A Basic-Systems Approach to Autobiographical Memory

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ABSTRACT—*Memory for complex everyday events involving vision, hearing, smell, emotion, narrative, and language cannot be understood without considering the properties of the separate systems that process and store each of these forms of information. Using this premise as a starting point, my colleagues and I found that visual memory plays a central role in autobiographical memory: The strength of recollection of an event is predicted best by the vividness of its visual imagery, and a loss of visual memory causes a general amnesia. Examination of autobiographical memories in individuals with posttraumatic stress disorder (PTSD) suggests that the lack of coherence often noted in memories of traumatic events is not due to a lack of coherence either of the memory itself or of the narrative that integrates the memory into the life story. Rather, making the traumatic memory central to the life story correlates positively with increased PTSD symptoms. The basic-systems approach has yielded insights into autobiographical memory's phenomenology, neuropsychology, clinical disorders, and neural basis.*

KEYWORDS—*autobiographical memory; recollection; neuropsychology; posttraumatic stress disorder*

Autobiographical memories are episodic memories: recollected events that belong to an individual's past. As studied by cognitive psychologists, autobiographical memories involve far more complex situations than do laboratory memories. In a typical episodic memory experiment in a laboratory, the events to be remembered are words or pictures shown on a computer screen during a brief session. They usually involve only one sensory modality (e.g., sight or hearing); show little variation in spatial, temporal, emotional, and narrative content or context; and have hardly any personal relevance. The events that are recalled as autobiographical memories are typically multimodal (involving vision, hearing, smell, taste, touch, and body sense or kinesthesis); they vary in spatial, temporal, emotional, and narrative content and context; and they have personal relevance. The relative complexity of real-life situations suggests that studies of autobiographical memory require additional theoretical and methodological considerations that are not needed in the typical laboratory study. Similar complexities exist whenever any real-world stimuli, rather than simplified laboratory stimuli, are studied (Rubin, 1995).

The following systems play a role in autobiographical memory: individual senses (especially vision, hearing, and smell); a multimodal spatial system, which notes the location of objects and people; emotion; language; a narrative system that keeps track of causal relations but that need not use language (Rubin, Schrauf, & Greenberg, 2003; Schrauf & Rubin, 2000); and an explicit memory system that coordinates or binds information from the other systems. Each of these systems has its own processes, forms of organization, and roles with respect to memory. Each system is well documented by evidence from cognitive-behavioral studies, individual differences research, neuroanatomy, neuropsychology, and neuroimaging. And each plays a different role in autobiographical memory.

One implication of the fact that multiple systems are involved in autobiographical memory is that the self is not a single entity (Conway & Pleydell-Pearce, 2000); rather, it is distributed among the individual systems. The continuity of the self emerges from the continuity of these separate systems and their interaction with each other and the world. In addition, much that people "remember" as part of their life story is really shared cultural knowledge about the life course. This shared knowledge can often be attributed to cultural expectations, rather than to an individual's autobiographical memory (Berntsen & Rubin, 2004). This article addresses implications of these observations for the phenomenology (subjective experience), neuropsychology, psychopathology, and neuroimaging of autobiographical memory.

PHENOMENOLOGY

Two phenomenological properties that are of central practical and philosophical importance to autobiographical memory are

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the sense of recollection and the belief that memories are accurate. To assess these properties, my collaborators and I asked people to generate between 15 and 30 autobiographical memories each and rate their memories on scales including "As I remember the event, I feel as though I am reliving the original event" (strength of recollection) and "I believe the event in my memory really occurred in the way I remember it and that I have not imagined or fabricated anything that did not occur" (belief in memory accuracy; Rubin, Schrauf, & Greenberg, 2003; Rubin & Siegler, 2004). To measure the relative importance of the component systems in autobiographical memory, we also asked people to rate their memories on scales of the vividness of visual imagery, auditory imagery, and spatial context; on how strongly the original emotions were reinstated; and on how coherent the narratives were. We then averaged each person's responses to each scale over the person's autobiographical memories. In several experiments, people's average strength of recollection was predicted by the vividness of visual imagery and to a lesser extent by their auditory imagery, emotion, and narrative coherence, whereas their average degree of belief in the accuracy of their memories was predicted by their ratings of the clarity of the spatial context of their memory and by narrative coherence. When spatial context was not included as a predictor, belief in memory accuracy was also predicted by visual imagery. Belief in memory accuracy was predicted more poorly than recollection with the cognitive variables, but was better predicted by several individual difference measures not associated with the autobiographical memories themselves. In particular, low scores on depression and dissociation and high scores on openness to experience correlated positively with belief in memory accuracy.

