# 2

# Placing Autobiographical Memory in a General Memory Organization

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## Introduction

This chapter introduces a new organization that includes the processes needed to define autobiographical memory and indicate its relation to other kinds of memories. By using processes that apply to memory in general, the organization notes what is different about autobiographical memory in an evidence-based systematic fashion. The approach is highly constructive in the tradition of Bartlett (1932) and Neisser (1967, 1976); autobiographical memories are produced at recall, not stored and retrieved. Autobiographical memory is considered to be a form of explicit memory that involves both a constructed scene and self-reference rather than a form of episodic memory (Tulving, 1983). This is because episodic memory is a complex amalgam of behavioral, neural, and theoretical processes that is better understood in terms of its component processes, as discussed in detail in this chapter's section titled "Autobiographical memory as explicit self-reference event memory". Autobiographical memories are created as scenes during recall (Rubin & Umanath, 2015) using the basic processes of cognition (Rubin, 2006). This approach leads to new insights about autobiographical memory and its place in the organization of memory in general.

## The added contribution of scene construction

I have argued earlier that autobiographical memories are constructed using basic processes (Rubin, 1988, 1998) including the individual senses, emotion, and language (Rubin, 2005, 2006; Rubin et al., 2003, 2008, 2011). However, recent research from neuropsychological damage cases, neuroimaging, and research with animals has made the role of recalling a scene clearer as summarized by the theory of event memory (Rubin & Umanath, 2015). For autobiographical memory, the theory provides a frame for spatially organizing the contents of a memory and for providing the basis for a sense of reliving, vividness, and belief in the accuracy and occurrence of the memory that is based on its recall.

According to the theory of event memory, mentally constructed remembered scene differs from an abstract idea and from a collection of objects and actions that could

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populate a scene but that have no clear location relative to each other or to the person remembering them. The remembered scene, like a picture of a scene, need not involve the person recalling it; here this is described by a separate self-reference dimension. The remembered scene, like a picture, is a single event, even if it represents multiple encodings. The remembered scene, like a picture, can occur without any specific phenomenological state. The remembered scene, like a picture, locates the person relative to the scene; it creates a locus in space and time for the person recalling the memory and thus helps support self-reference when it exists (Neisser, 1988).

I changed the basic systems model to one more heavily dependent on the concept of a mentally constructed scene because of evidence from studies of human neuropsychological damage. The loss of scene construction, such as the inability to imagine a prototypical beach on a sunny day, and the loss of autobiographical memory occur together in hippocampal amnesia (Hassabis et al., 2007; Maguire & Mullally, 2013; Tulving, 2002). Moreover, people with damage earlier in the visual ventral stream, which is needed to construct scenes, have a rarer form of amnesia: visual-memory-deficit amnesia (Greenberg et al., 2005; Greenberg & Rubin, 2003; Rubin & Greenberg, 1998). Visual-memory-deficit amnesia provides strong independent support for the role of scene construction because the damage often spares the hippocampi, which, although necessary, are much less specific to scene construction. For either type of damage, the inability to construct a scene and amnesia co-occur. A similar claim about autobiographical memory cannot be made for any other property of memory (Rubin & Umanath, 2015).

Functional magnetic resonance imaging (fMRI) studies of vision and memory support the neuropsychological findings that the visual ventral stream is centrally involved in both scene construction and autobiographical memory (e.g., Baldassano et al., 2016; Cabeza et al., 2004; Daselaar et al., 2008; Kanwisher & Dilks, 2014; see Rubin & Umanath, 2015 for a review). For instance, the parahippocampal place area is activated more by scenes than by objects, and for indoor scenes, its activation remains even if objects are removed, leaving just the walls and floor (Epstein & Kanwisher, 1998). The parahippocampal cortex is active for objects that evoke a strong sense of the surrounding space compared to ones that do not (Mullally & Maguire, 2011, 2013). Thus, the importance of event memory to autobiographical memory and its neural basis has strong converging evidence both from neuropsychological damage cases and from studies that measure activation when intact individuals are performing tasks.

## A general memory organization more suitable for autobiographical memory

The chapter first presents theoretical reasons for using a dimensional, rather than a hierarchical, organization for memory in general and autobiographical memory in particular. It then describes the three dimensions used for this organization and the benefits of using them. Next, additional dimensions that were not needed to classify the

types of memories, but that are useful to account for phenomena in autobiographical memory, are considered. Earlier research on the basic processes of autobiographical and episodic memory is then integrated into the dimensional model to create a more complete account of autobiographical memory.

## Dimensions versus hierarchies

Hierarchies and dimensions are two classic organizational systems in science. Unlike dimensions, in hierarchies the properties specified in one category do not have to extend to other categories. The extension of properties across categories, however, creates and makes predictions about new categories, including categories that may contain no known exemplars. Thus, the hierarchy of the biological taxonomy works to classify life forms, but unlike the dimensional structure of the periodic table of elements in chemistry, it did not predict specific categories for which life forms have not yet been observed. In contrast, the dimensions of the periodic table not only predicted categories for which elements had yet been observed, but because the dimensions had properties, they also predicted what properties those elements would have and under what conditions those elements would be observed. As observation and theory advanced together, more elements were predicted to fill missing categories in the table, and more were found.

Squire's hierarchy (1987) is the most widely used organization for human memory. Figure 2.1 is my synthesis of Squire (1987) with minor additions from Squire (2004). As illustrated in figure 2.2, instead of a hierarchy I propose a set of three dimensions, each based on a process that is conceptually independent of the others and that covers the range of categories in Squire's taxonomy. They are

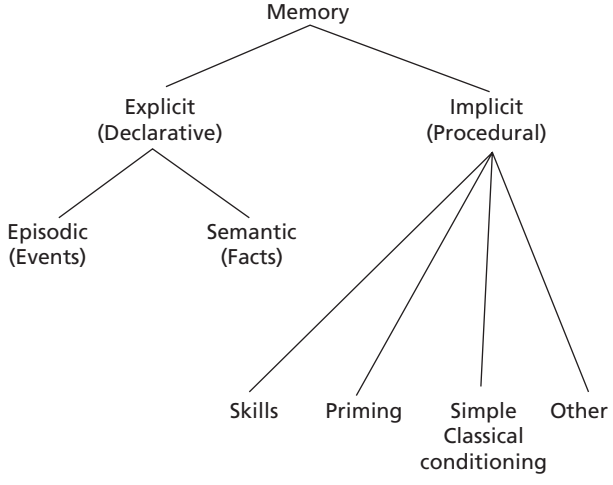


**Figure 2.1** A hierarchical organization of categories of memory.
Based on Squire (1987, 2004).

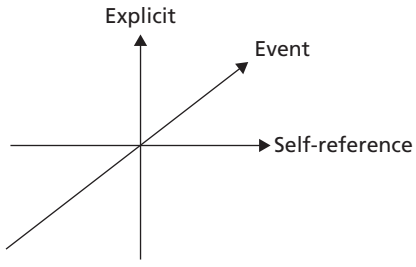


**Figure 2.2** A continuous dimensional organization of memory.

self-reference, event memory, and explicit processes. Although the dimensions are continuous, language and the existing literature are based on categories. Thus, using the extremes of the continuous dimensions to denote categories allows contact with the existing research literature. Viewed as dichotomies, the three dimensions combine to form eight categories in a non-hierarchical organization, as illustrated in figure 2.3. This alternative representation generates interesting, novel, and tractable theoretical propositions and points to gaps in the literature that are basic to understanding memory.

