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Beginnings of a Theory of Autobiographical Remembering

David C. Rubin
Duke University

This chapter is not a summary of past work, but an expansion of earlier thoughts (Rubin, 1995b, 1996) into the outline of a project for the future. It is a reaction to what has been the dominant metaphor in the study of human memory for the last few decades: the human mind as a computer. A better metaphor might be a mind modeled on what we know about the brain. I want to reconceptualize the phrase "having a memory" from a computer retrieval, where it is well understood, to a biological act where it is not. To do this I outline the minimum model that could provide autobiographical memories of the full-blown kind you might have when you remember what happened to you at the time of a nationally or internationally important event (Brown & Kulik, 1977; Conway, 1995; Winograd & Neisser, 1992), or remember experiencing a personally important event (Rubin & Kozin, 1984), or even the details from this morning's breakfast (Galton, 1879).

For the last few decades psychologists have viewed human memory as an analog of computer memory with its encoding, storage, and retrieval of information. We have concentrated on data structures and retrieval schemes, neglecting the different natures of the informational, sensory, emotional, and phenomenological qualities of memory (see Tulving, 1983, for a similar observation). After all, computers are highly flexible, general-purpose information processors. One of their strengths is that the exact

nature of the information they process is not important: It is all just bits and bytes.

In contrast to this general data processing of the computer, the brain processes different kinds of information in different systems, integrating these processes into a unitary consciousness. Unlike the computer, the individual neural systems are not viewed as the result of efficient engineering. The brain is most often viewed as a collection of spare parts that at each point in a long evolutionary history were patched together in a way that increased genetic fitness at each point in each existing niche. Parts that evolved for one purpose were modified for a new purpose. Under this view, complex cognitive behavior can be seen either as relying on recently expanded modules or as a novel integration of existing parts that underwent more modest changes. Autobiographical memory appears to follow the latter pattern. All brain systems that can benefit from experience, by definition, have a form of memory. Autobiographical memory requires the integration of many such systems.

For instance, autobiographical memory makes use of a well-developed spatial ability and the spatial memory that comes with it, an ability and memory that exists in various forms in various species. Spatial ability may have been modified for use in autobiographical memory, but it did not have to be invented. But even if I were to claim that autobiographical memory is a purely human, highly specialized faculty, I would not have to claim that it or the individual memories that are its products are localized in a single brain system. Language is the prototypical rapidly developed, species-specific, highly specialized human ability, and language is spread over a large part of the cortex, with damage in various locations causing different changes in behavior.

In pursuing this view, the first question becomes: What are the systems of the mind and brain that must be involved in having an autobiographical memory and how are they related? Put this way, the initial answer, and that is all I have to offer here, is the beginnings of a boxes-and-arrows flowchart of the type psychologists, inspired by computer models of the mind, are fond of producing. This is my first attempt at one. I try it now 20 years after it would have been stylish because each box and arrow is no longer just a promissory note for a to-be-filled-in mechanism, process, or mathematical equation. The boxes and arrows are not as free as they once were to change as needed to account for changes in the behaviors they were explaining. They have additional constraints because the boxes are linked to claims about neural systems. Claims about the boxes and arrows used to describe autobiographical memory in the mind must be consistent with neuropsychological studies of amnesia and ongoing work in brain imaging as well as with behavioral data. Instead of treating the mind as one large black box,

we treat it as a set of somewhat smaller black boxes. Not a major advance, but a step in what might be a useful direction.

To begin the search, I return to the behavior to be described, autobiographical memory. Philosophers (see Brewer, 1996, for a review) and psychologists (Tulving, 1983) have wondered whether autobiographical memory is something worth studying as a separate entity. I just assume that it is and begin by discussing its properties. For a working definition of autobiographical memory, I simply use the word *recollection* (Baddeley, 1992; Brewer, 1996). Autobiographical memory is conscious recall; it is episodic memory (Tulving, 1972, 1983). It is accompanied by a sense of reliving, a sense that the remembered event actually occurred to you at a specific place and time. A clear abstract, scholarly description comes from Brewer (1986), a description that he later expanded under the term *recollective memory* (Brewer, 1996):

> Recollective memory is memory for a specific episode from an individual's past. It typically appears to be a "reliving" of the individual's phenomenal experience during the earlier moment. Thus these memories typically contain information about place, actions, persons, objects, thoughts, and affect. . . . The information in this form of memory is expressed as a mental image. . . . They are accompanied by a belief that the remembered episode was personally experienced. . . . Recollective memories give rise to high confidence in the accuracy of their content. (pp. 60–61)