In addition to comparing people on the basis of their averaged memory scores, we also calculated correlations on our rating scales for each individual separately, using each person's set of 15 to 30 memories. We did this because most theories in cognitive psychology are about processes within an individual, not differences in average ability or propensity across individuals. The same variables that predicted strength of recollection and belief in memory accuracy in the first analysis were important in this second analysis, but in this case they predicted recollection and belief equally well.

To check the correlational findings involving vividness of visual memory and recollection, we had people take part in two half-hour events (Rubin, Burt, & Fifield, 2003). In each event, half the participants were blindfolded and half were not. Removing visual input reduced recollection ratings a week later. Viewing a videotape of the event a week later increased the participants' ratings of visual imagery for the event in which they were blindfolded but further reduced their ratings of recollection. Other people either viewed or listened (without pictures) to different events on videotape and were asked to imagine that they were taking part in them. Again, recollection was rated lower when there was no visual input, but in this case, subsequently adding visual input increased recollection for events that were initially only heard. It seems that supplemental visual information about an event cannot be inconsistent with a person's existing memory if that information is to increase the person's subjective rating of recollection for the event.

NEUROPSYCHOLOGY

Typically, neuropsychological studies of autobiographical memory have focused on losses in the explicit memory system—in particular, losses that involve the hippocampus and other structures in the medial temporal area of the brain. Damage to this system causes a loss of autobiographical memory (amnesia) because the component aspects of an autobiographical memory cannot be bound together and later retrieved. But what about damage that causes loss of memory in the senses and other systems mentioned earlier?

To examine this question, we searched the neuropsychology literature for individuals who lost memory in specific component systems (Greenberg & Rubin, 2003). For example, to study the influence of vision, we searched for cases of visual memory loss—that is, patients who could see and respond well enough to provide a reasonable drawing of an object in their sight, but who could not draw the object from memory and could not name it or tell what its use was when it was shown to them. Such cases are rare, but we found 11. Most involved damage to the occipital lobe (the back, visual-processing part of the brain) on both sides. If visual memory is central to autobiographical memory, then one might expect such damage to cause a general deficit in autobiographical memory because, without the vital visual information, other information about an event could not be cued.

What we found was consistent with this expectation. All 11 patients had amnesia that involved more than just their visual memory. The amnesia often included a near-total loss of autobiographical memory from before the onset of the visual-memory loss; even childhood memories were not spared. The loss of autobiographical memory for events that took place after the onset of the visual-memory loss was typically milder. Such a pattern of symptoms is not typical of the more common form of amnesia caused by damage to the explicit memory system. But the pattern of symptoms makes sense if what was lost in these patients was the store of visual memories and the ability to encode new ones. After such a loss, new autobiographical memories can still be encoded and retrieved, but without a visual component; old autobiographical memories, even well-rehearsed and well-consolidated childhood memories, are lost because the relevant visual information, which is a key part of the memory information, is lost. Thus, examining the individual systems that contribute to autobiographical memory led to the identification of a new form of amnesia.

What about deficits in the other systems claimed to be important in autobiographical memory? Do they also produce

deficits that go beyond the system directly affected (Greenberg & Rubin, 2003)? We were able to find cases of auditory memory loss that met criteria like those of visual memory loss, but the patients with auditory memory loss did not exhibit amnesia. Language loss also does not seem to affect autobiographical memory, just the ability to communicate it; given enough time, aphasics can write autobiographies. The exceptions are patients with a progressive disease called semantic dementia, which in many ways parallels the effects of visual-memory loss. Losses in narrative reasoning are difficult to test and have not been studied enough for a firm conclusion to be drawn.

PSYCHOPATHOLOGY

Considering basic systems and their interaction is also useful in understanding psychopathology. Emotion modulates memory, and emotional deficits have general effects on memory. Autobiographical memories are less specific in people with depression than in other people. Rather than recalling particular events that occurred at one time and place, people with depression tend to merge many similar occurrences together—recalling, for example, "times when we went to the beach" rather than "one time when we went" (Williams, 1996). Individuals with panic disorder and posttraumatic stress disorder (PTSD) have enhanced memory for threat-related stimuli, but individuals with generalized anxiety disorder and social phobia, two other anxiety disorders, show no clear pattern of results. One possible explanation of these findings is that autobiographical memories of situations that lead to panic and trauma are different from autobiographical memories of situations that lead to worry and social anxiety. In the former case, a specific, highly negative event has occurred; in the latter, such an event may only have been anticipated.