All the dimensions are continua, as shown in figure 2.2. Individual memories vary in a continuous fashion on the extent to which they display the property of dimensions at both the behavioral and neural level. For instance, people and objects vary on the dimension of self-reference; some people and objects can be placed in the middle range of a continuum away from those at the extremes. Similarly, although most memories may be considered explicit or implicit, many are not at the extremes and seem to drift across the boundary of being in and out of consciousness (Mandler, 1994; Singer, 1966). Thus, the change to dimensions allows for the possibility of formal, quantitative models based on continuous variables that hierarchies do not have. However, using the extremes of those continua as labels for categories simplifies communication and is necessary to maintain contact with the literature.

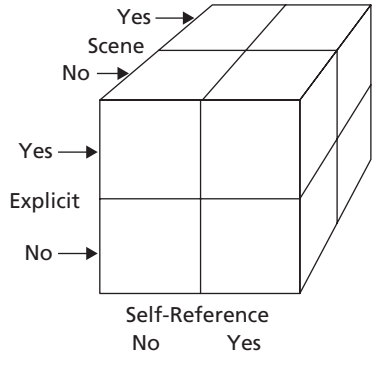


**Figure 2.3** A dimensional organization of memory in which each cell is a category.

## Selection criteria for the dimensions

The selection of dimensions follows directly from Squire's hierarchy and from what is now known about memory from studies of behavior, neural processes in intact organisms, and neuropsychological damage. Squire's two main divisions are explicit versus implicit memory and episodic versus semantic memory. The three dimensions shown in figures 2.2 and 2.3 are needed to account for episodic memory while replacing it with scientifically more useful concepts that are consistent with current knowledge of memory processes. One could argue that for many laboratory memory experiments, the dimensions of self-reference and event memory were of little use and not examined empirically because recall was tested for non-self-reference words or syllables shown in the same color, font, and location, on the same memory drum or computer screen in the same room. Nonetheless, from its earliest introduction to its most recent review paper, Tulving held that episodic memory was for events that happened to the person recalling them, at one time and location and thus by definition must contain at least a minimal event memory and self-reference (Tulving, 1972, 2002). Moreover, at its core, episodic memory was contrasted to semantic memory, which was free of the particular occasion of learning and had information that was generally true for all individuals; that is, they were event and self-reference free. In accounting for episodic memory, the dimensions also account for the explicit versus implicit division.

## The three dimensions

### Self-reference

The self-reference dimension, like the other two dimensions that follow, has a deceptively simple definition. Self-reference defines memories that are related to the person recalling them. Self-reference not only provides the processes for one of the three dimensions but is also part of nearly every definition of autobiographical memory, providing the "self" or "auto" prefix of autobiographical memory. Some memories may be higher in self-reference, such as those for events a person considers central to their identity and life story (Berntsen & Rubin, 2006), whereas others, such as memories of objects occasionally used, might be lower in self-reference. The judgment of self-reference can be made by the person recalling the memory or an observer. The concept of self-reference, and related topics dealing with the self, has a large and growing literature that integrates traditional laboratory memory research with clinical, social, and other areas in psychology and neuroscience.

The self has long played a central role in psychology (Leary & Tangney, 2012). To avoid the complexity of the concept of the self, psychology uses hyphenated selves (Allport, 1955). In these hyphenated terms, the *self* usually can be viewed as no more than a locus in space and time, which refers reflexively to the same person, possible at an earlier or future place and time. For instance, for the terms *self-concept* or *self-knowledge*, people

have a concept or knowledge of themselves in much the way they might have a concept or knowledge of an apple. The needed details of the *self* are particular to the theory describing *self-concept* or *self-knowledge* (e.g., Campbell et al., 2003; Hoyle, 2006). The same lack of details holds for the *self* of *self-reference* used here, and its inclusion as a dimension is an opportunity to explore its specific meaning within autobiographical memory research.

Neuroimaging studies of self-reference provide reasonably consistent findings. The most common areas to emerge in a variety of tasks in fMRI studies of self-reference are the medial prefrontal cortex and the posterior cingulate cortex (Denny et al., 2012; Kim & Johnson, 2012; Moran et al., 2009; Morel et al., 2014). Consistent with this pattern of activity, damage to the medial prefrontal cortex removes self-reference effects (Philippi et al., 2012; also see, Rubin et al., 2017). Thus, a plausible underlying neural basis for this dimension exists.

## Event memory

The second dimension is defined by the theory of event memory (Rubin & Umanath, 2015). Event memory stresses an ecological approach to memory that psychology minimized as it established itself as a science. In simplifying stimuli in order to understand complex problems of perception, memory, and neuroscience, researchers focused on isolated objects, considering the event, or scene, as a form of general context. However, for the intact, mobile organism, scenes are an important level of analysis on their own. Experiencing an event is generally talked about as a dichotomy, but the degree to which a scene is formed is a continuum. For the dimensional model and for autobiographical memory, the scene provides an organization for many of the other properties and contents of the memory.

The terms scene and scene construction are used in a variety of ways in the literature, where it can include measures as diverse as boundary extension, navigation, recall of isolated visual elements, and event segmentation. However, in this chapter, I restrict the terms to the concept described in Rubin and Umanath (2015) and summarized in this paragraph. A scene is, as in colloquial speech, a place where a real or fictitious event occurs. A scene must have contents organized in space relative to the viewer. As an example, consider the contents of a meeting you often attend (e.g., a faculty meeting): what were the main points, what was discussed and by whom (i.e., what you need in order to say you *know* what happened). Next, consider the scene: where were people sitting as seen from the location from which you recall the scene (i.e., your experience of the imagining the meeting without which you would be unlikely to say you *remember* it as an autobiographical memory). As would be the case with drawing a scene, a mentally constructed scene must be remembered from a single location. The act of mental scene construction thereby locates the person recalling it in relation to the rest of the event (Berntsen & Rubin, 2006; Butler et al., 2016; McIsaac & Eich, 2002; Nigro & Neisser, 1983; Rice & Rubin, 2011). In doing this, the act of constructing a

scene forces a person to imagine him- or herself in one particular location. The theory of event memory holds that this sense of being located relative to the event during recall is needed to report experiencing an autobiographical memory with a sense of reliving and the vividness of the event, and it provides evidence that the event was witnessed and therefore should be believed (Rubin & Umanath, 2015). We have long known that visual imagery is central to autobiographical memory (Brewer, 1986; Rubin, 2006; Rubin et al., 2003); the crucial novel claim is that this is due to the spatial layout and not just the contents of the autobiographical memory.