To complement Brewer's philosophical review of the properties of autobiographical memory, a clear example of the phenomenon of autobiographical memory comes from the classic passage from Proust (1928/1956) in which the smell and taste of a "petite madeleine" first produces "an exquisite pleasure . . . detached, with no suggestion of its origin" (p. 62) and then after a time "the memory returns . . . immediately the old grey house upon the street . . . rose up like the scenery of a theatre . . . and with the house the town" (pp. 65, 66). The sensory cues work quickly to change mood, but the memory comes more slowly, and when it does come it consists in large part of a visual image. Olfactory stimulation in a laboratory setting can be used reliably to produce similar effects, although the students' descriptions do not rival Proust's (Rubin, Groth, & Goldsmith, 1984).

Several observations are worth noting. First, the sequence of remembering was a rapid change in affect followed by a pause and then a linguistic label of the original occurrence of the cue, followed immediately by a visual image. Second, in addition to the linguistic description at which Proust excels, were large affective and visual imagery components. Third, Proust

was distracted by daily activities when he "mechanically" tasted the petite madeleine soaked in tea. The taste came as a surprise to him. It was out of the context in which he initially experienced it in his childhood. Such surprising, or initially unconscious activation, may often enhance the effect. The smell of coffee from a cup that is in view is more likely to be attributed to coffee present than coffee past. Unlabeled odors from unmarked or unseen containers provide similar out-of-context surprising stimuli in the laboratory.

Fourth, it takes a long time to produce a recollection even though olfaction can produce virtually instantaneous warnings of unpleasant or dangerous stimuli. In the written form, it takes Proust about two pages, which is relatively brief for Proust. In the laboratory it takes about 15 seconds in our current work. This is not out of line for autobiographical memory retrieval. In other work with word cues it takes undergraduates about 10 seconds to begin writing a memory (Rubin & Schulkind, in press a, in press b). There must be a great deal of conscious or unconscious cognition (i.e., brain activity) between the initial sensation and the recollection. As Proust (1928/1956) put it, "What is thus palpitating in the depths of my being must be the image, the visual memory, which, being linked to that taste, has tried to follow it into my conscious mind" (p. 64). This "palpitating" needs to be measured and understood. Fifth, no one would claim that petites madeleines soaked in tea are extremely positive universal stimuli for all people in all cultures. It must have helped that the taste was associated in life with an aunt and her room in Combray on Sunday mornings. Proust was describing long-term, episodic memory, and in particular how cues evoke past affect and life experiences.

Proust's anecdote is a unique case and needs to be treated that way. It is a stimulus for further analysis, not a final answer. For instance, we know that a change in affect need not be reported for all vivid memories (Rubin & Kozin, 1984). It is not clear whether the change in affect that occurs in olfactory cuing of vivid memories is all rapid. It is even less clear whether any change in affect that occurs from cuing by other senses, such as vision and audition, is rapid or whether any change in affect waits until the memory can been "seen" and described. With luck, future research will decide.

Psychologists have been slow to study autobiographical memory as a brain phenomenon that integrates many components. One reason to invoke the brain as a metaphor is to foster this integrative approach. Although the verbal reports of the memory-eliciting effects of tastes, smells, and other stimuli are frequent and consistent, they are anecdotal, introspective, subjective, complex, and thought to be difficult to bring under laboratory control. In fact, Miller (1962) began his chapter on "Memory" in his book *Psychology: The Science of Mental Life* with a quote from the same passage

of Proust I just used. Miller noted, "A prudent psychologist might well decide to leave such fragile flowers to Proust and his fellow artists" (p. 161). However, recent advances in autobiographical memory provide a solid new cognitive framework in which to study this phenomenon, and recent advances in brain imaging provide a new means to corroborate verbal reports with changes in neural activity.

It is clear from Brewer's and Proust's descriptions that autobiographical memory must have a minimum of five components. There must be some cuing that leads to a search process or processes that retrieves (and, to the extent needed, integrates) narrative, visual imagery, and affect components. In traditional accounts of cognitive psychology, the brain, and neuropsychology, these five components are usually viewed as five separate entities or processes. They are therefore easy to view as good candidates for subsystems of a larger integrated process. The five components—cuing, retrieval, language, imagery, and affect—are a first approximation. The five are a rough minimal set for recall; encoding is left out for now as the act of encoding is harder to study than the act of recall. Each component could and may need to be subdivided; certainly language and imagery do. No claims are made about the neural substrate of the components and their connection, except for the retrieval component, although many could be. Few claims are made about the arrows connecting these five boxes. The five components may not even be of the same kind. All are viewed here as processes operating on structures, but language, imagery, and perhaps affect can be seen as having storage functions that cuing and retrieval do not. Cuing, as separate from retrieval, is used as a combination of the classic role of perception and the need to allow for cuing by internal thoughts or states. With refinement, it is hoped that these a priori divisions will alter to fit the data better and to provide a more coherent theory, but for now this is my best attempt.