To test this hypothesis, my collaborators and I had undergraduates rate autobiographical memories of events in which they had experienced panic, trauma, worry, social anxiety, or contentment (Wenzel, Pinna, & Rubin, 2004). Memories of worry and social phobia were rated lower on strength of recollection, degree of belief in memory accuracy, and strength of visual and auditory imagery and knowledge of spatial context than were memories of either panic and trauma or contentment. Descriptions of panic and trauma memories were coded by raters as more specific than descriptions of memories of worry and social phobia or of contentment.

PTSD is of special interest because it is a diagnosis involving specific malfunctions of autobiographical memory; other forms of memory are relatively unaffected. In terms of our basic-systems approach, we hypothesize that one or more of the component systems of autobiographical memory or their integration must be altered in PTSD. When these hypotheses are tested, some observations made in clinical situations are supported; others are called into question (Berntsen, Willert, & Rubin, 2003; Rubin, Feldman, & Beckham, 2003).

For instance, reports of strength of visual imagery and of visceral emotional reactions are higher for memories of trauma than for other autobiographical memories. As stronger visual imagery and emotional reactions lead to higher levels of recollection for memories of nontraumatic events (Rubin, Schrauf, & Greenberg, 2003; Talarico, LaBar, & Rubin, 2004), the high levels of recollection in traumatic memories are expected. It is particularly expected in involuntary memories (that is, memories that come without any conscious effort to retrieve them), for which the reliving of emotions can be high. In contrast, our evidence does not support other researchers' claims that memories of trauma are internally incoherent and not connected in a coherent fashion to the life narratives of people with PTSD. Direct comparisons of the internal coherence of narrative memories of trauma in people with and without PTSD usually have failed to show clear differences. Moreover, we have consistently found that the more a person makes a trauma central to his or her life story or identity, the more PTSD symptoms the person is likely to show—a finding that runs directly counter to claims that traumas are isolated from patients' life stories. Changes in autobiographical memory are part of the diagnosis of PTSD, but before these changes will really be understood in a useful, theoretical fashion, the component systems and their interactions need to be examined more fully by looking at voluntary and involuntary memories of traumatic and nontraumatic events in people with and without PTSD.

NEUROIMAGING

Neuroimaging has begun to show what brain systems and structures are active during retrieval of autobiographical memories. When people's brain activity during the recall of autobiographical memories is compared to brain activity during a control condition, the locations of increased activity have shown that autobiographical memories are distributed over many neural systems. The exact brain areas identified depend on the imaging techniques used and the control tasks to which the autobiographical-memory retrieval tasks are compared; but regions throughout the brain, from frontal regions involved in retrieving episodic memories to posterior regions involved in sensory processing, are commonly found to be involved. For instance, when my collaborators and I compared retrieval of autobiographical memory with retrieval of semantic memory (memory for general information that does not come with a sense of recollection), we found that the amygdala (involved in emotion), the hippocampus (involved in episodic encoding and retrieval), and the right inferior frontal gyrus (involved in episodic retrieval) were more active during the retrieval of autobiographical memory than during semantic memory. Moreover, a correlational analysis revealed that these areas worked closely together during retrieval from autobiographical memory but not during retrieval from semantic memory (Greenberg et al., 2005).

