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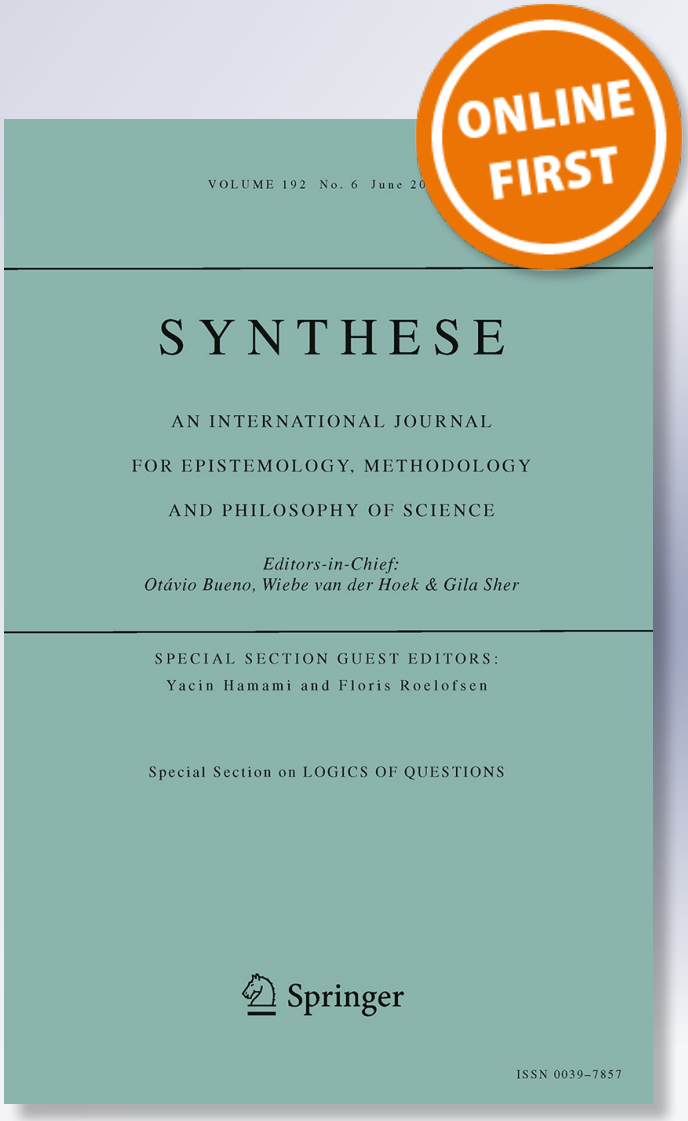

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Abstract Whether non-human animals can have episodic memories remains the subject of extensive debate. A number of prominent memory researchers defend the view that animals do not have the same kind of episodic memory as humans do, whereas others argue that some animals have episodic-like memory—i.e., they can remember what, where and when an event happened. Defining what constitutes episodic memory has proven to be difficult. In this paper, I propose a dual systems account and provide evidence for a distinction between *event memory* and *episodic memory*. Event memory is a perceptual system that evolved to support adaptive short-term goal processing, whereas episodic memory is based on narratives, which bind event memories into a retrievable whole that is temporally and causally organized around subject's goals. I argue that carefully distinguishing event memory from episodic memory can help resolve the debate.

Keywords Episodic memory · Episodic-like · Uniqueness debate · Mental time travel · Animal cognition · Event segmentation

The other animals have memory, but, of all that we are acquainted with, none, we venture to say, except man, shares in the faculty of recollection. The cause of this is that recollection is, as it were, a mode of inference.

Aristotle

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1 Introduction

Episodic memory is a critical psychological capacity and has frequently been claimed to be a cornerstone of personal identity. It is sometimes called 'recollective memory', 'personal memory', 'experiential memory', or 'direct memory' by philosophers. It is usually defined in contrast to semantic memory (Tulving 1972). There is some disagreement as to the nature of this division and the relationship between these two memory systems, both in terms of function and the neural structures involved (e.g. McKoon et al. 1986; Rubin and Umanath 2015). It is generally agreed, however, that episodic memory is concerned with the conscious recall of specific past experiences, whereas semantic memory involves the storage and retrieval of factual knowledge about the world. The difference is often referred to in terms of remembering versus knowing: episodic memory is concerned with remembering specific personal experiences, whereas semantic memory deals with what one knows about the world. Remembering getting soaked in the London rain last Tuesday is an example of episodic memory, but knowing that it often rains in England is an example of semantic memory because it need not be acquired as a result of a personal experience of getting wet (Suzuki and Clayton 2000).