Event memory is a general category of constructed scenes that includes autobiographical memories. Event memories can include actual witnessed events but also events about others and imagined events in the past and future. Such events all use similar processes, but vary on their degree of self-reference, effort needed for construction, and other factors (Rubin & Umanath, 2015). In addition, event memories need not be for a single occurrence; event memories can be intended as a summary or prototype (e.g., Posner & Keele, 1970) of a series of repeated events that can be constructed as the same basic scene (e.g., a generic, or future, faculty meeting you might attend).

Although the degree to which a memory has a well-developed scene is a dimension, for autobiographical memory having at least a minimal scene is a necessity. Memories of events need a "stage on which the remembered event is played or the "where" for the "what" to occur in" (Hassabis & Maguire, 2007, p. 304); they must have spatial organization (e.g., Burgess et al., 2001). Without spatial organization, the contents of an autobiographical memory lack their most basic context and therefore will be judged as knowledge (i.e., semantic memory). The scene allows the contents to be organized. "Space provides a critical contextual background for encoding and retrieving episodic memories" (Eichenbaum et al., 1999, p. 223). Judgments of field versus observer in memory (i.e., first versus third person perspective) depend on viewing a scene. Judgments of reliving, which help motivate the distinction between autobiographical memory and knowledge as different ontological categories, depend on having a scene. At the extreme of reliving in flashbulb memories and flashbacks, scenes are a key property (see Rubin & Umanath, 2015 for a review). Moreover, in autobiographical memory, reliving judgments depends on visual areas, especially in the ventral stream (Daselaar et al., 2008).

## Explicit processes

The third dimension is explicit versus implicit processes. It is the main dimension of the standard hierarchy shown in figure 2.1. The idea that some knowledge is available to conscious introspection, whereas other knowledge can only be demonstrated in a procedural manner, predated the experimental study of memory. Moreover, from the earliest experimental studies, explicit and implicit processes have been intertwined. Ebbinghaus (1885) choose an implicit measure based on trials saved in relearning lists to measure gains in explicit recall.

In the modern memory literature, this dimension is generally talked about as a dichotomy. However, a continuous dimension is supported by concepts of consciousness in which memories can slowly develop and become fully conscious as a result of a strategic search or can remain below the level of consciousness and drift into conscious recollection in times of boredom, daydreaming, or mind-wandering (Mandler, 1994; Singer, 1966; for a review see Berntsen, 2009). Consistent with this continuity, the judgment of explicit content often can be made on information that was initially recalled implicitly but that later reached the level of consciousness.

For the dimensional model, memories range from explicit to implicit, but for autobiographical memory, most definitions include only explicit memories. This is one reason to focus on the declarative—procedural (Squire, 1987), declarative—nondeclarative (Squire, 2004, p. 173), or available-to-conscious-recollection (Squire, 2004, p. 171) aspects of the explicit versus implicit distinction.

The distinction between explicit and implicit memory, though nearly universally accepted, is, as Squire appreciated, complex. For instance, Squire (1987, pp. 167–169) lists many divisions of memory closely related to the explicit versus implicit memory distinction that have developed in different theoretical frameworks. He also argued that it is hard to imagine a total separation of the neural systems for this distinction, because the later-evolving explicit memory processes depend in part on earlier-evolving implicit memory neural regions. Moreover, individual implicit categories in his hierarchy can sometimes be explicit. For instance, skills are often learned as explicit memories and become implicit with practice, and priming can have an explicit component.

Squire noted specific neural regions that were relevant to the implicit tasks he included. Squire's hierarchy (2004, p. 173) (figure 2.1) includes procedural skills and habits with a neural basis in the striatum; priming and perceptual learning with a neural basis in neocortex; simple classical conditioning of emotional responses with a neural basis in the amygdala; and simple classical conditioning of skeletal responses with a neural basis in the cerebellum. However, in a review of the "porous boundaries" between explicit and implicit memory, Dew and Cabeza (2011) conclude that the constructs used in the literature to distinguish between explicit and implicit memory have not yielded data consistent with the dichotomy. They conclude, "Simple dichotomies between explicit and implicit memory are inadequate given the current state of the memory literature" (Dew & Cabeza, 2011, p. 185). This only adds to the difficulty Squire (1987) noted in uncovering a single neural basis for implicit memory.

For current purposes, this implies that unlike the self-reference and event memory there is no empirical support for a plausible neural basis for an explicit–implicit dimension in the dimensional model. Rather, new constructs will be needed, or more likely, consistent with Dew and Cabeza (2011), a collection of processes that function to different extents in different situations. A well-developed account of the neural basis of consciousness or of short-term or working memory that indicates the areas responsible for a memory being in the conscious now would therefore clarify the implicit–explicit dimension. However, it does not exist.

Squire's placement of "simple classical conditioning" under implicit memory has also been contentious. On one hand, classical conditioning, with the possible addition of operant conditioning, can be viewed as a basic process involved in all memory. Squire (1994) viewed classical conditioning occurring both with and without awareness of the contingencies and provided evidence with control subjects, as well as amnesics to support this view (Clark & Squire, 1998, 1999). However, an opposing view was that "there is no convincing evidence for conditioning in human subjects without awareness of the contingencies" (Boakes, 1989, p. 389; Brewer, 1974). Lovibond and Shanks (2002) reanalyzed data provided by Clark and Squire and agreed with Boake's and Brewer's strong claim. This suggests that memories of conditioning should not routinely be classified as implicit, but as implicit or explicit depending on their recall, similar to skills that are performed implicitly after being learned explicitly.

## Three novel categories of memory

If the dimensional model as shown in figure 2.2 has each dimension divided into a dichotomy to provide the eight categories of figure 2.3, five of these eight categories do not fit easily into Squire's hierarchy and have tended to be overlooked as aspects of a general organization of memory. Labeling each of the categories by its coordinates on the three dimensions, they are: the two adjacent self-reference and non-self-reference implicit event memory, the two adjacent event and non-event implicit self-reference memory, and explicit non-self-reference event memory. They are not, by most definitions and theories, part of autobiographical memory, but they are related to autobiographical memory and help set the boundaries that distinguish autobiographical memory from other commonly studied real-world memory topics such as the effect of personality on memory, déjà vu, and memory for real and fictional events that happen to other people.

### Self-reference and non-self-reference implicit event memory

Implicit event memory includes effects in perception and action that are affected by their particular event-based context. Examples include recognizing people in, but not out, of their usual physical context (e.g., Mandler's 1980 example of not recognizing the butcher on the bus); knowing and adapting to what is coming next when walking a familiar route; or knowing where to reach for things without looking while attention is on a higher-level task. The dimensional model categorizes these examples as implicit event memory and places them within an organization of memory that allows them to be compared to other phenomena in terms of well-studied dimensions.