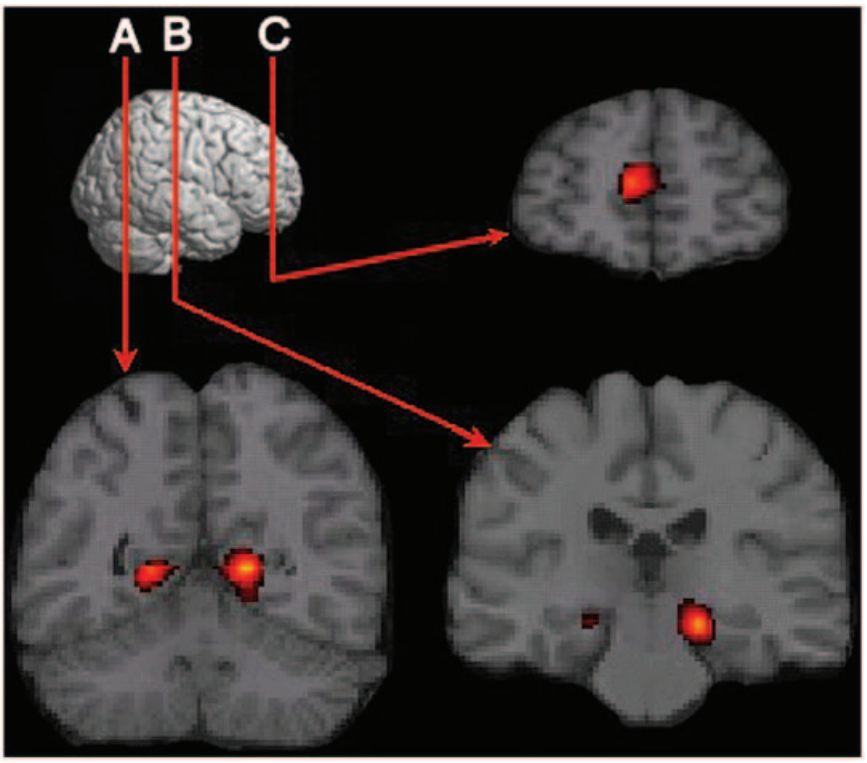

Fig. 1. Activation in brain areas during an autobiographical memory experiment. The upper left image shows a brain from the right side, with arrows indicating the location of the three cross-sections indicated by the letters A, B, and C. The color in each section indicates degree of difference in activation (yellow indicating highest activation and red indicating slightly less activation) between two conditions of the experiment: the activation when an individual correctly judged that a picture being viewed had been taken by that individual minus the activation when the individual correctly judged that the picture had been taken by someone else and only previously viewed in the laboratory. Thus the figure indicates the increases in activation that occurred when memory of the scene was more richly autobiographical. Section A shows activity in both hemispheres in the cuneus, a region involved in visual processing. That activity also extends towards the back of the brain to the primary visual cortex and to the front of the brain to the regions shown activated in section B. Section B shows activation in the hippocampal formation, which is involved in the binding of information in the basic systems during the encoding and retrieval of memories and in reports of recollection; and the right parahippocampal cortex, which is involved in spatial processing. Section C shows activity in the medial prefrontal left hemisphere, which is involved in tasks that draw on knowledge about the person recalling the event.

To try to connect the large number of neuroimaging studies of laboratory episodic memory with neuroimaging studies of autobiographical memory, we had undergraduates perform a controlled autobiographical memory task and a very similar laboratory task (Cabeza et al., 2004). For the autobiographical memory task, undergraduates took pictures of assigned locations on the Duke University campus over a 10-day period. For the laboratory task, the students viewed pictures other students had taken of the same locations. Then, during a functional magnetic resonance imaging (fMRI) scan, the students were again shown pictures and asked to judge whether the pictures were ones they took, ones they saw in the laboratory, or ones that they had not seen before.

All students saw pictures of the same locations; what differed was how each picture had been encoded into memory: Compared with pictures viewed in the lab, those that a student had taken him- or herself had a more varied visual, spatial, and temporal context during their encoding into memory and were more distinctive in terms of that student's ongoing activities. We expected that, compared with viewing pictures for an hour in a single laboratory setting, the more distinctive acts of scheduling times to find specific locations and composing and taking photographs of those locations would lead the autobiographical memories of these views to involve more visual and spatial processing, be recollected more strongly, and perhaps involve more processing related to the person's memory of connected events. As shown in Figure 1, our expectations about brain activity were confirmed.

CONCLUSION

What form would a model of memory take if it were built on a solid understanding of the mind and the brain rather than on the

computer metaphor most commonly used in cognitive psychology? A computer has only one form of information, not a number of different basic systems. In this review, I have emphasized that the mind and brain are divided into basic systems, each of which has its own functions, processes, structures, and forms of memory, and each of which involves different parts of the brain. Scientists who study the mind and the brain, including cognitive psychologists, have long assumed that such a division into basic systems exists, and in many cases they have divided their journals and societies along lines that match those systems. Using autobiographical memory as an example, I have attempted to show that it makes theoretical and biological sense to view cognition as the interaction among basic systems, each with its own unique properties, rather than to see the mind and brain as a homogenized information processor. Such a view leads to novel findings.

Recommended Reading

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