CUING

Although the example Proust used is of smell and taste, the more general case needs to be considered. Cues can be classified into three loose categories for purposes of exposition. First are internal cues such as known thoughts, emotions, and states of mind. Second are external cues that come from known, observable stimuli external to the person. Third are the memories that come unbidden (Berntsen, in press), which could be from either one of the first two categories but that have no likely known referent. The most is known about external cuing. Words rated as high in imagery and meaningfulness cue the oldest memories in undergraduates. Words

rated as high in imagery, meaningfulness, familiarity, and age of acquisition produce more memories and presumably produce memories more quickly. Correlations for these effects are around .5 (Rubin, 1980). Odors, contrary to expectation, do not cue older memories than words with the same referent, but do cue memories that were not thought about as often. As words that have the same referent as odors are all easy to image, the overall observation that odors cue old memories is not challenged, but refined (Rubin et al., 1984).

RETRIEVAL PROCESSES

Retrieval is the most mysterious aspect of the whole process. We as psychologists are always poorer at process than structure (Rubin, 1988), but here we are in even poorer shape than usual because most memory processes that we use come directly from the computer metaphor. Note that the title of this section, "Retrieval Processes," is straight from that metaphor. If we maintain the computer metaphor, reasonable understandings of the retrieval of autobiographical memories are certainly possible (Conway, 1996; Conway & Rubin, 1993; Reiser, Black, & Kalamarides, 1986; Tulving, 1983). In contrast, the mechanisms of retrieval in the brain are not as clear as those in the computer, which is one reason that we have kept the computer model.

However we view retrieval, we need to include integration with it. Either the multimodal narrative-imagery-affect autobiographical memories are integrated on retrieval, or they are stored as an integrated or connected unit, or they slowly become more integrated over time (Squire, 1992; Squire & Zola-Morgan, 1991) or repeated retrieval.

One observation about retrieval is especially noteworthy: It takes a very long time. In a sample of 20 undergraduates who were each cued individually with 124 words, the mean time to produce a memory was 10 seconds (Rubin & Schulkind, in press a, in press b), or in the more usual cognitive psychological measure, 10,000 milliseconds. Seventy-year-old volunteers took about 17,000 milliseconds. Elsewhere in the literature, in one of the earliest studies Robinson (1976) found his undergraduates also took about 10 seconds to retrieve memories for object and activity words, but 14 seconds for affect words. Fitzgerald and Lawrence's (1984) undergraduates were a bit faster, taking 7 seconds for nouns and 11 seconds for affect words. His older adults were slower (taking 8 and 14 seconds, respectively) and his junior high students faster (taking 4 and 6 seconds, respectively). As the stimuli used in autobiographical memory studies are perceived and responded to in a few hundred milliseconds in other tasks, there is a lot of

time being spent on retrieval; so much, that if I did not now take twice as long to think of the names of people I know and if I did not try to think of similar memories from similar cues in everyday life, I might consider the task too artificial. One cognitive mechanism that might produce such a delay is cyclical retrieval (Conway, 1996). Each successive retrieval serves as the cue for the next search. Such mechanisms are common in computer models and are consistent with a nervous system that has closed-loop pathways and well-developed efferent as well as afferent communication.

LANGUAGE AND NARRATIVE STRUCTURE

Language and especially narrative structure are necessary components of autobiographical memory. Autobiographical memories are usually recalled as narrative. They are told to another person and to oneself. What is included and excluded depends in part on the language available and the narrative structures used. If no words exist to describe something or if the narrative structure omits something, it is less likely to be remembered. Three examples illustrate this point. First, Brown and Kulik (1977) observed that reports of especially vivid, or flashbulb, memories tend to have canonical categories such as the place, ongoing event, informant, affect in others, own affect, and aftermath. Neisser (1982) countered that these may not be properties of flashbulb memories at all, but rather properties of the narrative genre used to report any news. Thus, Neisser claimed that these autobiographical memories are shaped by narrative conventions of the culture. Second, in trying to account for the vividness of such memories, Rubin and Kozin (1984) made the claim that all memories start out as clear vivid memories, but then most fade. The ones that remain are the ones that are rehearsed, or otherwise practiced, often by being told to others. Verbal rehearsal thus shapes the memories. Routine autobiographical memories follow the same pattern. Third, Barsalou (1988) asked people to recall events from their previous summer in the order in which they came to mind. The structures Barsalou formulated to describe and explain these data can be considered either as properties of a memory system or as properties of the narrative structure used to describe memories.