Episodic memory is widely studied in neuroscience, psychology, and to a lesser extent in philosophy. Part of the reason is that there are many different types of memory that common sense conception of memory does not distinguish. This makes the conceptual terrain of memory especially difficult to navigate without making fine-grained distinctions in consultation with the relevant empirical literature. Still, philosophers of mind are interested in the nature of memory in general; in the distinctions among different types of memory and in the relations of those types to each other (e.g. Bernecker 2008). Epistemologists considered how best to characterize epistemic status of memories in light of the so-called vices of memory such as forgetting and inaccuracies (Michaelian 2010, 2011a; Shanton 2010). More recently, philosophers of memory started to tackle fundamental questions about episodic memory with interdisciplinary methods. On the one hand, De Brigard (2013) offers a functional perspective on episodic memory and argues that ordinary cases of misremembering should not be seen as instances of memory's malfunction, but rather as the normal result of a larger cognitive system that assists the flexible recombination of different components into hypothetical cases. On the other hand, Michaelian (2011b) and Cheng and Werning (2015) consider whether memory constitutes a natural kind. Whereas Michaelian argues for a negative answer in the general case of memory, Cheng and Werning argue for a positive answer in the specific case of episodic memory.

In this paper, I consider whether episodic memory is a uniquely human capacity. Memory researchers are divided as to whether animals have the same kind of episodic memory as humans do (Tulving and Markowitsch 1998; Suddendorf and Corballis 1997; Clayton and Dickinson 1998; Griffiths et al. 1999; Morris 2001). Resolving the debate has proven to be difficult, as there is no consensus on what constitutes episodic memory. I propose a distinction between *event memory* and *episodic memory*, and argue that a dual systems account can help resolve the debate. As a first approximation, event memory consists of short-term perceptual records of momentary events, whereas episodic memory consists of longer-lasting records of unique experiences bound into

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a narrative. I review evidence for event and episodic memory and consider various features in which they differ.

The paper is organized as follows. I begin with a brief discussion of the uniqueness debate and propose a dual systems account. The following two sections are dedicated to the individual components of the dual system. First, I review recent work done in event segmentation literature to make a case for event memory. Second, I consider the case of childhood amnesia to analyze what is missing in young children's memories and argue that they lack a binding process that can bind event memories into goal-based episodes. Having introduced the two components of the dual system, I then compare the two systems and provide a summary of how the two systems functionally differ and how they interact. Finally, I return to the puzzle introduced at the paper's outset and offer my resolution.

1.1 A puzzle about episodic memory

Is episodic memory a uniquely human capacity? Different theorists working on memory have given different answers to this question. On the one hand, a group of prominent memory researchers answer the question in the affirmative. In the view they defend, "animals do not have the same kind of episodic memory as humans do" (Tulving and Markowitsch 1998, p. 203) as "nonhuman animals, including the great apes, are confined to a "present" that is limited by their current drive states" (Suddendorf and Corballis 1997). Proponents of this view emphasize a number of distinctive features of episodic memory, including its phenomenological, meta-representational, and temporal character; the role it plays in prospection and planning; and its late development and early deterioration.

Supporters of this view also endorse the "mental time travel" metaphor to differentiate episodic recall from other forms of remembering that might be found in animals or young children. Although speaking in terms of mental time travel is common in psychology, no psychologist believes that episodic memory is in fact a means of transporting one's self to different times. Rather, the idea is episodic memory assists mental reconstruction of personal events from the past and possible events from the future. Such reconstructions provide an ability to 'mentally travel' into the past and into the future. It is this "ability to travel mentally in time constitutes a discontinuity between humans and other animals" (Suddendorf and Corballis 1997). Following the literature, I call this view the *mental time travel theory.*

