structure. The undergraduates were then given 20 min to make up a new ballad that a critic would find difficult to pick out as new if it were mixed among the set of five ballads. Following that exercise, for both the content and the structure of the five ballads learned, they were given 20 min to record rules that they were aware of following, generalizations about the ballads, and the ballads' common properties. The students generated ballads about two thirds as long as the ballads they had learned. These new ballads used more than half of the 30 characteristics common to the five ballads. The undergraduates also explicitly reported about one quarter of these characteristics, but there was no statistical relationship between the characteristics used and the characteristics reported. Thus, after learning a few ballads, the undergraduates could produce a new ballad with many of the same features, often following rules that they could not formulate. It is important to note that the undergraduates were able to learn and benefit from many characteristics of the ballads simultaneously. Learning of this kind, though not what is usually tested in the memory laboratory, may be common and not especially difficult.

The basic-systems schemata outlined here have been shown to have effects on stability across singers over decades, on stability within singers over months, in the generation of new ballads, and in the recall and singing of old ballads. Even novices hearing a handful of ballads become sensitive to the ballad organization present in different systems. The demonstrated recall and composition did not arise from rote memorization of homogenized information, but was guided by schemata in the narrative, audition, visual-imagery, spatial-imagery, kinesthesia, and motor-output systems. It is these schemata in different systems working together that keep ballads stable.

Summary

In summary, oral traditions have schemata in many of the systems of the basic-systems model. These schemata have been noted and carefully described by the humanists who study oral traditions, and expanded and quantified here. Genres of oral traditions have their own particular forms of organization for narrative, language, visual imagery, auditory imagery, spatial imagery, music, and kinesthesia. In this section, I have discussed a few of these forms of organization for one oral tradition. These schemata in various systems can be shown to affect memory individually and in combination. Oral traditions are recalled verbally, and so the need for basic systems beyond language and narrative is not forced. Yet the stability and change present in oral traditions and their highly serial nature of recall, and lack of content addressability, can be understood only in terms of detailed schemata in numerous basic systems. Analyses based on homogenized information fail.

DISCUSSION

Goals and Limitations

There is much to be gained from integrating information over levels of analysis. Such integration was a driving force in the formation of disciplines such as cognitive science in the 1960s and cognitive neuroscience more recently. Here, I have tried to formulate a model of episodic memory by examining what can be gained from integrating behavioral and neural levels of analysis. I started with the view that episodic memory is produced by widely distributed systems, something that holds true for integrated behaviors as “simple” as naming an object (Watson et al., 1999) and as global as the cognitive behaviors that accompany aging (Rubin, 1999).

There are dangers with this approach. We do not want to replace episodic memory with a handful of systems and do no more than this. In addition, our existing definitions of the component systems must be renegotiated to integrate the information from all levels; behavior alone, or neuroscience alone, cannot define the systems if the approach used here is to be fruitful. Of most concern is the potential to lapse into a reductionist view of concepts like episodic memory, imagery, language, narrative, and emotion, which are cultural and social products as well as neural ones. Of most reassurance is the fact that most of the systems in the basic-systems model have extremely long intellectual histories, well-understood neural bases, and extensively studied behavioral properties; thus, they seem likely to withstand empirical tests.

I have provided evidence to support the usefulness of viewing memories as distributed across systems. I have tried to demonstrate that combining behavioral, neuroanatomical, neuropsychological, neuroimaging, and individual differences research on episodic memory reveals possibilities and limits speculation in ways that none of these literatures can do alone. With recent technological advances that allow more accurate localization of brain damage in patients, and that allow the localization of activation for various tasks in people without any known damage, more information about the neural basis of human behavior is becoming available. For the study of episodic memory, the role of the brain as merely a metaphor is decreasing, and the role of the brain as a physical entity about which a great deal is known is increasing. Sophisticated behavioral descriptions and analyses of complex behaviors will be needed if information from imaging technologies is to be used efficiently to understand episodic memory. I have presented evidence regarding complex, real-world stimuli, but studies using highly controlled laboratory stimuli involving multiple systems of the basic-systems model are possible and are needed. Reviewing the existing literature shows how little time cognitive psychologists have spent cataloguing and trying to understand how differences in and interactions among the basic systems affect episodic memory. The model presented here can be considered a first step in this direction.

A key theoretical problem remaining is how finely to divide the systems. For current purposes, and given our current level of knowledge about many of the systems needed for episodic memory, the level of basic systems used here is sufficient. However, the level of features is better for some purposes. In the case of vision, information is clearly lost because the model does not incorporate features such as color and motion and specialized areas such as those involved in face recognition. As at the basic-systems level, behavioral and neural data would need to be used in combination to define each feature. Another theoretical issue is the boundaries between systems. Usually these boundaries are clear, but in some cases, such as the boundary between the narrative and search-and-retrieval systems, there are no data to support a clear separation.

Integrating Knowledge From the Modal Model

One of my goals in writing this article was to replace the view of memory based on homogenized information and the 1960s computer metaphor with a model of memory that uses the brain as more than a metaphor. But there is no need to abandon what we have learned or the language we have developed to discuss it. For unimodal stimuli, especially verbal or pictorial stimuli without narrative or emotional content, existing models can be seen, to a large extent, as reduced forms of the basic-systems model of memory, forms that use only a subset of the systems needed for more complex stimuli. If one were to transform the current model of working memory into a form more compatible with the basic-systems model, a separate visual sketchpad and a separate spatial sketchpad would be needed, but these are supported by studies of working memory (Baddeley, 2001; Della Sala, Gray, Baddeley, Allamano, & Wilson, 1999), so dividing the visual-spatial sketchpad's functions into two sketchpads is not inconsistent with the existing literature. Similarly, the language system of the basic-systems model would include the functions of the phonological loop, and the central executive would become part of the search-and-retrieval system. Some functions of the newly added episodic buffer (Baddeley, 2000, 2001) might become part of a buffer in the search-and-retrieval system; others might be handled in buffers in the other systems. One main change to working memory would be the addition of buffers in most basic systems. For sensory systems, the visual aspects of the visual-spatial sketchpad can serve as an initial model. For other systems, such as emotion and narrative, the form is more open, but guidance can come from existing literature (e.g., Conway & Pleydell-Pearce, 2000; Sanders & Gernsbacher, 2004).

What About Memory Systems?

The modal model and episodic memory can be seen as fitting within the general memory-systems approach, which divides memory into systems like declarative memory, which has semantic and episodic subsystems, and nondeclarative memory,

which has skills, habits, conditioning, and priming subsystems (e.g., Squire, 2004; Squire, Knowlton, & Musen, 1993). There is debate about the wisdom of these divisions (e.g., Fuster, 1995; Toth & Hunt, 1999). The main distinctions made by the memory-systems approach remain in the basic-systems model; evidence supporting taxonomies similar to the systems and subsystems of Squire et al. is strong (Willingham & Goedert, 2001). But in the basic-systems model, the memory systems are described in terms of activity of the basic systems, and in some cases in terms of a lack of activity in the explicit memory system.

Development

One topic I have completely ignored so far is the life-span development of episodic memory. Each basic system has its own life-span developmental trajectory that contributes to that system's role in episodic memory. We know something about some trajectories for some systems for some parts of the life span, but what we know has not been clearly integrated (Rubin, 2002). It is hard to measure the development of the explicit memory system in isolation, but if the number of items needed to achieve a median score on the Wechsler Memory Scale (Wechsler, 1987) or similar tests were plotted as a function of age (Rubin, Rahhal, & Poon, 1998), and if there were norms for early development, then the graph would show a clear increase from birth (Bauer, 2004) and a clear decline with aging (Craik, 2000). The search-and-retrieval system is more difficult to index, but if we consider it to be related to working memory and fluid intelligence tasks, we could obtain life-span plots similar to those for explicit memory (e.g., Salthouse, 1996; Woodcock & Johnson, 1991); and if we consider the search-and-retrieval system as part of a frontal lobe cognitive system, then there is other evidence on this basic system's development and its decline in aging because of what is known about frontal lobe development and decline (Rubin, 1999).

We can get an approximate view of the development of aspects of the language system by using measures of mean length of utterance and vocabulary size. Vocabulary is a standard measure of fixed intelligence, and we know that it rises rapidly until early adulthood and then more slowly. We know that narrative develops a bit more slowly than language, and given that aspects of narrative are related to fluid intelligence, it may decline with aging. Sensory systems tend to decline with aging, and some of the decline is central, not peripheral (Lindenberger & Baltes, 1994). The early development of sensory systems has been studied extensively, and development in the coordination among the various senses is important (L.E. Bahrck & Lickliter, 2000). Visual imagery appears to be strongest in early childhood and becomes weaker with age if work on eidetic imagery is any indication (Jaensch, 1930).