In fact, most researchers who have examined the form and content of autobiographical memory have focused on narrative structure, as the following list shows. Robinson (1981) integrated theories of narrative from linguistics and folklore into cognitive psychology. His chapter in this volume (Robinson & Taylor, chap. 8) carries this early work forward. Barclay (1986, 1996; Barclay & Smith, 1992) examined the schematic nature of autobiographical memory and how it relates to the local and general

culture in which the individual is located. This produces the "conversational nature of autobiographical remembering" (Barclay & Smith, 1992, p. 82). Fitzgerald (1986, 1988, 1992) used concepts like *narrative thought* and *self-narratives* to account for autobiographical memory and how it changes over the life span and with mood shifts. 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). Using a psychoanalytic framework, Schafer (1981) and Spence (1982) noted the importance of narrative. Freeman (1993) tied narrative to autobiographical memory in a more humanistic approach, and Gergen and Gergen (1988) used narrative structure and communication to stress the social nature of remembering and of the self. On the more applied side Wagenaar, van Koppen, and Crombag (1993) documented the all-too-important role of a good story in the legal system. They found that observations that fit the narrative summary being prepared by the court were more likely to be summarized and thus "remembered" by the court, whereas observations that did not fit the narrative were more likely to be omitted and therefore "forgotten."

There has also been detailed analysis of the narrative structure of autobiographical memory in social situations. The narrative structure of autobiographical memory appears indistinguishable from the narrative structure of other social communication, and the recall of autobiographical memories is usually a social act (Hirst & Manier, 1996) that can define the social group (Bruner & Feldman, 1996). An especially interesting social situation is that of parents teaching their children the narrative conventions used in telling, and therefore in having autobiographical memories (Fivush, chap. 6, this volume; Fivush, Haden, & Reese, 1996; Fivush & Reese, 1992; Miller, Potts, Fung, Hoogstra, & Mintz, 1990; Miller & Sperry, 1988; Nelson, 1993). For example, Fivush et al. (1996) observed longitudinal changes in parent–child recall of unique family events such as trips taken during vacations. The style the parents used to draw out the children's autobiographical memories when the children were 3½ years old predicted the children's style at age 6.

IMAGERY

Imagery is another major component of autobiographical memory. Following Brewer's analyses, I concentrate on visual imagery. In general terms, visual imagery is an analog system that shares many properties with visual perception. It can be broken down behaviorally and neurally into spatial and object components (see Rubin, 1995a, for a review) and in its role in

autobiographical memory may need further division (Cornoldi, De Beni, & Pra Baldi, 1989). As Brewer (1986, 1996) noted, autobiographical memories consist in part of images, and this is one way to separate them from facts about one's life that are not autobiographical memories.

Imagery is a part of the metaphor of taking a picture that was used to name the *flashbulb memory* phenomenon (Brown & Kulik, 1977) and an attempt to rename it *vivid memory* (Rubin & Kozin, 1984). Imagery is found throughout the flashbulb memory literature as an important component of what makes vivid memories vivid (see Conway, 1995, and Winograd & Neisser, 1992, for recent reviews). In addition there is a literature on field versus observer point of view in autobiographical memory (i.e., on whether one sees oneself in the memory or sees it from the original observer's viewpoint) going back at least to Freud (see Robinson & Swanson, 1993, for a recent review). Thus, we have at least two metaphors of imagery: one as a static, accurate picture and another as a fluid mental-model image that can be seen from different points of view (both literally and figuratively). The contrast between the two metaphors is one reason that the classic conflict between the view of memories as fixed and memories as constructions (e.g., Neisser, 1967) becomes so heated when applied to autobiographical memory.