Déjà vu also appears to be implicit event memory. Consistent with the dependence of familiarity and reliving on event memory in explicit memory, in déjà vu there is a sense of familiarity and reliving without any explicit memory of a previous

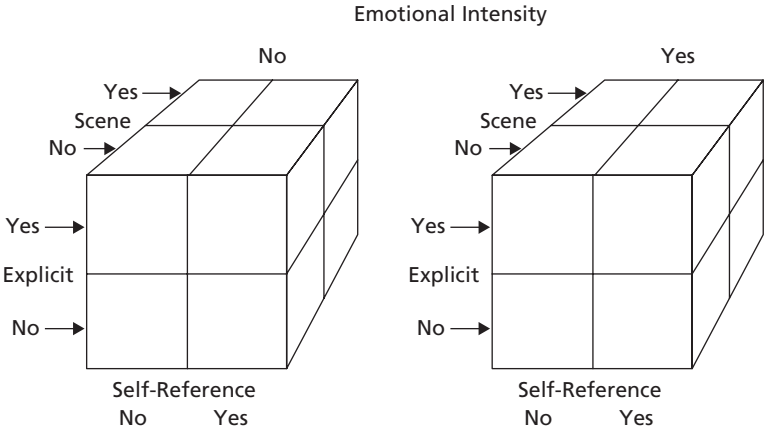


**Figure 2.4** Emotional intensity.

experience (Rubin & Umanath, 2015). Brown (2003, 2004) reports several studies, based on self-reports and on analyses of participants' descriptions, in which the most common trigger of a déjà-vu state is the similarity with an earlier scene. In a direct test of the claim that déjà vu depends on a similarity in scenes that is not explicitly noted, Cleary et al. (2009) matched the configural layout, but not the contents, of two scenes. One member of the pair was presented; the other was not. Only pairs involving presented scenes that were not recalled (i.e., were not brought into explicit memory) were examined further. The non-presented scenes of these pairs had an increased probability of déjà vu states when compared to control scenes, and, when these déjà vu states occurred, the familiarity of these non-presented scenes were rated higher.

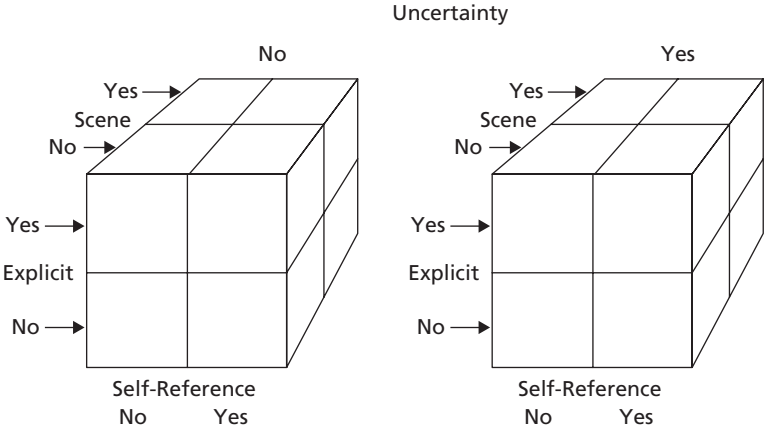


**Figure 2.5** Processes for the construction of uncertain events.

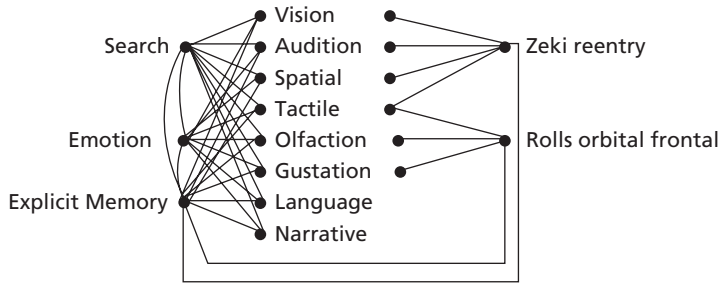


**Figure 2.6** Basic systems of cognition involved in memory.
Based on Rubin (2006).

## Event and non-event implicit self-reference memory

Implicit and explicit non-self-reference memories and explicit self-reference memories already have major literatures. Implicit self-reference memories do not. Whether all implicit self-reference memories differ from implicit non-self-reference memories in interesting ways is an open question, but at first glance, some implicit self-reference memories look like major components of personality and other habitual ways of acting. Considering them this way would help to integrate the individual differences variables, such as personality, into an organizational scheme for memory, providing a framework to examine their contributions. In terms of clinical phenomena, implicit self-reference memories might be considered as underlying aspects of anxiety disorders when they produce negative emotions. This could occur for complete events including posttraumatic stress disorder (PTSD) symptoms related to traumatic events and worry related to possible future events, and for non-event isolated objects in phobias.

## Explicit non-self-reference event memory

The theory of event memory imposes no restrictions on an event having self-reference or not (Rubin & Umanath, 2015). The dimensional organization therefore allows real and fictional events that are not autobiographical to be considered as their own non-self-reference explicit event category, something that is missing from the current episodic versus semantic conception of memory in which episodic memories must have self-reference (Larsen, 1988; Pillemer et al., 2015; Rubin, 1995). Larsen writes that Tulving's definition of episodic memory left such non-self-reference memories, including memories for events that were reported to the person recalling them, "in no-man's land, outside the taxonomy that came to guide memory research" (Larsen, 1988, p. 331). Moreover, people often have a sense of reliving for characters in an event with whom they identify or empathize. People can even remember another person's autobiographical memory as their own (Sheen et al., 2001). Much of social communication,

literature, and cinema depends upon such abilities to assimilate explicit non-self-reference event memories.

## Autobiographical memory as explicit self-reference event memory

Autobiographical memories are explicit self-reference event memories. Thus, they have a category of their own. Their relationships to each of the other seven categories of figure 2.3 are thus defined in terms of differing on one, two, or three dimensions, each defined by a process. If we want to add other dimensions to the model, we could divide this category further, a possibility that is considered 'in the section titled 'Additional dimensions for understanding autobiographical memory'. If we want to add other restrictions to the definition of autobiographical memory then they would be only part of the category, which is what happens to episodic memory.

In Tulving's episodic versus semantic memory distinction, episodic memories must be recalled explicitly by the person who experienced them. They also must be for an event remembered at a specific place and time; memories about objects free of their spatial and temporal context are semantic memories. Thus, in the dimensional model, episodic memories, like autobiographical memories, are explicit, self-related, event memories; like autobiographical memories, they fit into one category of the cube drawn in figure 2.3 rather than being a major division in a hierarchy as they are in Squire's hierarchy.

Episodic memories have numerous other properties, many of which can be viewed as independent processes (Tulving, 1983, p. 35, Table 3.1). When these are included, episodic memories become a subset of the category shown in figure 2.3. The most important of these properties for current purposes include the following. Episodic memories must come with a sense of reliving in the form of autonoetic consciousness or mental time travel (Rubin et al., 2003; Tulving, 1985). This depends on having a constructed event at recall, but not all event memories have a sense of reliving (Rubin & Umanath, 2015). Episodic memories must be recalled voluntarily (i.e., in retrieval mode; Tulving, 1984, pp. 230–231). Episodic memories must be for a single occurrence (Tulving, 1972, 1983, 2002), not a merging of information from similar occurrences, which is counter to the more process-oriented constructive approach to memory used to formulate dimensions (Rubin, 1988, 1995, 1998, 2006, 2014; Rubin & Umanath, 2015).