Thus, the various systems differ in their relative effectiveness over the life span; some appear to be described by a monotonically increasing function, others by a monotonically decreasing function, and still others by inverted-U-shaped curves of various

forms (see Rubin, 2002, for a hypothetical plot). Accordingly, changes in the systems' roles in episodic memory should be dynamic at the behavioral and neural levels of analysis. Still needed is a detailed analysis of how the developmental changes contribute to episodic memory and how the interactions among the systems develop. This will not be an easy task, but viewing issues of development in this way may prove helpful.

Forces for Change

In this article, I have not included collections of fMRI false-color images of the brain with many areas showing activity, but I have them if you want to see them. In terms of rhetorical force, though not logic or simplicity, they are the most powerful argument in favor of the basic-systems model of memory or something very close to it. When PET or fMRI images are shown, the areas of activity are rarely labeled with terms like "episodic memory," "semantic memory," or "long-term memory." They are often labeled with a variety of quaint terms—like "cuneus," "area 17," "V2", or "MT"—that refer to areas that are part of the systems outlined here. This is because the researchers doing the labeling took anatomy courses similar to the ones I did. The brain is routinely divided into the systems of the basic-systems model of memory, not the systems of memory theorists. As technology advances and the tasks given to subjects become more complex, it will become increasingly common to find that multiple areas are active and to report the co-occurrence of activity among areas. The rhetorical force of these fMRI and PET images, for better or worse, will lead to a change in how cognition is viewed (Fuster, 2003). It would be best to try to shape that change with theory based on both brain and behavior.

At a more scientific level, one use of fMRI has been to show that what appears to be one process at the behavioral level often involves different brain regions under different conditions. Thus, we advance from having one black box to having many. As more evidence from fMRI accumulates, cataloguing, systematizing, and examining which areas of brain are involved in which tasks may be the main way that the functions of neural structures will be decided (Cabeza & Nyberg, 2000). This is a task for which the basic-systems model is more useful than the computer metaphor of homogenized information.

But the strongest argument for considering a change in our model of episodic memory is the empirical work demonstrating that complex memory tasks are best understood by considering the separate component systems involved in performing them—systems that each have their own processes, schemata, and neural bases. Unless the results obtained in such work can be equally well understood in terms of homogenized information, there seems to be no alternative to a model similar to the one described here.

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REFERENCES

- Addis, D.R., McIntosh, A.R., Moscovitch, M., Crawley, A.P., & McAndrews, M.P. (2004). Characterizing spatial and temporal features of autobiographical memory retrieval networks: A partial least squares approach. *NeuroImage*, *23*, 1460–1471.
- Allport, D.A. (1985). Distributed memory, modular subsystems and dysphasia. In S. Newman & R. Epstein (Eds.), *Current perspectives in dysphasia* (pp. 32–60). Edinburgh, Scotland: Churchill Livingstone.
- Allport, G.W., & Postman, L. (1947). *The psychology of rumor*. New York: H. Holt and Co.
- Amedi, A., Malach, R., Hendler, T., Peled, S., & Zohary, E. (2001). Visuo-haptic object-related activation in the ventral visual pathway. *Nature Neuroscience*, *4*, 324–330.
- Andersen, F.G. (1985). *Commonplace and creativity: The role of formulaic diction in Anglo-Scottish traditional balladry*. Odense, Denmark: Odense University Press.
- Anderson, J.R. (1978). Arguments concerning representations for mental imagery. *Psychological Review*, *85*, 249–277.
- Anderson, J.R., Bothell, D., & Byrne, M.D. (2004). An integrated theory of the mind. *Psychological Review*, *111*, 1036–1060.
- Atkinson, R.C., & Shiffrin, R.M. (1971). The control of short-term memory. *Scientific American*, *225*, 82–90.
- Baddeley, A.D. (1986). *Working memory*. Oxford, England: Oxford University Press.
- Baddeley, A.D. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences*, *4*, 417–423.
- Baddeley, A.D. (2001). Is working memory still working? *American Psychologist*, *56*, 851–864.
- Baddeley, A.D., & Wilson, B. (1986). Amnesia, autobiographical memory, and confabulation. In D.C. Rubin (Ed.), *Autobiographical memory* (pp. 225–252). Cambridge, England: Cambridge University Press.
- Bahrick, H.P. (1970). Two-phase model for prompted recall. *Psychological Review*, *77*, 215–222.
- Bahrick, H.P. (1974). The anatomy of free recall. *Memory & Cognition*, *2*, 484–490.
- Bahrick, L.E., & Lickliter, R. (2000). Intersensory redundancy guides attentional selectivity and perceptual learning in infancy. *Developmental Psychology*, *36*, 190–201.
- Bakker, E.J. (1993). Discourse and performance: Involvement, visualization and “presence” in Homeric poetry. *Classical Antiquity*, *12*, 1–29.
- Barclay, C.R. (1996). Autobiographical remembering: Narrative constraints on objectified selves. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 94–125). Cambridge, England: Cambridge University Press.
- Barclay, C.R., & Smith, T.S. (1992). Autobiographical remembering: Creating personal culture. In M.A. Conway, D.C. Rubin, H. Spinnler, & W.A. Wagenaar (Eds.), *Theoretical perspectives on autobiographical memory* (pp. 75–97). Dordrecht, The Netherlands: Kluwer Academic.
- Barsalou, L.W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*, 577–660.
- Barsalou, L.W. (2003). Abstraction in perceptual symbol systems. *Philosophical Transactions of the Royal Society: B*, *358*, 1177–1187.
- Bartlett, F.C. (1932). *Remembering: A study in experimental and social psychology*. London: Cambridge University Press.
- Bauer, P.J. (2004). Getting explicit memory off the ground: Steps toward construction of a neuro-developmental account of changes in the first two years of life. *Developmental Review*, *24*, 347–373.
- Bayley, P.J., & Squire, L.R. (2002). Medial temporal lobe amnesia: Gradual acquisition of factual information by nondeclarative memory. *The Journal of Neuroscience*, *22*, 5741–5748.
- Belden, H.M., & Hudson, A.P. (Eds.). (1952). *The Frank C. Brown collection of North Carolina folklore* (Vols. 2–3). Durham, NC: Duke University Press.
- Bell, B.E., & Loftus, E.F. (1989). Trivial persuasion in the courtroom: The power of (a few) minor details. *Journal of Personality and Social Psychology*, *56*, 669–679.
- Bellezza, F.S. (1983). The spatial-arrangement mnemonic. *Journal of Educational Psychology*, *75*, 830–837.
- Berntsen, D. (2001). Involuntary memories of emotional events: Do memories of traumas and extremely happy events differ? *Applied Cognitive Psychology*, *15*, 135–158.
- Berntsen, D. (2002). Tunnel memories for autobiographical events: Central details are remembered more frequently from shocking than from happy experiences. *Memory & Cognition*, *30*, 1010–1020.
- Berntsen, D., & Rubin, D.C. (2002). Emotionally charged autobiographical memories across the lifespan: The recall of happy, sad, traumatic, and involuntary memories. *Psychology and Aging*, *17*, 636–652.
- Berntsen, D., & Rubin, D.C. (2004). Cultural life scripts structure recall from autobiographical memory. *Memory & Cognition*, *32*, 427–442.
- Berntsen, D., Willert, M., & Rubin, D.C. (2003). Splintered memories or vivid landmarks? Qualities and organization of traumatic memories with and without PTSD. *Applied Cognitive Psychology*, *17*, 675–693.
- Blaxton, T.A. (1989). Investigating dissociations among memory measures: Support for a transfer appropriate processing framework. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *15*, 657–668.
- Block, N. (Ed.) (1981). *Imagery*. Cambridge, MA: MIT Press.
- Bock, J.K. (1986). Syntactic persistence in language production. *Cognitive Psychology*, *18*, 355–387.
- Boroditsky, L. (2001). Does language shape thought? Mandarin and English speakers’ conceptions of time. *Cognitive Psychology*, *43*, 1–22.
- Bower, G.H. (1981). Mood and memory. *American Psychologist*, *36*, 129–148.
- Bower, G.H., & Bolton, L.S. (1969). Why are rhymes easier to learn? *Journal of Experimental Psychology*, *82*, 453–461.
- Bradley, M.M., Greenwald, M.K., Petry, M.C., & Lang, P.J. (1992). Remembering pictures: Pleasure and arousal in memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *18*, 379–390.