Another set of factors pulls in a different direction, however. Consider a second comparative question: are there analogues of episodic memory in primates and other animals? Some memory researchers have thought so, and in their view it would be quite surprising if there were not analogues of episodic memory in other animals (Clayton and Dickinson 1998; Griffiths et al. 1999; Morris 2001). Proponents of this view criticize phenomenological or linguistic demands placed on episodic memory on the grounds that these cannot be objectively measured in other animals, and emphasize Tulving's (1972) original characterization of episodic recall as the retrieval of information about 'where' a unique event or episode took place, 'what' occurred during the episode, and 'when' the episode happened. By using tasks demanding recollection of 'what, where and when' an event happened, for instance, Clayton and Dickinson

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(1998) showed that scrub jays can remember what type of food they have cached, when the event occurred, and where that particular caching took place. They argue that scrub jays have episodic-like memory. Following the literature, I call this view the *WWW theory*.

At first, these two views appear to be incompatible and philosophers of animal cognition are also divided as to which one is correct. Philosopher Rocco Gennaro (2009) argues that recent evidence accumulated in animal memory literature strongly suggests that many animals have episodic-like memory that involves a minimal self-concept and some capacity to mentally time travel. Peter Carruthers (2007) is not as convinced by the evidence as Gennaro. Although he does not explicitly subscribe to the mental time travel theory, Carruthers criticizes interpretations of the main experimental results and suggests simpler explanations of the data that do not involve the kind of meta-representational processes invoked in episodic recall. Philosopher Christoph Hoerl and psychologist Teresa McCormack (McCormack and Hoerl 2011) also think it is unlikely that non-human animals can think episodically, since, in their view, doing so requires a linear conception of time. Their argument relies on Campbell's (1994) distinction between temporal frameworks that can represent an event's position within a periodic cycle such as days or seasons and temporal frameworks that can represent events within a linear non-repeating dimension. McCormack and Hoerl argue that evidence so far suggests that non-human animals show sensitivity to the former type of temporal framework, not to the later.

One may not be forced to take sides however. A conciliatory conclusion could be endorsed, holding that both the WWW theory and the mental time travel view are partially correct when understood properly. In what follows, I argue for this option. To say why, however, I must first motivate and defend the alternative view that I favor. Once that has been accomplished, I will briefly return to this puzzle posed at the paper's outset and show why each view is partially correct.

1.2 The dual systems thesis

Here, in short, is the hypothesis I defend and elaborate on in the remainder of this paper: There are two different memory systems for personally experienced events, one phylogenetically older than the other. I will refer to the older system as the *event memory*, and the newer one as the *episodic memory*. Humans share the event memory system with young children and some animals. This is a perceptually based snapshot-like memory system that is mainly specialized for recent events. It is a system that evolved to support adaptive short-term goal processing, involves learning from repeated experiences, and is cue driven. It is a system that would allow most species to operate effectively in their environment day-to-day. The episodic memory system is based on narratives that bind a particular set of events into a past episode. It is temporally and causally organized around the subject's goals. It retains narrative episodes that are low in accuracy but spans larger time scales. Episodic memory provides an organizing context for event memories and requires conscious recollection.

A similar distinction within personally experienced memories can be traced back at least to Aristotle's discussion in *De Memoria* (Sorabji 1972), where he distinguishes between memory and reminiscing (See De Brigard 2014 for a discussion). According

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to Aristotle, to remember is to bring mind previously experienced individual events. Reminiscing, however, is an inferential process that involves putting events in logical relations to each other. In contemporary psychology, various theorists offer parallel distinctions, although a consensus on terminology and features has not emerged yet (See Pillemer 1998 for a discussion). Tulving and Schacter (1990), Schacter (1994) refer to this distinction in terms of perceptual representation system (PRS) and episodic memory. PRS is an early developing system that is involved in the recognition of specific perceptual objects whereas episodic memory binds together PRS's outputs with other kinds of information (e.g., semantic, contextual) to allow subsequent recall or recognition of multi-attribute events (Schacter 1994). Williams et al. (2008) draw a similar line between episodic and autobiographical memory, whereas Pillemer (1998) uses the terms imagistic and narrative memory and Schank (1995) suggests the terms event-based memory and story-based memory. Another pertinent distinction is made between conscious and non-conscious memory processes usually known as implicit and explicit memory (Roediger 1990). Explicit memory refers to intentional or conscious recollection of prior experiences such as episodic memory; implicit memory, by contrast, refers to changes in performance or behavior based on prior experiences, on tests that do not require any intentional or conscious recollection of those experiences. In an implicit memory task, for instance, a subject may complete a word fragment faster than normal without being aware that he or she viewed the word on a separate occasion one day earlier. Implicit memory, like PRS, is based on perception.