The combination of these and the other additional properties into a single theoretical entity has long been questioned by leading memory theorists (Anderson & Ross, 1980; McKoon & Ratcliff, 1979; McKoon et al., 1986; and in most commentaries in Tulving, 1984; for a review see Rubin & Umanath, 2015). Even though many current researchers would not subscribe to all these properties, they still govern most studies of episodic memory (e.g., items presented once for explicit voluntary recall that are judged as remembered instead of known). They also remain part of the dominant theory of memory, and reviewers still ask for clarification on whether a task is purely episodic

or semantic or contains elements of both. The use of underlying processes instead of a single combined concept of episodic memory should help clarify both its behavioral and its neural basis.

## The role of dimensions in organizing the effects of neuropsychological damage

Explicit self-reference event memories are autobiographical memories that, by definition, are lost in amnesia. Explicit non-self-reference event memories show a deficit in patients who cannot imagine a generic event and thus have a deficit in event memory (e.g., Hassabis et al., 2007). The two remaining explicit non-event categories that differ on self-reference are classified as semantic memory loss in the existing literature. These categories show loss with some neural damage, including that caused by Korsakov's syndrome (Butters & Cermak, 1986) and some cases of herpes simplex encephalitis (Wilson & Wearing, 1995). Moreover, consistent with the neural basis of event memory, the damage involved in these cases extends beyond the medial temporal and ventral stream areas involved in event memory. In addition, amnesics who lose event memory often still retain self-reference. For instance, Clive Wearing retained a sense of things and people related to him even though the memories indicating this were often confabulations (Wilson & Wearing, 1995). Thus, the dimensional approach helps to organize neuropsychological cases of memory loss in terms of dimensions developed to account for memory in general. Combined with added processes, including those for the individual senses, language, and narrative (Greenberg & Rubin, 2003), it could provide a more systematic view of neuropsychological damage than the existing hierarchy does.

## Additional dimensions for understanding autobiographical memory

The three dimensions discussed cover the range of categories represented in Squire's hierarchy. However, for topics commonly studied in autobiographical memory research, additional dimensions are useful. The two dimensions I offer are not intended to be complete, but rather to show that the dimensional model could be extended as needed for other purposes. One reason to choose these dimensions is that they are a change from the basic systems model that will be considered in the next section.

### Emotional intensity

A fourth dimension, not shown in figures 2.2 and 2.3, is emotional intensity (Talarico et al., 2004). Valence is not as easy to include as a dimension because the effects of

valence are not as robust as those of emotional intensity, and because positive versus negative valence are not extremes of a single dimension (Bradley et al., 1992; Rubin & Talarico, 2009; Talarico et al., 2004). Rather emotional intensity would need to be divided into two dimensions, one for positive and one for negative emotions. This is a reasonable alternative, but one I do not pursue here.

Adding emotional content would double the number of categories to 16, as shown in figure 2.4. We have discussed eight of these already by assuming that they were not emotionally intense. In terms of categories, this leaves emotionally intense memories that may be self-reference or not, explicit or implicit, and event memories or not.

Explicit emotionally intense memories are commonly studied. Implicit emotionally intense memories that change one's emotional reaction without the memory itself reaching consciousness might be considered as underlying aspects of anxiety disorders if there is a specific memory at work, but one the person is not aware of. Implicit emotional intensity is a common aspect of memories for events and thus for complete scenes. For instance, a person might feel strong emotions without recalling any event that is responsible for the emotions in a particular place or experience symptoms of PTSD in a situation that has some general relation to an earlier trauma. Implicit emotional intensity can also occur for isolated objects that are not part of scenes, as in phobias.

## Uncertainty

People believe they know what occurred in some memories; for other memories, including memories for imaginary events and events in the future, they are more uncertain. The certainty with which events are thought to occur underlies much of mental time travel, so I use it as shown in figure 2.5, as a more general dimension than past versus future (De Brigard & Gessell, 2016). The further an event is into the future or past or the less well-known its future location, the less certain and more schematic it becomes; moreover, the uncertainty increases faster into the future (Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2004; Szpunar & McDermott, 2008; Spreng & Levine, 2006; Trope & Liberman, 2010).

Most of the differences in past versus future events that are not accounted for by uncertainty can be accounted for by the proposed emotional intensity dimension. Because alternative events in the future might actually happen, but alternative events in the past cannot occur, future events can be more emotionally intense. If the request is for unspecified or positive future events, positive valence increases (Berntsen & Bohn, 2010; D'Argembeau & Van der Linden, 2006; Finnbogadóttir & Berntsen, 2013; Newby-Clark & Ross, 2003). The effects are even larger for future events that are requested to be negative. For example, participants rated PTSD symptoms for their future negative events that were clearly in the clinical diagnosis range; for past negative events cued by the same topics, they were not (Rubin, 2014).

The standard past versus future literature in cognitive psychology (e.g., Berntsen & Bohn, 2010; Buckner & Carroll, 2007; D'Argembeau, 2012; Hassabis & Maguire, 2007; Schacter & Addis, 2007; Szpunar, 2010) evolved heavily from Tulving's (1985, 2002) theoretical development of mental time travel for explicit memory. Thus, most of the eight categories introduced by considering events without known content crossed with the eight categories shown in figure 2.2 have been explored, especially uncertain explicit self-reference memories. However, some have not. Uncertain implicit self-reference and non-self-reference memories have not been studied and may be involved in the emotions associated with fear and worry that come without an explicit awareness of why they arise. These are studied in fear conditioning and in clinical psychology but are not part of the standard past versus future memory literature and could be better integrated into it.

## The basic systems model and its integration with the dimensional model

### Similarities and difference of the dimensional and basic systems models

This section describes the overall basic systems model, emphasizing processes not already described. It examines how the dimensional and basic systems models integrate to provide a more comprehensive understanding of autobiographical memory at both a behavioral and neural level of analysis. The integration of these models is mostly an update of the basic system model as both models share the same fundamental neural-based, constructivist view of cognition. In both models, the emphasis is on the processes that produce memories. Moreover, the basic systems and dimensional model share many other assumptions including the emphasis on visual processes in the integration of memories.

Figure 2.6 depicts the basic system model (Rubin, 2005, 2006, 2012, 2015). This model, which considers memory and cognition in terms of basic systems, predates the dimensional model by a decade. It does not include event memory, and it was restricted to explicit episodic memories, including autobiographical memories. A major difference between the models is that the basic systems model started with major cognitive systems that had well-defined behavior and neural properties, such as the various sensory systems and language needed to account for all episodic and autobiographical memory. In contrast, the dimensional model first focused on the three dimensions needed to account for the organization of types of memories included in Squire's hierarchy, and then was extended to other dimensions that might be useful for autobiographical memory using emotional intensity and uncertainty as examples.