- Bransford, J.D., McCarrell, N.S., Franks, J.J., & Nitsch, K.E. (1977). Toward unexplaining memory. In R. Shaw & J.D. Bransford (Eds.), *Perceiving, acting, and knowing: Toward an ecological psychology* (pp. 431–466). Hillsdale, NJ: Erlbaum.
- Brewer, W.F. (1980). Literary theory, rhetoric, stylistics: Implications for psychology. In R.J. Spiro, B.C. Bruce, & W.F. Brewer (Eds.), *Theoretical issues in reading comprehension* (pp. 221–239). Hillsdale, NJ: Erlbaum.
- Brewer, W.F. (1996). What is recollective memory? In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 19–66). Cambridge, England: Cambridge University Press.
- Bronson, B.H. (1969). *The ballad as song*. Berkeley: University of California Press.
- Brown, R. (1965). *Social psychology*. New York: Free Press.
- Brown, R., & Kulik, J. (1977). Flashbulb memories. *Cognition*, 5, 73–99.
- Brown, R., & Lenneberg, E.H. (1954). A study in language and cognition. *Journal of Abnormal and Social Psychology*, 49, 454–462.
- Bruner, J. (1986). *Actual minds, possible worlds*. Cambridge, MA: Harvard University Press.
- Bruner, J., & Feldman, C.F. (1996). Group narrative as a cultural context of autobiography. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 291–317). Cambridge, England: Cambridge University Press.
- Bucci, W. (1995). The power of narrative: A multiple code account. In J.W. Pennebaker (Ed.), *Emotion, disclosure, & health* (pp. 93–122). Washington, DC: American Psychological Association.
- Buchan, D. (1972). *Ballad and the folk*. London: Routledge & Kegan Paul.
- Buckner, R.L., & Wheeler, M.E. (2001). The cognitive neuroscience of remembering. *Nature Reviews Neuroscience*, 2, 624–634.
- Cabeza, R., & Nyberg, L. (2000). Imaging cognition II: An empirical review of 275 PET and fMRI studies. *Journal of Cognitive Neuroscience*, 12, 1–47.
- Cabeza, R., Prince, S.E., Daselaar, S.M., Greenberg, D.L., Budde, M., Dolcos, F., LaBar, K.S., & Rubin, D.C. (2004). Brain activity during episodic retrieval of autobiographical and laboratory events: An fMRI study using a novel photo paradigm. *Journal of Cognitive Neuroscience*, 16, 1583–1594.
- Cacioppo, J.T., & Gardner, W.L. (1999). Emotion. *Annual Review of Psychology*, 50, 191–214.
- Cahill, L., & McGaugh, J.L. (1998). Mechanisms of emotional arousal and lasting declarative memory. *Trends in Neurosciences*, 21, 294–299.
- Cain, W.S. (1979). To know with the nose: Keys to odor identification. *Science*, 203, 467–470.
- Calvert, G., Spence, C., & Stein, B.E. (Eds.). (2004). *The handbook of multisensory processes*. Cambridge, MA: MIT Press.
- Carroll, J.B. (1993). *Human cognitive abilities: A survey of factor-analytic studies*. Cambridge, England: Cambridge University Press.
- Carruthers, P. (1996). *Language, thought, and consciousness: An essay in philosophical psychology*. Cambridge, England: Cambridge University Press.
- Chafe, W. (1982). Integration and involvement in speaking, writing and oral literature. In D. Tannen (Ed.), *Spoken and written language: Exploring orality and literacy* (pp. 35–53). Norwood, NJ: Ablex.
- Chafe, W. (1990). Some things that narratives tell us about the mind. In B.K. Britton & A.D. Pellegrini (Eds.), *Narrative thought and narrative language* (pp. 79–98). Hillsdale, NJ: Erlbaum.
- Chase, W.G., & Ericsson, K.A. (1981). Skilled memory. In J.R. Anderson (Ed.), *Cognitive skills and their acquisition* (pp. 141–186). Hillsdale, NJ: Erlbaum.
- Christianson, S.-Å. (1992). Emotional stress and eyewitness memory: A critical review. *Psychological Bulletin*, 112, 284–309.
- Christianson, S.-Å., & Safer, M.A. (1996). Emotional events and emotions in autobiographical memories. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 218–243). Cambridge, England: Cambridge University Press.
- Cohen, A.B. (1973). *Poor Pearl, poor girl!: The murdered-girl stereotype in ballad and newspaper*. Austin: University of Texas Press.
- A collection of old ballads: Corrected from the best and most ancient copies extant*. (1723). London: Printed for F. Roberts.
- Conway, M.A. (2004). Memory and the self. *Journal of Memory and Language*, 53, 594–628.
- Conway, M.A., & Pleydell-Pearce, C.W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review*, 107, 261–288.
- Conway, M.A., & Rubin, D.C. (1993). The structure of autobiographical memory. In A.F. Collins, S.E. Gathercole, M.A. Conway, & P.E. Morris (Eds.), *Theories of memory* (pp. 103–137). Hove, England: Erlbaum.
- Conway, M.A., Turk, J.D., Miller, S.L., Logan, J., Nebes, R.D., Meltzer, C.C., & Becker, J.T. (1999). A positron emission tomography (PET) study of autobiographical memory retrieval. *Memory*, 7, 679–702.
- Cooper, L.A., & Shepard, R.N. (1975). Mental transformations in the identification of left and right hands. *Journal of Experimental Psychology: Human Perception and Performance*, 1, 48–56.
- Craik, F.I.M. (2000). Age-related changes in human memory. In D. Park & N. Schwarz (Eds.), *Cognitive aging: A primer* (pp. 75–92). New York: Psychology Press.
- Craik, F.I.M., & Lockhart, R.S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 11, 671–684.
- Crovitz, H.F., & Schiffman, H. (1974). Frequency of episodic memories as a function of their age. *Bulletin of the Psychonomic Society*, 4, 517–518.
- Crowder, R.G. (1976). *Principles of learning and memory*. Hillsdale, NJ: Erlbaum.
- Crowder, R.G., & Schab, F.R. (1995). Imagery for odors. In F.R. Schab & R.G. Crowder (Eds.), *Memory for odors* (pp. 93–107). Mahwah, NJ: Erlbaum.
- Damasio, A.R. (1989). Time-locked multiregional retroactivation: A systems-level proposal for the neural substrates of recall and recognition. *Cognition*, 33, 25–62.
- Damasio, A.R. (1994). *Descartes' error: Emotion, reason, and the human brain*. New York: G.P. Putnam's Sons.
- Daselaar, S.M., Rice, H.J., Greenberg, D.L., LaBar, K.S., Rubin, D.C., & Cabeza, R. (2005, November). *Time course of episodic retrieval activity: Brain regions involved in constructing and maintaining autobiographical memories*. Paper presented at the annual meeting of the Society for Neuroscience, Washington, DC.
- De Beni, R., & Cornoldi, C. (1988). Imagery limitations in totally congenitally blind subjects. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 650–655.
- de Wijk, R.A., Schab, F.R., & Cain, W.S. (1995). Odor identification. In F.R. Schab & R.G. Crowder (Eds.), *Memory for odors* (pp. 21–37). Mahwah, NJ: Erlbaum.