Although particulars of the various models differ, core characteristics of the two systems are strikingly similar across disparate research domains. Roughly speaking, the first system is characterized as perceptual and unconscious; the second is characterized as verbal and conscious. Many theoretical accounts identify the perceptual system as a more primitive system, developing earlier both ontogenetically and phylogenetically.

I propose to recast the distinction in terms of *event memory* and *episodic memory*. In the literature, event memory is generally taken to be synonymous with episodic memory,[1] but carefully distinguishing them can clarify the confusion between episodic-like memory of the WWW theory and fully fledged episodic memory of the mental time travel theory.

2 Event segmentation

According to the dual systems thesis, the process underlying event memory is closely linked to event perception. The motivation behind a growing body of research on event perception is that people perceive activity in terms of discrete events and ongoing processing resources are devoted to this perceptual process (see Zacks and Tversky 2001 for a review). Perceptual processes segment continous flux of activity into discrete events. In this event segmentation process, physical change is used to identify event boundaries, i.e. to identify where one event ends and the other begins. When asked to

[1] A recent exception is Rubin and Umanath's (2015) distinction between event memory, which is based on construction of a scene, and episodic memory, which is defined as a type of event memory accompanied by a sense of reliving involving the self.

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identify event boundaries, people tend to divide activity at locations that correspond to maxima in the number of physical features that are changing. For instance, in Newtson, Engquist and Bois's (1977) experiment, naive viewers divided films depicting human activities into parts that felt most natural to them. The positions of the actors were then coded using dance notation. The locations in time at which the naive observers segmented the activity corresponded to points at which the positions of the actors' bodies were changing the most. Furthermore, there is good agreement about what make up the typical parts of everyday activities within relatively homogenous samples of participants (Newtson and Engquist 1976; Bower et al. 1979). The objective basis of event boundaries in terms of maxima in feature changes combined with reasonable inter-rater reliability suggests that events are perceptually salient.

It would be helpful to draw an analogy between object perception and event perception (Zacks and Tversky 2001). Perception of events is like perception of objects and these maxima in feature changes are like contour discontinuities in objects. They mark the boundaries of parts and correspond to locations of maximal perceptual change. As with objects, there is evidence that these points are particularly important for event identification. For instance, when slide shows are made from a movie of some activity, sequences made of perceptually identified event boundaries are better categorized than sequences of non-boundaries (Newtson and Engquist 1976). Similarly, recognition of sign language is better for sequence of frames in which the most change occur (Parish et al. 1990). There is evidence that 6-month-old infants are able to use such perceptual event boundaries to individuate and enumerate events, even in the midst of continuous activity (Wynn 1996). Changes in sensory features such as color, sound and movement seem to be critical in event segmentation (Zacks and Swallow 2007).

According to Zacks et al.'s (2007) event segmentation theory, segmentation of ongoing activity into discrete events is a spontaneous part of ongoing perception and does not require conscious attention. The grain of segmentation can be adjusted automatically depending on current context and tasks. Information that is needed to perform skilled activities is rapidly encoded into long-term memory. This information remains accessible in short-term memory and can be rapidly recalled when it is retrieved with a cue.

Perhaps most relevant to the event memory and the dual systems thesis is that event segmentation is not only a perceptual capacity, but also has downstream effects on memory encoding. Several studies suggest that perceptual information from event boundaries is preferentially accessible in memory. In one experiment (Newtson and Engquist 1976), participants watched a movie and then saw still pictures from event boundaries, points in between boundaries, and from a similar movie they had not seen. They then reported which pictures came from the movie they had watched. Pictures taken from event boundaries are remembered with higher accuracy. In another study (Schwan and Garsoffky 2004), participants viewed short movies of everyday events and then recalled them. The movies are presented either intact, with deletions that corresponded to intervals surrounding event boundaries, or with deletions of intervals in between event boundaries. Memory for the edited movies with preserved event boundaries was as good as memory for intact movies, but memory for edited movies with deleted intervals around event boundaries was poorer. In yet another series of experiments (Boltz 1992), participants viewed a feature film with no commercial breaks

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or a film with commercial breaks. The breaks were congruent or incongruent with event boundaries. Commercials at event boundaries improved later recall of the activity, whereas commercials at non-boundaries impaired memory. Moreover, individuals who are good at segmenting events remember them better than do individuals who are poor at segmenting (Zacks et al. 2006). Additionally, the grain of segmentation also effects the overall amount of information that can be recalled: Multiple studies have reported that fine-grained segmentation of movies leads to more detailed recall of the events depicted than does coarse-grained segmentation (Hanson and Hirst 1989; Lassiter and Slaw 1991).