In addition, in the dimensional model, all dimensions, including emotional intensity and uncertainty, had to be general enough to be crossed with all the other dimensions already in the model, a requirement that could be met by almost all of the basic systems

shown in figure 2.6. There are two exceptions. One is explicit memory, because episodic and autobiographical memory by most definitions are forms of explicit memory and thus did not need a continuum. The other is the search system, which described conscious goal-directed search, but not other forms of memory retrieval. This system needs to be expanded to include the recall of explicit memories that are not the result of a conscious goal-directed search to allow for involuntary autobiographical memories (Berntsen, 2009).

Another difference is that the development and inclusion of event memory as an important process in memory altered the previous understanding of the roles of the dorsal (or where) system and the ventral (or what) system that were discussed extensively in the basic systems model. Knowing the location of an object within a scene can no longer be viewed as a dorsal stream function; rather, it becomes a ventral stream function that may involve interactions with the dorsal stream.

In the basic systems model, several neural regions were discussed for the coordination or integration of the systems to construct memories. Each was based on considerable empirical support. A "dumb" system that was part of the hippocampal-based explicit memory system bound everything that occurred at the same time. A "smart" system that was part of the emotion system modulated the encoding of memories based on the discrepancy between what was expected and what occurred, interest, or emotional arousal. A "smarter" system that was part of the frontal search system searched for components of a memory when cued by other components and used inhibitory mechanisms to suppress dominant responses that did not fit all the criteria set by the known cues. Finally, a spatial coordination system located in primary visual cortex and the ventral stream coorordinated information that was spatially related, including what later became event memory. The spatial coordination system is based on both neural theories about vision (Zeki, 1993) and theories of behavior (Barsalou, 1999). All these forms of coordination among systems are still needed.

## The role of individual difference in the dimensional and basic systems model

Experimental studies try to produce results that hold over a wide range of individuals. Research on individual differences focusing on how people differ is usually not integrated into this research (Cronbach, 1957). However, in this case, individual differences in the extent to which the various processes were used informed both models and their application to clinical disorders. In one early study, undergraduates nominated 20 autobiographical memories that would be distinctive enough that the name they gave to each of the memories would allow it to be recalled later (Rubin et al., 2004). The participants recalled the 20 autobiographical memories and rated them on 17 scales commonly used in autobiographical memory studies, including measures of reliving, belief, emotions, narrative, and sensory systems, as well ratings of overgeneral memories and the age of the memories. The recall and ratings of the 20 memories were done at two

sessions separated by two weeks. The median correlation of the individuals' average rating on each of the 17 scales taken two weeks apart was 0.90. When the mean of 10 of the memories was correlated with the remaining 10 and the correlations, corrected to be comparable with that of the full set of 20 memories, the median did not decrease. Thus, there was considerable stability in the individuals' average rating on each scale, consistent with a constructive view of autobiographical memory, in which stable individual differences in cognitive style were important. Moreover, the stability was not caused by using the same memories, as it occurred when different subsets of the memories were compared.

In a study of PTSD, 75 participants diagnosed with PTSD and 45 controls rated word-cued, important, positive, and negative memories (Rubin et al., 2011). For all four types of memories, there were significant differences between the means of the PTSD and control groups on scales that correlated highly with PTSD symptom severity. These included emotional reactions as measured by ratings of emotional intensity and ratings of physiological reactions, the frequency that the memories occurred as measured by ratings of voluntary rehearsal and the frequency of involuntary memories, and ratings of centrality to the life story. The differences were large, averaging 1.24, 1.43, 1.04, 1.23, and 0.84 on the five 7-point scales, respectively. The differences were smaller and usually not significant on scales that did not correlate with PTSD symptom severity. Thus, there were substantial differences in the ratings of individual processes related to PTSD. Moreover, the difference occurred no matter if the memories were word-cued, important, positive, or negative. A similar study with undergraduates who varied in their PTSD symptom severity produced a similar pattern of results with smaller effects (Rubin et al., 2008). Such a replicable pattern of differences in the ratings for both traumatic and non-traumatic memories informs our understanding of individual differences in memory processes in PTSD by demonstrating a general tendency that affects memories that vary on valence and importance. This changes the focus from trauma memories being a special class of memories to one in which they can be understood using general processes that apply in varying degrees to all autobiographical memories.

## Autobiographical memory as the explicit construction of self-relevant past scenes

Where does all this leave us? Based on considerable empirical evidence, there is reason to privilege event memory in autobiographical memory. Self-reference and explicit memory follow from most common definitions and theories of autobiographical memory. Once this is done, the three dimensions of the dimensional model become necessary processes to consider in the construction of autobiographical memory. However, they are not enough. Other dimensions, or processes, are needed for a comprehensive theory. Many of these can be drawn with minor modification from the basic systems model, such as, narrative, language, and sensory systems beyond those needed for event memory. In addition, integrating the two models provides mechanisms that

the dimensional model lacked for the construction of memories. In particular, using the spatial coordination process from the basic systems model provides a mechanism for the event memory needed for the dimensional model.

When the models are combined, they provide a good account of many phenomena that is consistent with behavioral and neural results. These include how autobiographical memories that have properties related to each of the processes can be constructed, how they can vary over recalls and adapt to new information, goals, and situations that arise. They can also integrate accounts of variability in these processes both in individuals and in clinical syndromes.

As advances in our study of behavior and its neural basis continue, applications to more complex phenomena become tractable and the results more precise. The neurocognitive theory of autobiographical memory proposed here accounts for behavior in individuals with and without a variety of specific deficits in a way that converges with what is known about its neural basis. Moreover, autobiographical memory is given a clear conceptual location in relation to other kinds of memory that indicates dimensions along which it differs. This allows autobiographical memory to be separated from episodic memory in this conceptual space using specified properties of the two concepts.

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## References

Allport, G. W. (1955). *Becoming: Basic considerations for a psychology of personality*. New Haven: Yale University Press.

Anderson, J. R. & Ross, B. H. (1980). Evidence against a semantic–episodic distinction. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 441–466.

Baldassano, C., Esteva, A., Fei-Fei, L., & Beck, D. M. (2016). Two distinct scene-processing networks connecting vision and memory. *eNeuro*, *3*, ENEURO.0178–16.2016.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences*, *22*, 577–660.

Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. London: Cambridge University Press.

Berntsen, D. (2009). *Involuntary autobiographical memories. An introduction to the unbidden past*. Cambridge: Cambridge University Press.

Berntsen, D. & Bohn, A. (2010). Remembering and forecasting: The relation between autobiographical memory and episodic future thinking. *Memory & Cognition*, *38*, 265–278.

Berntsen, D. & Rubin, D. C. (2006). The centrality of event scale: A measure of integrating a trauma into one's identity and its relation to post-traumatic stress disorder symptoms. *Behaviour Research and Therapy*, *44*, 219–231.

Boakes, R. A. (1989). How one might find evidence for conditioning in adult humans. In T. Archer & L.-G. Nilsson (eds.), *Aversion, avoidance and anxiety: Perspectives on learning and memory* (pp. 381–402). Hillsdale, NJ: Erlbaum.

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, & Cognition*, *18*, 379–390.

Brewer, W. F. (1974). There is no convincing evidence for operant or classical conditioning in adult humans. In W. B. Weimer & D. S. Palermo (eds.), *Cognition and the symbolic processes* (pp. 1–42). Hillsdale, NJ: Erlbaum.