- Della Sala, S., Gray, C., Baddeley, A.D., Allamano, N., & Wilson, L. (1999). Pattern span: A tool for unwinding visuo-spatial memory. *Neuropsychologia*, *37*, 1189–1199.
- Dolcos, F., LaBar, K.S., & Cabeza, R. (2004). Interaction between the amygdala and the medial temporal lobe memory system predicts better memory for emotional events. *Neuron*, *42*, 855–863.
- Dudukovic, N.M., Marsh, E.J., & Tversky, B. (2004). Telling a story or telling it straight: The effects of entertaining versus accurate retellings on memory. *Applied Cognitive Psychology*, *18*, 125–143.
- Duncan, J., Martens, S., & Ward, R. (1997). Restricted attentional capacity within but not between sensory modalities. *Nature*, *387*, 808–810.
- Duncan, J., & Owen, A.M. (2000). Common regions of the human frontal lobe recruited by diverse cognitive demands. *Trends in Neurosciences*, *23*, 475–483.
- Eich, E. (1995). Searching for mood dependent memory. *Psychological Science*, *6*, 67–75.
- Eich, E., Macaulay, D., & Ryan, L. (1994). Mood dependent memory for events of the personal past. *Journal of Experimental Psychology: General*, *123*, 201–215.
- Eich, J.E. (1978). Fragrances as cues for remembering words. *Journal of Verbal Learning and Verbal Behavior*, *17*, 103–111.
- Ekman, P. (1992). Are there basic emotions? *Psychological Review*, *99*, 550–553.
- Engelkamp, J. (2001). *Memory for action*. Hove, England: Psychology Press.
- Engen, T. (1982). *The perception of odors*. New York: Academic Press.
- Engen, T., & Ross, B.M. (1973). Long-term memory of odors with and without verbal descriptions. *Journal of Experimental Psychology*, *100*, 221–227.
- Ericsson, K.A., & Simon, H.A. (1993). *Protocol analysis: Verbal reports as data* (rev. ed.). Cambridge, MA: MIT (Bradford Books).
- Falchier, A., Clavagnier, S., Barone, P., & Kennedy, H. (2002). Anatomical evidence of multimodal integration in primate striate cortex. *Journal of Neuroscience*, *22*, 5749–5759.
- Farah, M.J. (1984). The neurological basis of mental imagery: A componential analysis. *Cognition*, *18*, 245–272.
- Farah, M.J. (1988). Is visual imagery really visual? Overlooked evidence from neuropsychology. *Psychological Review*, *95*, 307–317.
- Felleman, D.J., & Van Essen, D.C. (1991). Distributed hierarchical processing in the primate cerebral cortex. *Cerebral Cortex*, *1*, 1–47.
- Fink, G.R., Markowitsch, H.J., Reinkemeier, M., Bruckbauer, T., Kessler, J., & Heiss, W. (1996). Cerebral representation of one's own past: Neural networks involved in autobiographical memory. *Journal of Neuroscience*, *16*, 4275–4282.
- Fitzgerald, J.M. (1992). Autobiographical memory and conceptualizations of the self. In M.A. Conway, D.C. Rubin, H. Spinnler, & W.A. Wagenaar (Eds.), *Theoretical perspectives on autobiographical memory* (pp. 99–114). Dordrecht, The Netherlands: Kluwer Academic.
- Fitzgerald, J.M. (1996). Intersecting meanings of reminiscence in adult development and aging. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 360–383). Cambridge, England: Cambridge University Press.
- Fivush, R., Haden, C., & Reese, E. (1996). Remembering, recounting, and reminiscing: The development of autobiographical memory in social context. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 341–359). Cambridge, England: Cambridge University Press.
- Fivush, R., & Haden, C.A. (Eds.). (2003). *Autobiographical memory and the construction of a narrative self: Developmental and cultural perspectives*. Mahwah, NJ: Erlbaum.
- Fodor, J. (1983). *The modularity of mind: An essay on faculty psychology*. Cambridge, MA: MIT Press.
- Foley, J.M. (1990). *Traditional oral epic: The Odyssey, Beowulf, and the Serbo-Croatian return song*. Berkeley: University of California Press.
- Foley, J.M. (1991). *Immanent art: From structure to meaning in traditional oral epic*. Bloomington: Indiana University Press.
- Freeman, M. (1993). *Rewriting the self: History, memory, narrative*. London: Routledge.
- Friedman, W.J. (1993). Memory for the time of past events. *Psychological Bulletin*, *113*, 44–66.
- Fuster, J. (1995). *Memory in the cerebral cortex*. Cambridge, MA: MIT Press.
- Fuster, J. (2003). *Cortex and mind*. Oxford, England: Oxford University Press.
- Galton, F. (1879). Psychometric experiments. *Brain*, *2*, 149–162.
- Garcia, J. (1981). Tilting at the paper mills of academe. *American Psychologist*, *36*, 149–158.
- Gardiner, J.M., Ramponi, C., & Richardson-Klavehn, A. (1998). Experiences of remembering, knowing, and guessing. *Consciousness and Cognition*, *7*, 1–26.
- Gary, M., Manning, C.G., Loftus, E.F., & Sherman, S.J. (1996). Imagination inflation: Imagining a childhood event inflates confidence that it occurred. *Psychonomic Bulletin & Review*, *3*, 208–214.
- Geiselman, R.E., & Crawley, J.M. (1983). Incidental processing of speaker characteristics: Voice as connotative information. *Journal of Verbal Learning and Verbal Behavior*, *22*, 15–23.
- Gergen, K.J., & Gergen, M.M. (1988). Narrative and the self as relationship. *Advances in Experimental Social Psychology*, *21*, 17–56.
- Gibson, J.J. (1966). *The senses considered as perceptual systems*. Boston: Houghton Mifflin.
- Gilboa, A., Winocur, G., Grady, C.L., Hevenor, S.J., & Moscovitch, M. (2004). Remembering our past: Functional neuroanatomy of recollection of recent and very remote personal events. *Cerebral Cortex*, *14*, 1214–1225.
- Glenberg, A.M. (1997). What memory is for. *Behavioral and Brain Sciences*, *20*, 1–55.
- Glenberg, A.M., Schroeder, J.L., & Robertson, D.A. (1998). Averting the gaze disengages the environment and facilitates remembering. *Memory & Cognition*, *26*, 651–658.
- Goldstone, R.L., & Barsalou, L.W. (1998). Reuniting perception and conception. *Cognition*, *65*, 231–262.
- Goodglass, H. (1993). *Understanding aphasia*. San Diego: Academic Press.
- Greenberg, D.L., Eacott, M.J., Brechin, D., & Rubin, D.C. (2005). Visual memory loss and autobiographical amnesia: A case study. *Neuropsychologia*, *43*, 1493–1502.
- Greenberg, D.L., Rice, H.J., Cooper, J.J., Cabeza, R., Rubin, D.C., & LaBar, K.S. (2005). Coactivation of the amygdala, hippocampus and inferior frontal gyrus during autobiographical memory retrieval. *Neuropsychologia*, *43*, 659–674.
- Greenberg, D.L., & Rubin, D.C. (2003). The neuropsychology of autobiographical memory. *Cortex*, *39*, 687–728.
- Habermas, T., & Bluck, S. (2000). Getting a life: The emergence of the life story in adolescence. *Psychological Bulletin*, *126*, 748–769.

- Hasher, L., & Zacks, R.T. (1979). Automatic and effortful processes in memory. *Journal of Experimental Psychology: General*, 108, 356–388.
- Havelock, E.A. (1963). *Preface to Plato*. Cambridge, MA: Harvard University Press.
- Havelock, E.A. (1978). *The Greek concept of justice: From its shadow in Homer to its substance in Plato*. Cambridge, MA: Harvard University Press.
- Herz, R.S., & Eich, E. (1995). Commentary and envoi. In F.R. Schab & R.G. Crowder (Eds.), *Memory for odors* (pp. 159–175). Mahwah, NJ: Erlbaum.
- Herz, R.S., & Engen, T. (1996). Odor memory: Review and analysis. *Psychonomic Bulletin & Review*, 3, 300–313.
- Hintzman, D.L. (1993). Twenty-five years of learning and memory: Was the cognitive revolution a mistake? In D.E. Meyer & S. Kornblum (Eds.), *Attention and performance XIV: Synergies in experimental psychology, artificial intelligence, and cognitive neuroscience* (pp. 359–391). Cambridge, MA: MIT Press.
- Hirst, W., & Manier, D. (1996). Remembering as communication: A family recounts its past. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 271–290). Cambridge, England: Cambridge University Press.
- Hough, M.S. (1990). Narrative comprehension in adults with right and left hemisphere brain-damage: Theme organization. *Brain and Language*, 38, 253–277.
- Huber, W., & Gleber, J. (1982). Linguistic and nonlinguistic processing of narratives in aphasia. *Brain and Language*, 16, 1–18.
- Hunkin, N.M., Parkin, A.J., Bradley, V.A., Burrows, E.H., Aldrich, F.K., Jansari, A., & Burdon-Cooper, C. (1995). Focal retrograde amnesia following closed head injury: A case study and theoretical account. *Neuropsychologia*, 33, 509–523.
- Hunter, I.M.L. (1984). Lengthy verbatim recall (LVR) and the mythical gift of tape-recorder memory. In K.M.J. Lagerspetz & P. Niemi (Eds.), *Psychology in the 1990s* (pp. 425–440). Amsterdam: North Holland.
- Hyde, T.S., & Jenkins, J.J. (1973). Recall for words as a function of semantic, graphic, and syntactic orienting tasks. *Journal of Verbal Learning and Verbal Behavior*, 12, 471–480.
- Hyman, I.E., Jr., & Pentland, J. (1996). The role of mental imagery in the creation of false childhood memories. *Journal of Memory and Language*, 35, 101–117.
- Hyman, I.E., Jr., & Rubin, D.C. (1990). Memorabeatlia: A naturalistic study of long-term memory. *Memory & Cognition*, 18, 205–214.
- Ishai, A., Ungerleider, L.G., & Haxby, J.V. (2000). Distributed neural systems for the generation of visual images. *Neuron*, 28, 979–990.
- Izard, C.E. (1992). Basic emotions, relations among emotions, and emotion – cognition relations. *Psychological Review*, 99, 561–565.
- Jacoby, L.L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, 30, 513–541.
- Jaensch, E.R. (1930). *Eidetic imagery and typological methods of investigation*. (O. Oeser, Trans.). London: Kegan Paul, Trench, Trubner, & Co.
- James, T.W., Humphrey, G.K., Gati, J.S., Servos, P., Menon, R.S., & Goodale, M.A. (2002). Haptic study of three dimensional objects activates extrastriate visual areas. *Neuropsychologia*, 40, 1706–1714.
- James, W. (1890). *The principles of psychology* (Vols. 1–2). New York: Henry Holt and Co.
- Johnson, M.K., Foley, M.A., Suengas, A.G., & Raye, C.L. (1988). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General*, 117, 371–376.
- Johnson, M.K., Hashtroudi, S., & Lindsay, D.S. (1993). Source monitoring. *Psychological Bulletin*, 114, 3–28.
- Johnson, M.K., & Raye, C.L. (1981). Reality monitoring. *Psychological Review*, 88, 67–85.
- Johnson-Laird, P.N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness*. Cambridge, MA: Harvard University Press.
- Jones-Gotman, M., & Zatorre, R.J. (1993). Odor recognition memory in humans: Role of right temporal and orbitofrontal regions. *Brain and Cognition*, 22, 182–198.
- Jonides, J., Lacey, S.C., & Nee, D.E. (2005). Processes of working memory in mind and brain. *Current Directions in Psychological Science*, 14, 2–5.
- Kaas, J.H., & Collins, C.F. (2004). The resurrection of multisensory cortex in primates: Connection patterns that integrate modalities. In G. Calvert, C. Spence, & B.E. Stein (Eds.), *The handbook of multisensory processes* (pp. 285–293). Cambridge, MA: MIT Press.
- Kausler, D.H. (1974). *The psychology of verbal learning and memory*. New York: Academic Press.
- Kennedy, J.M. (1993). *Drawing and the blind: Pictures to touch*. New Haven: Yale University Press.
- Kerr, N.H. (1983). The role of vision in “visual imagery” experiments: Evidence from the congenitally blind. *Journal of Experimental Psychology*, 112, 265–277.
- Kittredge, G.L. (1904). Introduction. In H.C. Sargent & G.L. Kittredge (Eds.), *English and Scottish popular ballads edited from the collection of Francis James Child* (pp. xi–xxxi). Boston: Houghton Mifflin Co.
- Kolers, P.A., & Roediger, H.L., III. (1984). Procedures of mind. *Journal of Verbal Learning and Verbal Behavior*, 23, 425–449.
- Kolers, P.A., & Smythe, W.E. (1984). Symbol manipulation: Alternatives to the computational view of mind. *Journal of Verbal Learning and Verbal Behavior*, 23, 289–314.
- Kopelman, M.D. (2000). Focal retrograde amnesia and the attribution of causality: An exceptionally critical review. *Cognitive Neuropsychology*, 17, 585–621.
- Kopelman, M.D., & Kapur, N. (2001). The loss of episodic memories in retrograde amnesia: Single-case and group studies. *Philosophical Transactions of the Royal Society: B*, 356, 1409–1421.
- Koriat, A., & Pearlman-Avni, S. (2003). Memory organization of action events and its relationship to memory performance. *Journal of Experimental Psychology: General*, 132, 435–454.
- Kosslyn, S.M. (1980). *Image and mind*. Cambridge, MA: Harvard University Press.
- Kosslyn, S.M., Pinker, S., Smith, G., & Shwartz, S.P. (1979). On the demystification of mental imagery. *Behavioral and Brain Sciences*, 2, 535–581.
- Kroll, J.F., & de Groot, A.M.B. (1997). Lexical and conceptual memory in the bilingual: Mapping form to memory in two languages. In A.M.B. de Groot & J.F. Kroll (Eds.), *Tutorials in bilingualism: Psycholinguistic perspectives* (pp. 169–199). Mahwah, NJ: Erlbaum.
- LaBar, K.S., Rice, H.J., Daselaar, S.M., Greenberg, D.L., Cabeza, R., & Rubin, D.C. (2005, November). *The phenomenology of autobiographical recall: Neural correlates of emotional intensity and reliving*. Paper presented at the annual meeting of the Society for Neuroscience, Washington, DC.