Taken together, studies of memory for events suggest that online perception of events determines how event memories are encoded. People remember event boundaries better than non-boundaries, which supports the idea that event boundaries are used to encode event memories. Event memories consist of time slices of maximal feature change. They are formed on the basis of perceptual segmentation, which utilizes changes in sensory features such as movement, color, sound and so forth. Consequently, perceptual features are represented in event memories. Consistent with this idea, descriptions of event boundaries from memory are found to be richer and more detailed than descriptions of non-boundaries (Schwan et al. 2000), which suggests an underlying vivid perceptual representation. These perceptual representations are predominantly in the form of visual images, although they can be multimodal as well.

Event memories are generally short-lived. Unless further instances of the same type of event are encountered, the information is not retained over significant amounts of time. However, repeated exposure to similar events leads to the creation of a script for the series of events. A script is a general knowledge structure that represents the knowledge abstracted from a class of similar events, rather than knowledge of any one specific event (Schank and Abelson 1977). It consists of a sequence of actions that are temporally ordered. Thus, people have scripts for familiar experiences like eating in restaurants, going shopping, visiting the dentist, and so on. Scripts explain the common observation that in remembering routine, familiar, often-repeated events we seem to have a generic memory in which individual occasions, or episodes, have fused into a composite. Script acquisition is a difficult and understudied problem, and many factors are known to influence the generation of script-like information such as frequency of encounters, prior information etc. (Sakamoto and Love 2004; Palmeri and Nosofsky 1995). The workings of event memory are also another factor for the acquisition of generic, script-like knowledge. These scripts, in return, can influence segmentation of subsequent events (Zacks and Swallow 2007). So, there can be a top down influence on event segmentation in addition to the bottom up perceptual processes.

All these elements of event memory, especially those associated with the event boundaries, bear the mark of a system that assists short-term record of progress in current context and tasks and learning from repeated experiences. Facts concerning the other memory system and the type of organization that it provides help fill out the picture. That event boundary itself is one of the common features at different levels of processing only strengthens the conclusion that event memory, event segmentation and identification are all deeply linked. Thus the explanation of the properties of the event memory will be found in the perceptual capacity of segmenting continuous

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stream of activities into discrete events and encode them into memory. As such, the first component of the dual systems thesis is now in place: one of the two main processes composing personally experienced memories is what I will henceforth call, in shorthand, the *event segmentation process*.

3 Narrative binding

This leaves the process underlying episodic memory, which binds events into a goal-based episode. According to the dual systems thesis, this process is closely tied to our storytelling capacity and the conversations that narrative exchanges take place. It provides one way to store events as units that can be easily found, easily told, and be made useful for a variety of purposes by binding them into narratives. Unlike the event segmentation, this process is not perceptual and does not support acquisition of generic knowledge from repeated experiences. Rather, it serves to retain unique one-time experiences over longer periods of time. This involves not only ordering and interpreting events temporally and causally, but also finding goals or purposes that bind these events into a retrievable whole.

In the developmental psychological literature, childhood amnesia presents a case akin to the puzzle introduced at the outset of this chapter, i.e. whether episodic memory is unique to humans. People can remember a fairly continuous record for the years after the age of 6 or 7, but for the period before this age, memories are sparse and fragmented. The term "childhood amnesia" is used as a label for deficient recall within this period, which lasts from birth to approximately four or five years of age. The controversy in the animal memory case repeats itself in the memories of young children. Mental time travel theorists generally deny that young children have episodic memory (Tulving 2005), whereas WWW theorists argue that young children have episodic-like memory (Clayton and Russell 2009). Whatever we may call it, however, both parties seem to agree that young children have memories of some sort. The term "childhood amnesia" is actually a misnomer, as there is good reason to think that children before the age of five are not amnesic. In fact, children begin to talk about their past as soon as they begin talking (see Nelson and Fivush 2004 for a review).