Brewer, W. F. (1986). What is autobiographical memory? In D. C. Rubin (ed.), *Autobiographical memory* (pp. 25–49). Cambridge: Cambridge University Press.

Brown, A. S. (2003). A review of the déjà vu experience. *Psychological Bulletin*, *129*, 394–413.

Brown, A. S. (2004). *The déjà vu experience*. New York: Psychology Press.

Buckner, R. L. & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences*, *11*, 49–57.

Burgess, N., Becker, S., King, J. A., & O'Keefe, J. (2001). Memory for events and their spatial context: Models and experiments. *Philosophical Transactions of the Royal Society of London Series B: Biological Sciences*, *356*, 1493–1503.

Butler, A. C., Rice, H. J., Wooldridge, C. L., & Rubin, D. C. (2016). Visual imagery in autobiographical memory: The role of repeated retrieval in shifting perspective. *Consciousness & Cognition*, *42*, 253–327.

Butters, N. & Cermak, L. S. (1986). A case study of the forgetting of autobiographical knowledge: Implications for the study of retrograde amnesia. In D. C. Rubin (ed.), *Autobiographical memory* (pp. 253–272). Cambridge: Cambridge University Press.

Cabeza, R., Prince, S. E., Daselaar, S. M., Greenberg, D. L., Budde, M., Dolcos, F., et al. (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.

Campbell, J. D., Assanand, S., & Di Paula, A. (2003). The structure of the self-concept and its relation to psychological adjustment. *Journal of Personality*, *71*, 115–140.

Clark, R. E. & Squire, L. R. (1998). Classical conditioning and brain systems: The role of awareness. *Science*, *280*, 77–81.

Clark, R. E. & Squire, L. R. (1999). Human eyeblink classical conditioning: Effects of manipulating awareness of the stimulus contingencies. *Psychological Science*, *10*, 14–18.

Cleary, A. M., Ryals, A. J., & Nomi, J. S. (2009). Can déjà vu result from similarity to a prior experience? Support for the similarity hypothesis of déjà vu. *Psychonomic Bulletin & Review*, *16*, 1082–1088.

Cronbach, L. J. 1975. Beyond the two disciplines of scientific psychology. *American Psychologist*, *30*, 671–84.

Daselaar, S. M., Rice, H. J., Greenberg, D. L., Cabeza, R., LaBar, K. S., & Rubin, D. C. (2008). The spatiotemporal dynamics of autobiographical memory: Neural correlates of recall, emotional intensity, and reliving. *Cerebral Cortex*, *18*, 217–229.

D'Argembeau, A. (2012). Autobiographical memory and future thinking. In D. Berntsen & D. C. Rubin (eds), *Understanding autobiographical memory: Theories and approaches* (pp. 311–330). Cambridge: Cambridge University Press.

D'Argembeau, A. & Van der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and Cognition*, *13*, 844–858.

D'Argembeau, A. & Van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition*, *15*, 342–350.

De Brigard, F. & Gessell, B. S. (2016). Time is not of the essence: Understanding the neural correlates of mental time travel. In: Klein, S. B., Michaelian, K. & Szpunar, K. K. (eds), *Seeing the future: Theoretical perspectives on future-oriented mental time travel* (pp. 153–179). New York: Oxford University Press.

Denny, B. T., Kober, H., Wager, T. D., & Ochsner, K. N. (2012). A meta-analysis of functional neuroimaging studies of self- and other judgments reveals a spatial gradient for mentalizing in medial prefrontal cortex. *Journal of Cognitive Neuroscience*, *24*, 1742–1752.

Dew, I. T. Z. & Cabeza, R. (2011). The porous boundaries between explicit and implicit memory: Behavioral and neural evidence. *Annals of the New York Academy of Science*, *1224*, 174–190.

Ebbinghaus, H. (1885/1964). *Memory: A contribution to experimental psychology* (transl. H. A. Ruger & C. E. Bussenius). New York: Dover. (Original work published 1885.)

Eichenbaum, H., Dudchenko, P., Wood, E., Shapiro, M., & Tanila, H. (1999). The hippocampus, memory, and place cells: Is it spatial memory or a memory space? *Neuron*, *23*, 209–226.

Epstein, R. & Kanwisher, N. (1998). A cortical representation of the local visual environment. *Nature*, *392*, 598–601.

Finnbogadóttir, H. & Berntsen, D. (2013). Involuntary future projections are as frequent as involuntary memories, but more positive. *Consciousness and Cognition*, *22*, 272–280.

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. & Rubin, D. C. (2003). The neuropsychology of autobiographical memory. *Cortex*, *39*, 687–728.

Hassabis, D., Kumaran, D., Vann, S., & Maguire, E. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences of the United States of America*, *104*, 1726–1731.

Hassabis, D. & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, *11*, 299–306.

Hoyle, R. H. (2006). Self-esteem and self-knowledge. In M. H. Kernis (ed.), *Self-esteem issues and answers: A sourcebook on current perspectives* (pp. 208–215). New York: Psychology Press.

Kanwisher, N. & Dilks, D. D. (2014). The functional organization of the ventral visual pathway in humans. In J. S. Werner & L. M. Chalupa (eds.), *The new visual neurosciences* (pp. 733–746). Cambridge, MA: MIT Press.

Kim, K. & Johnson, M. K. (2012). Extended self: Medial prefrontal activity during transient association of self and objects. *Social Cognitive and Affective Neuroscience*, *7*, 199–207.

Larsen, S. F. (1988). Remembering without experiencing: Memory for reported events. In U. Neisser & E. Winograd (eds.), *Remembering reconsidered: Ecological and traditional approaches to the study of memory* (pp. 326–355). Cambridge: Cambridge University Press.

Leary, M. R. & Tangney, J. P. (2012). The self as an organizing construct in the behavioral and social sciences. In M. R. Leary & J. P. Tangney (eds.), *Handbook of self and identity* (2nd edn) (pp. 3–14). New York: Guilford Press.

Lovibond, P. F. & Shanks, D. R. (2002). The role of awareness in Pavlovian conditioning: Empirical evidence and theoretical implications. *Journal of Experimental Psychology: Animal Behavior Processes*, *28*, 3–26.

Maguire, E. A. & Mullally, S. L. (2013). The hippocampus: A manifesto for change. *Journal of Experimental Psychology: General*, 142, 1180–1189.

Mandler, G. (1980). Recognizing: The judgment of previous occurrence. *Psychological Review*, *87*, 252–271.

Mandler, G. (1994). Hypermnesia, incubation, and mind popping: On remembering without really trying. In C. Umilta & M. Moscovitch (eds.), *Attention and performance: Conscious and unconscious information processing* (pp. 3–33). Cambridge: MIT Press.

McIsaac, H. K. & Eich, E. (2002). Vantage point in episodic memory. *Psychonomic Bulletin and Review*, *9*, 146–150.

McKoon, G. & Ratcliff, R. (1979). Priming in episodic and semantic memory. *Journal of Verbal Learning and Verbal Behavior*, *18*, 463–480.