- Lawless, H., & Engen, T. (1977). Associations to odors: Interference, mnemonics, and verbal labeling. *Journal of Experimental Psychology: Human Learning and Memory*, 3, 52–59.
- Lawless, H.T., & Cain, W.S. (1975). Recognition memory for odors. *Chemical Senses and Flavor*, 1, 331–337.
- Laws, G.M., Jr. (1964). *Native American balladry: A descriptive study and a bibliographical syllabus*. Philadelphia: The American Folklore Society.
- LeDoux, J.E. (1995). Emotion: Clues from the brain. *Annual Review of Psychology*, 46, 209–235.
- Levine, D.N., Calvanio, R., & Popovics, A. (1982). Language in the absence of inner speech. *Neuropsychologia*, 20, 391–409.
- Levine, D.N., Warach, J., & Farah, M. (1985). Two visual systems in mental imagery: Dissociation of “what” and “where” in imagery disorders due to bilateral posterior cerebral lesions. *Neurology*, 35, 1010–1018.
- Levine, L.J., & Pizzaro, D.A. (2004). Emotion and memory research: A grumpy overview. *Social Cognition*, 22, 530–554.
- Lindenberger, U., & Baltes, P.B. (1994). Sensory functioning and intelligence in old age: A strong connection. *Psychology & Aging*, 9, 339–355.
- Loftus, E.F. (1979). *Eyewitness testimony*. Cambridge, MA: Harvard University Press.
- Logie, R.H. (1995). *Visuo-spatial working memory*. Hove, England: Erlbaum.
- Lord, A.B. (1960). *The singer of tales*. Cambridge, MA: Harvard University Press.
- Lord, A.B. (1991). *Epic singers and oral tradition*. Ithaca, NY: Cornell University Press.
- Lucy, J.A. (1992). *Language diversity and thought: A reformulation of the linguistic relativity hypothesis*. New York: Cambridge University Press.
- Luria, A.R. (1972). *The man with a shattered world*. New York: Basic Books.
- Macaluso, E., & Driver, J. (2004). Functional imaging evidence for multisensory spatial representations and cross-modal attentional interactions in the human brain. In G. Calvert, C. Spence, & B.E. Stein (Eds.), *The handbook of multisensory processes* (pp. 529–548). Cambridge, MA: MIT Press.
- Mandler, J.M., & Johnson, N.S. (1977). Remembrance of things parsed: Story structure and recall. *Cognitive Psychology*, 9, 111–151.
- Mantyla, T. (1986). Optimizing cue effectiveness: Recall of 500 and 600 incidentally learned words. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 12, 66–71.
- Mantyla, T., & Nilsson, L.G. (1988). Cue distinctiveness and forgetting: Effectiveness of self-generated retrieval cues in delayed recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 14, 502–509.
- Marian, V., & Neisser, U. (2000). Language-dependent recall of autobiographical memories. *Journal of Experimental Psychology: General*, 129, 361–368.
- Markowitsch, H.J. (2000). The anatomical bases of memory. In M.S. Gazzaniga (Ed.), *The new cognitive neurosciences* (pp. 781–796). Cambridge, MA: MIT Press.
- Mayes, A.R. (2000). Selective memory disorders. In E. Tulving & F.I.M. Craik (Eds.), *The Oxford handbook of memory* (pp. 427–440). New York: Oxford University Press.
- McAdams, D.P. (2001). The psychology of life stories. *Review of General Psychology*, 5, 100–122.
- McCarthy, W.B. (1990). *The ballad matrix: Personality, milieu, and the oral tradition*. Bloomington: Indiana University Press.
- McClelland, J.L., McNaughton, B.L., & O'Reilly, R.C. (1995). Why there are complementary learning systems in the hippocampus and neocortex: Insights from the successes and failures of connectionist models of learning and memory. *Psychological Review*, 102, 419–457.
- McDonald, R.M., Ergis, A., & Winocur, G. (1999). Functional dissociation of brain regions in learning and memory: Evidence for multiple systems. In J.K. Foster & M. Jelicic (Eds.), *Memory: Systems, process or function?* (pp. 66–103). New York: Oxford University Press.
- McGaugh, J.L. (2004). The amygdala modulates the consolidation of memories of emotionally arousing experiences. *Annual Review of Neuroscience*, 27, 1–28.
- McNeill, D. (1992). *Hand and mind*. Chicago: University of Chicago Press.
- Morrow, D.G., Bower, G.H., & Greenspan, S.L. (1989). Updating situation models during narrative comprehension. *Journal of Memory and Language*, 28, 292–312.
- Moscovitch, M. (1989). Confabulation and the frontal systems. In H.L. Roediger, III, & F.I.M. Craik (Eds.), *Varieties of memory and consciousness: Essays in honour of Endel Tulving* (p. 133–160). Hillsdale, NJ: Erlbaum.
- Moscovitch, M. (1992). Memory and working-with-memory: A component process model based on modules and central systems. *Journal of Cognitive Neuroscience*, 4, 257–267.
- Moscovitch, M., & Melo, B. (1997). Strategic retrieval and the frontal lobes: Evidence from confabulation and amnesia. *Neuropsychologia*, 35, 1017–1034.
- Murre, J.M.J. (1999). Interaction of cortex and hippocampus in a model of amnesia and semantic dementia. *Reviews in the Neurosciences*, 10, 267–278.
- Murre, J.M.J., Graham, K.S., & Hodges, J.R. (2001). Semantic dementia: Relevance to connectionist models of long-term memory. *Brain*, 124, 647–675.
- Nadel, L., & Moscovitch, M. (1997). Memory consolidation, retrograde amnesia and the hippocampal complex. *Current Opinion in Neurobiology*, 7, 217–227.
- Neisser, U. (1967). *Cognitive psychology*. New York: Appleton-Century-Crofts.
- Neisser, U. (1976). *Cognition and reality: Principles and implications of cognitive psychology*. San Francisco: Freeman.
- Neisser, U. (1982). Snapshots or benchmarks? In U. Neisser (Ed.), *Memory observed* (43–48). San Francisco: W.H. Freeman.
- Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical Psychology*, 1, 35–59.
- Nelson, D.L. (1981). Many are called but few are chosen: The influence of context on the effects of category size. In G.H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 15, pp. 129–162). New York: Academic Press.
- Nelson, K. (1993). The psychological and social origins of autobiographical memory. *Psychological Science*, 4, 7–14.
- Nelson, K., & Fivush, R. (2004). The emergence of autobiographical memory: A social cultural developmental theory. *Psychological Review*, 111, 486–511.
- Newell, A. (1973). You can't play 20 questions with nature and win: Projective comments on the papers of this symposium. In W.G. Chase (Ed.), *Visual information processing* (pp. 283–308). New York: Academic Press.
- Noesselt, T., Hillyard, S.A., Woldorf, M.G., Schoenfeld, A., Hagner, T., Jancke, L., Tempelmann, C., Hinrichs, H., & Heinze, H.J. (2002). Delayed striate cortical activation during spatial attention. *Neuron*, 35, 575–587.