Imagery has a central role in autobiographical memory for several reasons. The first is that it provides a powerful memory aid (Paivio, 1971, 1986, 1991), an observation that predates experimental work on imagery by a millennium or two. Almost all the mnemonic systems developed from the time of the ancient Greeks and Romans through the Middle Ages to the present generation of stage mnemonists and authors of books on how to improve memory are based on visual imagery (Paivio, 1971; Yates, 1966). Most of the evidence for imagery's mnemonic role comes from long-term memory effects, but imagery is also important in short-term or working memory (Baddeley, 1986) and can even be seen as having most of its effects there rather than in long-term representation (Marschark, Richman, Yuille, & Hunt, 1987).

Imagery is also important in autobiographical memory because of its role in increasing the specific, relived, personally experienced aspect of autobiographical memory. Specific, concrete details do more than improve memory. Concrete details make stories seem more accurate, thoughtful, and believable (Pillemer, 1992; Pillemer, Desrochers, & Ebanks, chap. 9, this volume; Pillemer, Picariello, Law, & Reichman, 1996). Although vivid images do not guarantee accuracy (Winograd & Neisser, 1992), people act as if memory for details implies that the central points are remembered correctly. For instance, eyewitness testimony is more effective if details are included, even if they are irrelevant to the case (Bell & Loftus, 1989), and sensory details make people likely to judge that they did an action rather

than just thought about it (Johnson, Hashtroudi, & Lindsay, 1993; Johnson & Raye, 1981). You are more likely to decide that you really did lock the door as opposed to just thinking you did if you can image yourself doing it. Chafe (1982, 1990) noted that language varies along the dimension of *involvement*. Involvement is marked by the use of first person and of dialogue, the same traits that are present when one seems to others to be reliving an experience or seeing it in one's mind's eye. Thus evidence that the rememberer has an image is routinely taken as evidence for a relived, personally experienced, accurate autobiographical memory.

In this role of increasing the specific, imagery and narrative interact. The language of a journal article, which I have lapsed from at times here, is abstract, general, and low in imagery; a good story is not. Bruner (1986) made this distinction in isolating two kinds of thought. The narrative mode of thought "strives to put its timeless miracles into the particulars of experience, and to locate the experience in time and place. The paradigmatic mode, by contrast seeks to transcend the particular by higher and higher reaching for abstraction" (p. 13). It is no accident that *Time, Newsweek,* and other magazines begin articles on general topics with specific, concrete case studies.

Imagery integrates with affect as well as narrative structure. Specific details aid in maintaining emotional balance (Williams & Dritschel, 1988), and increase affect, intimacy, and immediacy when compared to abstract statements that remove the events described from particular situations (Pillemer, 1992), and foster involvement (Chafe, 1982, 1990). Concrete details that increased affect, intimacy, immediacy, and involvement should lead to more frequent tellings and through this rehearsal mechanism to easier future recall.

Specific details are more likely to be mentioned if a speaker has an image, and thus a listener is likely to take specific details as a sign the speaker has an image. However, specific details are also part of the narrative and affective component as well as imagery. For some of the added functions of the specific, it is still reasonable to argue that the image is the driving force. Imagery is a process, of which we are sometimes aware, that aids memory. In the everyday sense of memory as reliving an experience, however, an image of which one is aware may be the memory, whereas the words may not be the memory at all but just a way of describing it.

The intimate relation of having an image and having an autobiographical memory, however, does cause problems. The two metaphors of imagery as a picture and imagery as a mental model are in conflict. Having an image makes a memory more believable. However, from both the literature on field versus observer perspective as well as the more general view of imagery as an analog system that allows actions and events to be simulated, imagery allows memory to be malleable (Rumelhart & Norman, 1986; Shepard,

1978). Thus imagery both increases the belief that memories are accurate and facilitates changes from initial perception. In the quote defining autobiographical memory earlier in the chapter, Brewer (1996) noted that an autobiographical memory includes both a belief of being a veridical record and a report of visual imagery. The conflict that can arise due to discrepancies between the belief that autobiographical memories are veridical and their accuracy is one of the most interesting and heated debates in all of memory research, as the chapters on eyewitness testimony in the companion volume show. The visual imagery component of autobiographical memory is a central contributor to this conflict.

AFFECT

Affect is another main component of autobiographical memory, but unlike narrative and imagery, affect is traditionally seen as outside cognition rather than as an aspect of it. As seen in the work of Christianson and Safer (1996) and of Williams (1996; Williams et al., 1996), affect has profound effects on autobiographical memory. It can focus attention on one aspect of a scene and it can reduce the ability to retrieve specific, as opposed to generic autobiographical memories of generalized categories of events. Recent work on the psychological and neural basis of affect and its relation to memory is growing (e.g., Christianson, 1992; the journal *Cognition and Emotion*) and should provide a too often ignored way of understanding autobiographical memory.