Unlike the animal case, in the case of young children we have detailed verbal reports of these memories, which can help us to spot the differences between young children and older children and adults' memory. Studies on prelinguistic children suggest that they have considerable event segmentation abilities (Baldwin et al. 2001; Saylor et al. 2007) and event understanding (Tomasello and Kruger 1992; Akhtar and Tomasello 1996). There is also good evidence that even very young children have strong and orderly scripts for *repeated* routine experiences in their lives (Nelson 1986). However, when young children are tested for their recall of a *novel* experience, their memories are deficient in several organizational dimensions. For instance, Price and Goodman (1990) tested 2.5- to 5-year-old children for their experience of a novel episode (visiting a wizard). Whether assessed through verbal report or re-enactment, the younger children evidenced less temporal sequence knowledge and made more ordering mistakes than did the older children. Moreover, the older children recalled a causal connection between an action that occurred early in the sequence and one that occurred late in

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the sequence, whereas the younger children did not. In a related study, when asked to sort pictures of a novel clay-making event into categories, young children put together pictures that share objects (e.g. the actions performed on the bowl), whereas adults put together the pictures that share activities (e.g. mixing ingredients together) (Ratner et al. 1986). Thus, younger children's memory representations are not organized around goals to the same extent as are older children's and adults.

It seems that young children have difficulty in organizing their experiences. This organization problem is especially evident in the case of novel experiences. Their memory for routine and repeated experiences is highly organized in terms of temporally and causally ordered scripts. For one-time experiences, however, temporal and causal relations between events are not properly specified. Young children do not seem to relate events to each other in these dimensions to the same extent as older children and adults. More importantly, their memory representations are centered on objects, compared to goal-based representations of older children and adults. So, young children remember the events to some extent, but they do not remember these events as a temporally and causally organized unit centered on their goals.

Given this general description of the organization problem, it is quite clear that the event segmentation process would not be of any help. As we have seen, event segmentation is a perceptual process specialized for breaking apart continuous flux of activity into discrete events. Its output is fleeting and fragmentary memories based on event boundaries at different grains of segmentation. Moreover, event memory is tied to current tasks. Event memories are retained as long as they are relevant for current tasks, otherwise rapidly forgotten. Learning from event segmentation occurs for repeated experiences, but even then it produces generic knowledge structures in the form of scripts that are disconnected from the original experience. In short, the event segmentation process can explain what young children have, not what they lack.

What young children lack is a *binding process* that takes these fleeting and fragmentary event memories as inputs and binds them into a retrievable episode that is temporally and causally organized around subject's goals. We can distinguish three main components of this binding process (Travis 1997). One component is to link multiple events into a temporal sequence. Events occur in a sequential order in time, such as before or after another event. The binding process needs to track where in time each event occurred in the sequence. The second component, then, is to establish causal relations between pairs of temporally distant events. Although temporal contiguity can be used as a proxy for causal relation if the two events occur close in time, in many cases events have their effects delayed. The binding process needs to make causal inferences between temporally separated events. Finally, the third component is to ascribe goal status to a particular event, and use this as the focal point of the memory representation. Children need such a binding process to represent casual relations between temporally separated events and to represent them in a converging structure, in which multiple events are bound together to enable a single outcome.

Narrative has nearly all the components one would expect of a binding process, given the contours of the relevant organization problem. Narratives mimic the temporal and casual sequence of events and normatively contain a setting, a triggering event, a sequence of attempted solutions, and a resolution (Labov and Waletzky 1967). More importantly, narratives are structured by goals (Zwaan and Radvansky 1998; Graesser

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et al. 1994; Trabasso and Nickels 1992). Narratives organize events into a whole by interpreting and connecting a series of events in order to get an outcome, namely the goal. Narratives begin with some events or states that bring about a goal, or introduces a problem for the attainment of an existing goal, and through a sequence of episodes the protagonist tries to find some way to realize the goal. Narratives come to an end when the goal is achieved, or the protagonist refrains from the goal through some transformation. Thus, the events in a narrative take the form of a goal-directed sequence. In this sequence, earlier events occur for the sake of some goal; they are usually the type of events that bring about this goal. Moreover, different episodes of a story are connected to each other through goal-plan hierarchies. A character may fail to achieve his or her goal or may foresee difficulties in fulfilling the goal and then establish a subgoal in order to achieve the superordinate goal. The subgoal, in turn, motivates the actions and eventually the outcome of another episode. In this way, goals, attempts, and outcomes organize events into a goal-plan hierarchy. Thus, a goal-plan hierarchy is a highly important organizational process in narratives that can be utilized to bind event memories.