- Norman, D.A., & Bobrow, D.G. (1979). Descriptions: An intermediate stage in memory retrieval. *Cognitive Psychology*, *11*, 107–123.
- Nyberg, L., Persson, J., Habib, R., Tulving, E., McIntosh, A.R., Cabeza, R., & Houle, S. (2000). Large scale neurocognitive networks underlying episodic memory. *Journal of Cognitive Neuroscience*, *12*, 163–173.
- Ochsner, K.N. (2000). Are affective events richly recollected or simply familiar? The experience and process of recognizing feelings past. *Journal of Experimental Psychology: General*, *129*, 242–261.
- O'Craven, K.M., & Kanwisher, N. (2000). Mental imagery of faces and places activates corresponding stimulus-specific brain regions. *Journal of Cognitive Neuroscience*, *12*, 1013–1023.
- Ogden, J., & Barker, K. (2001). Imagery used in autobiographical recall in early and late blind adults. *Journal of Mental Imagery*, *25*, 153–176.
- Ogden, J.A. (1993). Visual object agnosia, prosopagnosia, achromatopsia, loss of visual imagery, and autobiographical amnesia following recovery from cortical blindness: Case M.H. *Neuropsychologia*, *31*, 571–589.
- Ong, W.J. (1982). *Orality and literacy: The technologizing of the word*. London: Methuen.
- Paivio, A. (1971). *Imagery and verbal processes*. New York: Holt, Rinehart & Winston.
- Paivio, A. (1975). Perceptual comparisons through the mind's eye. *Memory & Cognition*, *3*, 635–647.
- Paivio, A. (1986). *Mental representations: A dual coding approach*. New York: Oxford University Press.
- Paivio, A. (1991). Dual coding theory: Retrospect and current status. *Canadian Journal of Psychology*, *45*, 255–287.
- Pakkenberg, B., Pelvig, D., Marner, L., Bundgaard, M.J., Gundersen, H.J., Nyengaard, J.R., & Regeur, L. (2003). Aging and the human neocortex. *Experimental Gerontology*, *38*, 95–99.
- Parry, M. (1971). Homeric formulae and Homeric metre. In A. Parry (Ed. & Trans.), *The making of Homeric verse: The collected papers of Milman Parry* (pp. 191–239). Oxford, England: Oxford University Press. (Original work published 1928)
- Pascual-Leone, A., & Walsh, V. (2001). Fast backprojections from the motion to the primary visual area necessary for visual awareness. *Science*, *292*, 510–512.
- Pasupathi, M. (2001). The social construction of the personal past and its implications for adult development. *Psychological Bulletin*, *127*, 651–672.
- Penfield, W., & Mathieson, G. (1974). Memory. Autopsy findings and comments on the role of hippocampus in experiential recall. *Archives of Neurology*, *31*, 145–154.
- Perrig, W., & Kintsch, W. (1985). Propositional and situational representations of text. *Journal of Memory and Language*, *24*, 503–518.
- Pickel, K.L. (2004). When a lie becomes the truth: The effects of self-generated misinformation on eyewitness memory. *Memory*, *12*, 14–26.
- Piefke, M., Weiss, P.H., Zilles, K., Markowitsch, H.J., & Fink, G.R. (2003). Differential remoteness and emotional tone modulate the neural correlates of autobiographical memory. *Brain*, *126*, 650–668.
- Pillemer, D.B. (1998). *Momentous events, vivid memories: How unforgettable moments help us understand the meaning of our lives*. Cambridge, MA: Harvard University Press.
- Pillemer, D.B., Desrochers, A.B., & Eubanks, C.M. (1998). Remembering the past in the present: Verb tense shifts in autobiographical memory narratives. In C.P. Thompson, D.J. Herrmann, D. Bruce, J.D. Reed, D.G. Payne, & M.P. Toglia (Eds.), *Autobiographical memory: Theoretical and applied perspectives* (pp. 145–162). Mahwah, NJ: Erlbaum.
- Piolino, P., Giffard-Quillon, G., Desgranges, B., Chetelat, G., Baron, J.C., & Eustache, F. (2004). Re-experiencing old memories via hippocampus: A PET study of autobiographical memory. *NeuroImage*, *22*, 1371–1383.
- Popov, Y., & Rokhlin, L. (n.d.). *I.P. Pavlov, psychopathology and psychiatry: Selected works* (D. Myshne & S. Belsky, Trans.). Moscow: Foreign Languages Publishing House.
- Previc, F.H. (1998). The neuropsychology of 3-D space. *Psychological Bulletin*, *124*, 123–164.
- Prinz, J.J. (2002). *Furnishing the mind: Concepts and their perceptual basis*. Cambridge, MA: MIT Press.
- Pulvermuller, F. (1999). Words in the brain's language. *Behavioral and Brain Sciences*, *22*, 253–336.
- Purves, D., & Lotto, R.B. (2003). *Why we see what we do: An empirical theory of vision*. Sunderland, MA: Sinauer Associates.
- Rescorla, R.A., & Holland, P.C. (1982). Behavioral studies of associative learning in animals. *Annual Review of Psychology*, *33*, 265–308.
- Ribot, T. (1882). *Diseases of memory: An essay in the positive psychology* (W.H. Smith, Trans.). New York: D. Appleton.
- Richmond, W.E. (1989). *Ballad scholarship: An annotated bibliography*. New York: Garland Publishing.
- Robinson, J.A. (1976). Sampling autobiographical memory. *Cognitive Psychology*, *8*, 578–595.
- Robinson, J.A. (1996). Perspective, meaning, and remembering. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical memory* (pp. 199–217). Cambridge, England: Cambridge University Press.
- Robinson, J.A., & Swanson, K.L. (1993). Field and observer modes of remembering. *Memory*, *1*, 169–184.
- Roediger, H.L., III. (1980). Memory metaphors in cognitive psychology. *Memory & Cognition*, *8*, 231–246.
- Rolls, E.T. (2000). Memory systems in the brain. *Annual Review of Psychology*, *51*, 599–630.
- Rolls, E.T. (2004). Multisensory neuronal convergence of taste, somatosensory, visual, olfactory, and auditory inputs. In G. Calvert, C. Spence, & B.E. Stein (Eds.), *The handbook of multisensory processes* (pp. 311–331). Cambridge, MA: MIT Press.
- Rösler, F., Heil, M., & Hennighausen, E. (1995). Distinct cortical activation patterns during long-term memory retrieval of verbal, spatial, and color information. *Journal of Cognitive Neuroscience*, *7*, 51–65.
- Rothkopf, E.Z. (1971). Incidental memory for location of information in text. *Journal of Verbal Learning and Verbal Behavior*, *10*, 608–613.
- Rubin, D.C. (1977). Very long-term memory for prose and verse. *Journal of Verbal Learning and Verbal Behavior*, *16*, 611–621.
- Rubin, D.C. (1980). 51 properties of 125 words. *Journal of Verbal Learning and Verbal Behavior*, *19*, 736–755.
- Rubin, D.C. (1982). On the retention function for autobiographical memory. *Journal of Verbal Learning and Verbal Behavior*, *21*, 21–38.
- Rubin, D.C. (1985). Memorability as a measure of processing: A unit analysis of prose and list learning. *Journal of Experimental Psychology: General*, *114*, 213–238.
- Rubin, D.C. (1988). Go for the skill. In U. Neisser & E. Winograd (Eds.), *Remembering reconsidered: Ecological and traditional*