The effects of affect can often be seen as interactions with the imagery component. Christianson and Safer (1996) compared the focusing of memory on emotionally salient objects in an event to the focusing of attention in vision, allowing the focusing to be mediated by imagery. The inability of depressed individuals to retrieve specific, single-occurrence autobiographical memories documented by Williams may be related to the inability of abstract versus concrete, imageable memories to produce specific details (Chase & Ericsson, 1981; Schwanenflugel, Akin, & Luh, 1992). In addition, Robinson (1996) and Pillemer et al. (chap. 9, this volume) observed that changes in the viewer's perspective of an image affects the intensity of affect.

THE NEURAL BASIS OF RECOLLECTION

Existing neuropsychology, along with recent work using imaging techniques, is beginning to show what areas of the cortex are activated when

retrieval occurs. A much greater neuropsychology and brain-imaging effort is devoted to the visual imagery and language components that can help support theoretical claims for these processes. Whatever the ultimate definition and localization of language, visual imagery, affect, and retrieval, it is clear that they are subsystems of the mind and brain (e.g., Damasio, 1989, 1994). Each component can be seen as an aspect of a system that evolved for purposes other than having autobiographical memories and each has been adapted and integrated for that purpose.

In addition, there is considerable evidence on the neural basis of autobiographical memory itself from the neuropsychological study of specific types of amnesias that can help localize various memory functions. For instance, some frontal lobe patients confabulate wildly, showing an intact ability to create autobiographical "memories," but they have severe problems finding and integrating facts and monitoring their recall against reality (Baddeley & Wilson, 1986). Other observations about the nature of autobiographical memory could continue with particular lesions or diseases, each with its own particular damage site or neurotransmitter deficit that in combination with other cases can help triangulate on the neural underpinnings of autobiographical memory. Unfortunately, what we know here is not always easy to apply. In most neuropsychological cases, the syndrome does not fit neatly into existing cognitive theories, every case is different from all other cases in both behavior and neurology, and different investigators report different things, especially if one includes historical cases. This variety, however, does broaden the range of observations.

Although brain imaging and neuropsychology provide considerable evidence and analysis, there is no comprehensive neurally based model of how autobiographical memory works and so the task of integrating these findings remains. From our behavioral analysis the model will have at least language, imagery (both spatial and object), affect, and memory retrieval, and, if Proust's experience is to be modeled, olfactory cuing. The most is known about the language and imagery components, but even here the effect of studies of acquired cortical blindness or particular types of language loss on autobiographical memory are generally missing (but see Ogden, 1993, for a fascinating exception). Even the extent to which the basic data for a memory are stored together in one location or separately in these and other components is open, but retrieval or integration over the 10-second process of a cue evoking a memory is needed and provides a unique window on the nature of the integration process. We know the perceptual portion of the cuing process must be rapid. Next, if Proust's example is general, at least for olfaction, comes the affect component. Retrieval ends with activation in the visual and language areas. The exact time course and localization within general neural systems remains to be discovered.

We have less certain expectations of where and in what sequence brain activity will occur during the long time that occurs between the initial perceptual effect of the cue and the retrieval of a memory. Although there is a growing body of knowledge on the neural basis of episodic memory in general (e.g., Aggleton, 1991; Buckner, 1996; Kapur, 1993; Mishkin, Malamut, & Bachevalier, 1984; Nyberg, Cabeza, & Tulving, 1996; Petri & Mishkin, 1994; Squire, 1987, 1992; Tulving, 1989), in the context of the framework and task used here, the least is known about the process of retrieval. Having the less well localized retrieval portion of the process bounded by the more well localized processes of sensation and visual imagery is an ideal preparation for exploration.

Admitting our large degree of ignorance, there is considerable evidence about the most likely source of the "retrieval" or integration component(s) that is active when we have a full-blown autobiographical memory. There are two sources of evidence that both point to the same locations. The first line of evidence comes from neuropsychological and animal studies of amnesia (for reviews see Petri & Mishkin, 1994, and Squire, 1987). From such studies, it is known that damage either to the hippocampus and surrounding areas in the medial temporal lobe or damage to the mediodorsal thalamic and mammillary nuclei can both cause dense amnesias (e.g., Kapur, Thompson, Cook, Lang, & Brice, 1996). As these two areas can be considered as parts of a common circuit (Petri & Mishkin, 1994), this circuit could be (or could contain) the retrieval component.