McKoon, G., Ratcliff, R., & Dell, G. S. (1986). A critical evaluation of the semantic–episodic distinction. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *12*, 295–306.

Moran, J. M., Heatherton, T. F., & Kelley, W. M. (2009). Modulation of cortical midline structures by implicit and explicit self-relevance evaluation. *Social Neuroscience*, *4*, 197–211.

Morel, N., Villain, N., Rauchs, G., Gaubert, M., Piolino P., et al. (2014). Brain activity and functional coupling changes associated with self-reference effect during both encoding and retrieval. *PLoS One*, *9*, e90488.

Mullally, S. L. & Maguire, E. A. (2013). Exploring the role of space defining objects in constructing and maintaining imagine scenes. *Brain and Cognition*, *82*, 100–107.

Neisser, U. (1967). *Cognitive psychology*. Englewood Cliffs, NJ: Prentice-Hall.

Neisser, U. (1976). *Cognition and reality: Principles and implications of cognitive psychology*. New York: Freeman.

Neisser, U. (1988). Five kinds of self-knowledge. *Philosophical Psychology*, *1*, 35–59.

Newby-Clark, I. R. & Ross, M. (2003). Conceiving the past and future. Personality and *Social Psychology Bulletin*, *29*, *807–818*.

Nigro, G. & Neisser, U. (1983). Point of view in personal memories. *Cognitive Psychology*, *15*, 467–482.

Philippi, C. L., Duff, M. C., Denburg, N. L., Tranel, D., & Rudrauf, D. (2012). Medial PFC damage abolishes the self-reference effect. *Journal of Cognitive Neuroscience 24*, 475–481.

Pillemer, D., Steiner, K., Kuwabara, K., Thomsen, D. K., & Svob, C. (2015). Vicarious memories. *Consciousness and Cognition*, *36*, 233–245.

Posner, M. J. & Keele, S. (1970). Retention of abstract ideas. *Journal of Experimental Psychology*, *83*, 304–308.

Rice, H. & Rubin, D. (2011). Remembering from any angle: The flexibility of visual perspective during retrieval. *Consciousness and Cognition*, *20*, 568–577.

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: Cambridge University Press.

Rubin, D. C. (1995). *Memory in oral traditions: The cognitive psychology of epic, ballads, and counting-out rhymes*. New York: Oxford University Press.

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. (2005). A basic-systems approach to autobiographical memory. *Current Directions in Psychological Science*, *14*, 79–83.

Rubin, D. C. (2006). The basic-systems model of episodic memory. *Perspectives on Psychological Science*, *1*, 277–311.

Rubin, D. C. (2012). The basic system model of autobiographical memory. In D. Berntsen & D. C. Rubin (eds.). *Understanding autobiographical memory: Theories and approaches* (pp. 11–32). Cambridge: Cambridge University Press.

Rubin, D. C. (2014). Schema driven construction of future autobiographical traumatic events: The future is much more troubling than the past. *Journal of Experimental Psychology: General*, *143*, 612–630.

Rubin, D. C. (2015). A basic systems account of trauma memories in PTSD: Is more needed? In L. A. Watson, D. Berntsen & D. C. Rubin (eds.). *Clinical perspective on autobiographical memory: Theories and approaches* (pp. 41–64). Cambridge: Cambridge University Press.

Rubin, D. C., Boals, A., & Berntsen, D. (2008). Memory in posttraumatic stress disorder: Properties of voluntary and involuntary, traumatic and non-traumatic autobiographical memories in people with and without PTSD symptoms. *Journal of Experimental Psychology: General*, *137*, 591–614.

Rubin, D. C., Dennis, M. F., & Beckham, J. C. (2011). Autobiographical memory for stressful events: The role of autobiographical memory in posttraumatic stress disorder. *Consciousness and Cognition*, *20*, 840–856.

Rubin, D. C. & Greenberg, D. L. (1998). Visual memory-deficit amnesia: A distinct amnesic presentation and etiology. *Proceedings of the National Academy of Sciences*, *95*, 5413–5416.

Rubin, D. C., Li, D., Hall, S. A., Kragel, P. A., & Berntsen, D. (2017 online). Taking tests in the magnet: Brain mapping standardized tests. *Human Brain Mapping*, *38*, 5706–5725.

Rubin, D. C., Schrauf, R. W., & Greenberg D. L. (2003). Belief and recollection of autobiographical memories. *Memory & Cognition*, *31*, 887–901.

Rubin, D. C. & Talarico, J. M. (2009). A comparison of dimensional models of emotion: Evidence from emotions, prototypical events, autobiographical memories, and words. *Memory*, *17*, 802–808.

Rubin, D. C. & Umanath, S. (2015). Event memory: A theory of memory for laboratory, autobiographical, and fictional events. *Psychological Review*, *122*, 1–23.

Schacter, D. L. & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *362*, 773–786.

Sheen, M., Kemp, S., & Rubin, D. C. (2001). Twins dispute memory ownership: A new false memory phenomenon. *Memory & Cognition*, *29*, 779–788.

Singer, J. L. (1966). *Daydreaming: An introduction to the experimental study of inner experience*. New York: Random House.

Spreng, R. N., & Levine, B. (2006). The temporal distribution of past and future autobiographical events across the lifespan. *Memory & Cognition*, *34*, 1644 –1651.

Squire, L. R. (1987). *Memory and brain*. New York: Oxford University Press.

Squire, L. R. (1994). Declarative and nondeclarative memory: Multiple brain systems supporting learning and memory. In D. L. Schacter & E. Tulving (eds.), *Memory systems 1994* (pp. 203–231). Cambridge, MA: MIT Press.

Squire, L. R. (2004). Memory systems of the brain: A brief history and current perspective. *Neurobiology of Learning and Memory*, *82*, 171–177

Szpunar, K. K. (2010). Episodic future thought: An emerging concept. *Perspectives on Psychological Science*, *5*, 142–162.

Szpunar, K. K. & McDermott, K. B. (2008). Episodic future thought and its relation to remembering: Evidence from ratings of subjective experience. *Consciousness and Cognition*, *17*, 330–334.

Talarico, J. M., LaBar K. S., & Rubin, D. C. (2004). Emotional intensity predicts autobiographical memory experience, *Memory & Cognition*, *32*, 1118–1132.

Trope, Y. & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review*, *117*, 440–463.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (eds.), *Organization of memory* (pp. 381–402). New York: Academic Press.

Tulving, E. (1983). *Elements of episodic memory*. Oxford: Clarendon Press.

Tulving, E. (1984). Précis of elements of episodic memory. *Behavioral and Brain Sciences*, *7*, 223–268.

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

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology*, *53*, 1–25.

Wilson, B. A. & Wearing, D. (1995). Prisoner of consciousness: A state of just awakening following herpes simplex encephalitis. In R. Campbell & M. A. Conway (eds), *Broken memories: Case studies in memory impairment*, (pp. 14–30). Malden: Blackwell.

Zeki, S. (1993). *A vision of the brain*. Oxford: Blackwell.