- approaches to the study of memory* (pp. 374–382). Cambridge, England: Cambridge University Press.
- Rubin, D.C. (1995a). *Memory in oral traditions: The cognitive psychology of epic, ballads, and counting-out rhymes*. New York: Oxford University Press.
- Rubin, D.C. (1995b). Stories about stories. In R.S. Wyer, Jr. (Ed.), *Knowledge and memory: The real story* (pp. 153–164). Hillsdale, NJ: Erlbaum.
- Rubin, D.C. (1998). Beginnings of a theory of autobiographical remembering. In C.P. Thompson, D.J. Herrmann, D. Bruce, J.D. Reed, D.G. Payne, & M.P. Toglia (Eds.), *Autobiographical memory: Theoretical and applied perspectives* (pp. 47–67). Mahwah, NJ: Erlbaum.
- Rubin, D.C. (1999). Frontal-striatal circuits in cognitive aging: Evidence for the caudate. *Aging, Neuropsychology, and Cognition*, 6, 241–259.
- Rubin, D.C. (2002). Autobiographical memory across the lifespan. In P. Graf & N. Ohta (Eds.), *Lifespan development of human memory* (pp. 159–184). Cambridge, MA: MIT Press.
- Rubin, D.C. (2005). A basic systems approach to autobiographical memory. *Current Directions in Psychological Science*, 14, 79–83.
- Rubin, D.C., & Berntsen, D. (2003). Life scripts help to maintain autobiographical memories of highly positive, but not highly negative, events. *Memory & Cognition*, 31, 1–14.
- Rubin, D.C., Burt, C.D., & Fifield, S.J. (2003). Experimental manipulation of the phenomenology of memory. *Memory & Cognition*, 31, 877–886.
- Rubin, D.C., Feldman, M.E., & Beckham, J.C. (2003). Reliving, emotions, and fragmentation in the autobiographical memories of veterans diagnosed with PTSD. *Applied Cognitive Psychology*, 18, 17–35.
- Rubin, D.C., & Greenberg, D.L. (1998). Visual memory deficit amnesia: A distinct amnesic presentation and etiology. *Proceedings of the National Academy of Sciences, USA*, 95, 5413–5416.
- Rubin, D.C., & Greenberg, D.L. (2003). The role of narrative in recollection: A view from cognitive and neuropsychology. In G. Fireman, T. McVay, & O. Flanagan (Eds.), *Narrative and consciousness: Literature, psychology, and the brain* (pp. 53–85). New York: Oxford University Press.
- Rubin, D.C., Groth, L., & Goldsmith, D.J. (1984). Olfactory cuing of autobiographical memory. *American Journal of Psychology*, 97, 493–507.
- Rubin, D.C., Hinton, S., & Wenzel, A. (1999). The precise time course of retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 25, 1161–1176.
- Rubin, D.C., & Kontis, T.C. (1983). A schema for common cents. *Memory & Cognition*, 11, 335–341.
- Rubin, D.C., & Kozin, M. (1984). Vivid memories. *Cognition*, 16, 81–95.
- Rubin, D.C., Rahhal, T.A., & Poon, L.W. (1998). Things learned in early adulthood are remembered best. *Memory & Cognition*, 26, 3–19.
- Rubin, D.C., Schrauf, R.W., & Greenberg, D.L. (2003). Belief and recollection of autobiographical memories. *Memory & Cognition*, 31, 887–901.
- Rubin, D.C., & Siegler, I.C. (2004). Facets of personality and the phenomenology of autobiographical memory. *Applied Cognitive Psychology*, 18, 913–930.
- Rubin, D.C., Stoltzfus, E.R., & Wall, K.L. (1991). The abstraction of form in semantic categories. *Memory & Cognition*, 19, 1–7.
- Rubin, D.C., & Wallace, W.T. (1989). Rhyme and reason: Analyses of dual cues. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 15, 698–709.
- Rubin, D.C., Wallace, W.T., & Houston, B.C. (1993). The beginnings of expertise for ballads. *Cognitive Science*, 17, 435–462.
- Rumelhart, D.E., McClelland, J.L., & the PDP Research Group. (1986). *Parallel distributed processing: Explorations in the microstructure of cognition: Vol. 1. Foundations*. Cambridge, MA: MIT Press.
- Rumelhart, D.E., & Norman, D.A. (1986). Representation in memory. In R.C. Atkinson, R.J. Herrnstein, G. Lindzey, & R.D. Luce (Eds.), *Steven's handbook of experimental psychology: Vol. 2. Learning and cognition* (2nd ed., pp. 511–587). New York: Wiley.
- Ryan, L., Nadel, L., Keil, K., Putnam, K., Schnyer, D., Trouard, T., & Moscovitch, M. (2001). Hippocampal complex and retrieval of recent and very remote autobiographical memories: Evidence from functional magnetic resonance imaging in neurologically intact people. *Hippocampus*, 11, 707–714.
- Salthouse, T.A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review*, 103, 403–428.
- Sanders, T.J.M., & Gernsbacher, M.A. (2004). Accessibility in text and discourse processing. *Discourse Processes*, 37, 79–89.
- Schab, F.R., & Crowder, R.G. (1995). *Memory for odors*. Mahwah, NJ: Erlbaum.
- Schacter, D.L., Norman, K.A., & Koutstaal, W. (1998). The cognitive neuroscience of constructive memory. *Annual Review of Psychology*, 49, 289–318.
- Schafer, R. (1981). Narration in the psychoanalytic dialogue. In W.J.T. Mitchell (Ed.), *On narrative* (pp. 25–49). Chicago: University of Chicago Press.
- Schank, R.C., & Abelson, R.P. (1995). Knowledge and memory: The real story. In R.S. Wyer Jr. (Ed.), *Knowledge and memory: The real story*. Hillsdale, NJ: Erlbaum.
- Schmajuk, N.A., & DiCarlo, J.J. (1992). Stimulus configuration, classical conditioning, and hippocampal function. *Psychological Review*, 99, 268–305.
- Schneider, G.E. (1967). Contrasting visuomotor functions of tectum and cortex in the golden hamster. *Psychologische Forschung*, 31, 52–62.
- Schooler, J.W., & Engstler-Schooler, T.Y. (1990). Verbal overshadowing of visual memories: Some things are better left unsaid. *Cognitive Psychology*, 22, 36–71.
- Schrauf, R.W. (2000). Bilingual autobiographical memory: Experimental studies and clinical cases. *Culture and Psychology*, 6, 387–417.
- Schrauf, R.W. (2003). A protocol analysis of retrieval in bilingual autobiographical memory. *The International Journal of Bilingualism*, 7, 235–256.
- Schrauf, R.W., Pavlenko, A., & Dewaele, J.-M. (2003). Bilingual episodic memory: An introduction. *The International Journal of Bilingualism*, 7, 221–233.
- Schrauf, R.W., & Rubin, D.C. (1998). Bilingual autobiographical memory in older adult immigrants: A test of cognitive explanations of the reminiscence bump and the linguistic encoding of memories. *Journal of Memory and Language*, 39, 437–457.
- Schrauf, R.W., & Rubin, D.C. (2000). Internal languages of retrieval: The bilingual encoding of memories for the personal past. *Memory & Cognition*, 28, 616–623.
- Scoville, W.B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery, and Psychiatry*, 20, 11–21.