The second line of evidence supports the idea that the limbic structures in the medial temporal lobe are the main source of the retrieval component, although this localization within a circuit may be an accident of the way the data were collected. Penfield, in his classic studies, was able to produce a dreamlike sense of reliving in his patients by stimulating the surface of their brains while probing for localization of function during surgery (see Squire, 1987, for a review and critique of this work). Whether these experiential responses were memories or new constructions is not at issue here; the often vivid sense of reliving is the relevant point. Whether these experiential responses were a dream or a memory is only important here if the sense of reliving in dreams and in recollections have different neural substrates. As Squire (1987) noted in his review of Penfield's work and studies that follow it, cases of experiential responses were rare, occurring in only about 8% of the stimulations of the temporal lobes. However, they were highly localized, occurring only with stimulation of the temporal lobes. Moreover, in later studies medial temporal lobe limbic structures were always involved in the complex experiential responses that most closely match what we would call a sense of reliving. Squire (1987) hypothesized that "limbic structures may possess such a capacity to evoke experiential phenomena because they have afferent and efferent connections to widespread areas of neocortex, in-

cluding temporal neocortex" (p. 82). Thus, for now our best guess at the localization of the retrieval or integration component is the medial-temporal/medial-thalamic circuit.

A third line of evidence could come from neuroimaging studies of people having autobiographical memories, preferably vivid autobiographical memories. Such evidence is possible. One general technical problem is that at the current time it is not clear how the magnitude of change in metabolic measures associated with neuronal activity relates to the processes of interest. Small increases in firing above a baseline (or moderate increases above a noisy baseline) may be undetected but important. For instance, the hippocampus has been shown to be important for memory from damage studies but does not appear to be as noticeable in activation measures in tasks where it might be expected (McCarthy, 1995). With more experience, the strengths and limits of the various sources of evidence should become clearer.

Although there is little work testing autobiographical memory directly, there has been considerable study of episodic memory in laboratory tasks. Encoding and retrieval of episodic memories are mediated by separate locations in the prefrontal cortex, encoding being mediated by the left hemisphere and retrieval by the right (Nyberg et al., 1996). More specifically, during retrieval the right anterior prefrontal area at or near Brodmann area 10 is active (Buckner, 1996). The relation of these frontal lobe centers to the more traditional medial-temporal/medial-thalamic circuit remains a challenge that may be clarified by neuroimaging studies of autobiographical memory or reexamination of neuropsychological cases. It is possible that the retrieval component postulated here may have to be further divided, for example possibly into one involved in determining specific temporal periods and one involving integration. Alternatively, the sense of reliving that has been attributed to the retrieval component may not really be a part of the retrieval component or even have a location in any component. Rather it might occur when several of the components, isolated here as being necessary for autobiographical memory, work in unison. Thus activity in the medial-temporal/medial-thalamic circuit, an area that in Squire's (1987) words has "afferent and efferent connections to widespread areas of neocortex" (p. 82), would be a symptom rather than a cause of the sense of reliving.

There remains one problem with the view that the medial-temporal/medial-thalamic circuit is the source of retrieval. Damage to this circuit appears to produce mainly anterograde amnesia; memories prior to the onset of the amnesia can often be recalled, whereas memories after the onset cannot. Therefore, from the damage studies, it appears that this circuit may be an encoding more than a retrieval area. In contrast, from the stimulation studies, the circuit appears to be a retrieval center.

There are at least three resolutions to this problem. The first is to accept

Squires' view that the medial-temporal/medial-thalamic circuit is needed for encoding and only initially for retrieval, with very long-term memory occurring without the need for the medial-temporal/medial-thalamic circuit. Under this view, the various aspects of older autobiographical memories connect to each other directly without the need of a retrieval component as hypothesized here. If one aspect of the memory is activated, that aspect could activate the other aspects directly as in most distributed models of long-term memory. From the evidence available, very long-term memory could still use the medial-temporal/medial-thalamic circuit for difficult retrievals like the one Proust described, but it would not be needed for all memories.

The second resolution is to ask what damage produces severe retrograde as well as anterograde amnesia; that is what damage affects all recollection, both of events prior and after the onset of the amnesia. Damage that produces such amnesias could provide evidence to help localize the retrieval or integration mechanism. There are two general causes of such retrograde amnesia (Hodges & McCarthy, 1993). One is herpes simplex encephalitis with medial temporal lobe damage. Another case of localized damage is in alcoholic Korsakoff's amnesia (e.g., Butters & Cermak, 1986), in which the mediodorsal thalamic and mammillary nuclei are affected. Although the retrograde amnesia is not complete, it usually extends back several decades, and even for the older memories it is difficult to get detailed autobiographical memories (Zola-Morgan, Cohen, & Squire, 1983). Depression also produces a general loss of specific recollections (Williams, 1996; Williams et al., 1996).