- Segal, S.J., & Fusella, V. (1970). Influence of imaged pictures and sounds on detection of visual and auditory signals. *Journal of Experimental Psychology*, *83*, 458–464.
- Shannon, C.E., & Weaver, W. (1949). *The mathematical theory of communication*. Urbana: University of Illinois Press.
- Sharot, T., Delgado, M.R., & Phelps, E.A. (2004). How emotion enhances the feeling of remembering. *Nature Neuroscience*, *7*, 1376–1380.
- Shepard, R.N. (1978). The mental image. *American Psychologist*, *33*, 125–137.
- Shettleworth, S.J. (1998). *Cognition, evolution, and behavior*. New York: Oxford University Press.
- Simon, H.A. (1969). *The sciences of the artificial*. Cambridge, MA: MIT Press.
- Simons, J.S., & Spiers, H.J. (2003). Prefrontal and medial temporal lobe interactions in long-term memory. *Nature Reviews Neuroscience*, *4*, 637–648.
- Skinner, B.F. (1974). *About behaviorism*. New York: Knopf.
- Smyth, M.M., & Waller, A. (1998). Movement imagery in rock climbing: Patterns of interference from visual, spatial, and kinaesthetic secondary tasks. *Applied Cognitive Psychology*, *12*, 145–157.
- Solomon, K.O., & Barsalou, L.W. (2001). Representing properties locally. *Cognitive Psychology*, *43*, 129–169.
- Solomon, K.O., & Barsalou, L.W. (2004). Perceptual simulation in property verification. *Memory & Cognition*, *32*, 244–259.
- Solso, R.L., & Biersdorff, K.K. (1975). Recall under conditions of cumulative cues. *Journal of General Psychology*, *93*, 233–246.
- Spence, D.P. (1982). *Narrative truth and historical truth: Meaning and interpretation in psychoanalysis*. New York: Norton.
- Squire, L.R. (1987). *Memory and brain*. New York: Oxford University Press.
- Squire, L.R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review*, *99*, 195–231.
- Squire, L.R. (2004). Memory systems of the brain: A brief history and current perspective. *Neurobiology of Learning and Memory*, *82*, 171–177.
- Squire, L.R., Knowlton, B., & Musen, G. (1993). The structure and organization of memory. *Annual Review of Psychology*, *44*, 453–495.
- Squire, L.R., Stark, C.E., & Clark, R.E. (2004). The medial temporal lobe. *Annual Review of Neuroscience*, *27*, 279–306.
- Talarico, J.M. (2002). *The influence of emotion on autobiographical memories: An historical review*. Unpublished manuscript, Duke University, Durham, NC.
- Talarico, J.M., LaBar, K.S., & Rubin, D.C. (2004). Emotional intensity predicts autobiographical memory experience. *Memory & Cognition*, *32*, 1118–1132.
- Talarico, J.M., & Rubin, D.C. (2003). Confidence, not consistency, characterizes flashbulb memories. *Psychological Science*, *14*, 455–461.
- Taylor, H.A., & Tversky, B. (1992). Spatial mental models derived from survey and route descriptions. *Journal of Memory and Language*, *31*, 261–292.
- Toth, J.P., & Hunt, R.R. (1999). Not one versus many, but zero versus any: Structure and function in the context of the multiple memory systems debate. In J.K. Foster & M. Jelicic (Eds.), *Memory: Systems, process or function?* (pp. 232–272). New York: Oxford University Press.
- Trevarthen, C.B. (1968). Two mechanisms of vision in primates. *Psychologische Forschung*, *31*, 299–348.
- Tulving, E. (1983). *Elements of episodic memory*. New York: Oxford University Press.
- Tulving, E. (1985). Memory and consciousness. *Canadian Psychology*, *26*, 1–12.
- Tversky, B., & Marsh, E.J. (2000). Biased retellings of events yield biased memories. *Cognitive Psychology*, *40*, 1–38.
- Tye, M. (1991). *The imagery debate*. Cambridge, MA: MIT Press.
- Underwood, B.J. (1969). Attributes of memory. *Psychological Review*, *76*, 559–573.
- Ungerleider, L.G., & Mishkin, M. (1982). Two cortical visual systems. In D.J. Ingle, M.A. Goodale, & R.J.W. Mansfield (Eds.), *Analysis of visual behavior* (pp. 549–586). Cambridge, MA: MIT Press.
- van der Kolk, B.A., & Fisler, R. (1995). Dissociation and the fragmentary nature of traumatic memories: Overview and exploratory study. *Journal of Traumatic Stress*, *8*, 505–525.
- Van Essen, D.E., Anderson, C.H., & Felleman, D.J. (1992). Information processing in the primate visual system: An integrated systems perspective. *Science*, *255*, 419–423.
- Vermetten, E., & Bremner, J.D. (2003). Olfaction as a traumatic reminder in posttraumatic stress disorder: Case reports and review. *Journal of Clinical Psychiatry*, *64*, 202–207.
- Wallace, W.T., & Rubin, D.C. (1988a). Memory of a ballad singer. In M.M. Gruenberg, P.E. Morris, & R.N. Sykes (Eds.), *Practical aspects of memory: Current research and issues: Vol. 1. Memory in everyday life* (pp. 257–262). New York: Wiley.
- Wallace, W.T., & Rubin, D.C. (1988b). “The wreck of the old 97”: A real event remembered in song. In U. Neisser & E. Winograd (Eds.), *Remembering reconsidered: Ecological and traditional approaches to the study of memory* (pp. 283–310). Cambridge, England: Cambridge University Press.
- Wallace, W.T., & Rubin, D.C. (1991). Characteristics and constraints in ballads and their effects on memory. *Discourse Processes*, *14*, 181–202.
- Watkins, M.J. (1979). Engrams as cuegrams and forgetting as cue overload: A cuing approach to the structure of memory. In C.R. Puff (Ed.), *Memory organization and structure*. New York: Academic Press.
- Watkins, M.J. (1990). Mediationism and the obfuscation of memory. *American Psychologist*, *45*, 328–335.
- Watson, M.E., & Rubin, D.C. (1996). Spatial imagery preserves temporal order. *Memory*, *4*, 515–534.
- Watson, M.E., Welsh-Bohmer, K.A., Hoffman, J.M., Lowe, V., & Rubin, D.C. (1999). The neural basis of naming impairments in Alzheimer’s disease revealed through positron emission tomography. *Archives of Clinical Neuropsychology*, *14*, 347–357.
- Wechsler, D. (1987). *Wechsler Memory Scale-Revised: Manual*. San Antonio: Psychological Corp.
- Weiss, P.H., Marshall, J.C., Zilles, K., & Fink, G.R. (2003). Are action and perception in near and far space additive or interactive factors? *NeuroImage*, *18*, 837–846.
- Westmacott, R., Leach, L., Freedman, M., & Moscovitch, M. (2001). Different patterns of autobiographical memory loss in semantic dementia and medial temporal lobe amnesia: A challenge to consolidation theory. *Neurocase*, *7*, 37–55.
- Wheeler, M.A., & McMillan, C.T. (2001). Focal retrograde amnesia and the episodic-semantic distinction. *Cognitive, Affective, & Behavioral Neuroscience*, *1*, 22–36.
- Wheeler, M.A., Stuss, D.T., & Tulving, E. (1997). Toward a theory of episodic memory: The frontal lobes and autoecic consciousness. *Psychological Bulletin*, *121*, 331–354.

- Wheeler, M.E., Petersen, S.E., & Buckner, R.L. (2000). Memory's echo: Vivid remembering reactivates sensory-specific cortex. *Proceedings of the National Academy of Sciences, USA*, 97, 11125–11129.
- Whiting, B.J. (1955). *Traditional British ballads*. New York: Appleton-Century-Crofts.
- Whorf, B.L. (1956). *Language, thought, and reality: Selected writings of Benjamin Lee Whorf*. Cambridge, MA: MIT Press.
- Williams, D.M., & Hollan, J.D. (1981). The process of retrieval from very long-term memory. *Cognitive Science*, 5, 87–119.
- Williams, M.J.G. (1996). Depression and the specificity of autobiographical memory. In D.C. Rubin (Ed.), *Remembering our past: Studies in autobiographical remembering* (pp. 244–267). Cambridge, England: Cambridge University Press.
- Willingham, D.B. (2001). *Cognition: The thinking animal*. Upper Saddle River, NJ: Prentice-Hall.
- Willingham, D.B., & Goedert, K. (2001). The role of taxonomies in the study of human memory. *Cognitive, Affective, & Behavioral Neuroscience Journal*, 1, 250–265.
- Winograd, E., & Church, V.E. (1988). Role of spatial location in learning face-name associations. *Memory & Cognition*, 16, 1–7.
- Woldorff, M.G., Liotti, M., Seabolt, M., Busse, L., Lancaster, J.L., & Fox, P.T. (2002). The temporal dynamics of the effects in occipital cortex of visual-spatial selective attention. *Cognitive Brain Research*, 15, 1–15.
- Woodcock, R.W., & Johnson, M.B. (1991). *Woodcock-Johnson Psycho-Educational Battery-Revised: Tests of cognitive ability*. Allen, TX: DLM Teaching Resources.
- Wulf, H.H. (1979). *Aphasia, my world alone*. Detroit, MI: Wayne State University Press.
- Yates, F.A. (1966). *The art of memory*. Chicago: University of Chicago Press.
- Yonelinas, A.P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory & Language*, 46, 441–517.
- Zatorre, R.J., Jones-Gotman, M., Evans, A.C., & Meyer, E. (1992). Functional localization and lateralization of human olfactory cortex. *Nature*, 360, 339–340.
- Zechmeister, E.B., & McKillip, J. (1972). Recall of place on the page. *Journal of Educational Psychology*, 63, 446–453.
- Zeki, S. (1993). *A vision of the brain*. Oxford, England: Blackwell.
- Zimmer, H.D., Cohen, R.L., Guynn, M.J., Engelkamp, J., Kormi-Nouri, R., & Foley, M.A. (2001). *Memory for action: A distinct form of episodic memory?* Oxford: Oxford University Press.
- Zwicky, A.M. (1976). Well, this rock and roll has got to stop. Junior's head is as hard as a rock. In S.S. Mufwene, C.A. Walker, & S.B. Steever (Eds.), *Papers from the Twelfth Regional Meeting, Chicago Linguistic Society* (pp. 676–697). Chicago: Chicago Linguistic Society.