Alternatively, one could look at cases that had only retrograde amnesia. These are rarer, but do exist. Some retrograde amnesias have no clearly associated anatomical damage and are called *functional retrograde amnesia* (e.g., Schacter, Wang, Tulving, & Freedman, 1982) even if their onset was caused by a physical insult (e.g., Treadway, McCloskey, Gordon, & Cohen, 1992). Other retrograde amnesias have known neural bases and are called *focal retrograde amnesia* (Kapur, 1993). Several of these amnesias are accompanied by left temporal lobe abnormalities in electroencephalograms, positron emission tomography, or magnetic resonance imaging. Often these cases begin with both anterograde and retrograde amnesia, but after a period of time only the retrograde amnesia remains. From evidence such as this as well as other cases (Kapur et al., 1996), one might suspect that cortical damage is necessary for retrograde amnesia, but as in all of neuropsychology, nothing is simple and other cases lead to different conclusions (Hodges & McCarthy, 1993). Teasing apart necessary from sufficient in complex interconnected systems is not easy, but it still could be that damage to the left temporal lobe produces (or even is necessary for) retrograde amnesia in the absence of anterograde amnesia.

A third resolution is to examine the retrograde memory of patients in

more detail, especially the retrograde memories patients that have anterograde amnesia but are claimed to have no retrograde amnesia. To what extent are their retrograde memories really complete? How would they be rated on the scales we normally use to assess autobiographical memories such as scales of vividness and emotionality? Can examination of such memories show the degree to which anterograde amnesia patients have a sense of reliving, or vivid autobiographical memories, or recollection in general? Is there any relation between the type and severity of damage and the type and severity of retrograde memory loss?

In this regard the case description by Hodges and McCarthy (1993) is especially interesting. A 67-year-old man suffered bilateral lesions to the mediodorsal thalamic nuclei and the pathway connecting them to the mammillary nuclei. He had both dense anterograde and retrograde amnesias, demonstrating that damage to just the medial-thalamic circuit can cause severe retrograde amnesia. In studying the retrograde amnesia in detail it was found to be for autobiographical memories and public events, but his ability to identify famous people and order when in time they were famous was spared. Hodges and McCarthy suggested that the deficit might be in a thematic retrieval framework. Their patient was unable to index, retrieve, and integrate autobiographical memories but well may have had the component information for such memories.

Thus, a review of the neuropsychological and animal memory literature leaves several important questions about the long-term role of the retrieval or integration component. However, posing the question suggests the kinds of evidence that would be needed to address these questions. Much of this evidence exists, but like an autobiographical memory it needs to be retrieved and integrated.

Two other observations remain. First, when there is a long period of retrograde amnesia, it often stops in early adulthood. Other evidence suggests that this is a special period for encoding memories (Rubin, Rahhal, & Poon, 1996; Rubin & Schulkind, in press a, in press b; Rubin, Wetzler, & Nebes, 1986). Ways of integrating this observation and contrasting it with the more continuous time line view held in the consolidation views of neuropsychology remain open. Second, following Brewer's (1996) review of the literature, the time at which an event occurred has not been considered here as an intrinsic aspect of an autobiographical memory. However, there is evidence for time as an organizing factor that can describe the nature of memory loss in functional retrograde amnesia (e.g., Treadway et al., 1992) and in focal retrograde amnesia (e.g., Butters & Cermak, 1986).

SUMMARY

The goal of this chapter has been to explore what it would mean to begin developing a comprehensive theory of retrieval from autobiographical

memory within an individual, a theory that could benefit from what we know about the brain, behavior, and phenomenology (Larsen, chap. 10, this volume) during the act of having an autobiographical memory. Given the observations and theories reviewed here, converging evidence from these three domains should be of both theoretical and applied value.

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AUTOBIOGRAPHICAL MEMORY

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Edited by

Charles P. Thompson
Kansas State University

Douglas J. Herrmann
Indiana State University

Darryl Bruce
St. Mary's University

J. Don Read
University of Lethbridge

David G. Payne
State University of New York, Binghamton

Michael P. Toglia
State University of New York, Cortland

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