In fact, the conclusion that the binding process is subserved by narratives is nearly inescapable when one considers more details about episodic memory. It has often been observed and long been known that memories may be altered, distorted, even fabricated (e.g., Bartlett 1932; Ross 1989; Loftus 1993). Current opinion holds that all memories are reconstructed, to some extent, each time they are brought to mind (Conway and Pleydell-Pearce 2000). Reconstructed memories are therefore liable to conform to the general character of the original experience but to be inaccurate in specific details.

In such reconstructions, narrative skills enable providing a good story, not an accurate one. According to Brewer and Lichtenstein (1982), one important aspect of what makes a story good is its ability to arouse particular emotional responses in the audience. When narrating an experience, pruning some details and embellishing others with fictional elements can help to make it more funny, interesting, dramatic and so forth.[2] In line with this idea, for instance, Marsh and Tversky (2004) found that participants who kept diaries of naturally occurring retellings of real events reported large amounts of distortion in terms of selectivity and exaggeration: 61 % of the narratives they told about their own lives were distorted in at least one way. When we reconstruct the narrative version of an experience, the past is inadvertently distorted (DePaulo et al. 1996; Marsh and Tversky 2004). A number of studies have shown a quantity-accuracy trade-off in the memory reports of both children and adults (Koriat and Goldsmith 1994, 1996; Koriat et al. 2001; Roebers et al. 2001). The general finding across these studies is that the more elaborate and the more coherent a memory report, the less accurate it becomes. In particular, Kulkofsky et al. (2008) showed that in preschool children narrative skills enable the reporting of more information,

[2] This does not mean that all distortions of memory are emotional at their basis. Memory distortions encompass a wide range of phenomena such as misattribution—i.e., cases where even though some form of memory is present, it is attributed to a wrong time, place or person—and suggestibility—i.e., the tendency to incorporate information provided by others (e.g. due to misleading questions) into one's own recollections (Schacter 1999). Rather the focus is here on one important and pervasive class of distortion that is related to narrative construction.

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while decreasing the proportion of information that was accurate. Just as adults often exaggerate and embellish narratives about the past at the cost of accuracy (DePaulo et al. 1996; Marsh and Tversky 2004), young children do so as well when sharing them with others. It seems as though the original event-based memory is lost and a narrative-based copy is formed in the process.

But the payoff seems to be memorability: narratives make event memories more memorable. A salient feature of narratives is that they are strikingly memorable. Although the narrative "Little Red Riding Hood" is much more complex than a 20-digit number, the narrative is much easier to remember (Sperber 1985). Narrative elements that are central to the goal structure of a narrative are more easily remembered than peripheral elements (Black and Bower 1980; Mandler et al. 1980; Trabasso and van den Broek 1985). Memory enhancement for narratively organized events can also be tested directly. Pipe et al. (1996) had one group of 5-year-olds experience a novel pirate event with full narration by an accompanying adult, and another group experienced the same event, but with "empty" narration (e.g., "First we do this, then we do this," etc.). Children in the full narrative group recalled more about the event both verbally and in action than did children in the empty narrative group.

This enhanced memory for narratively organized events has also been confirmed in a more naturalistic setting in Pillemer's fire alarm study (Pillemer et al. 1994). The study is based on an accident that occurred at the Wellesley College Child Study Center in 1984, when burning popcorn set off a fire alarm. The children—one class about 3.5 years old, another about 4.5 years old were evacuated from the building and waited outside while police and firemen checked the building. After it was determined that there was no real fire, the teachers explained what had happened and normal school life resumed. Two weeks later, children were interviewed. Although all of them still remembered the fire alarm at that point, there were already intriguing age differences. The younger children rarely began their accounts at the proper beginning (i.e., with the fact that they were inside the school when the alarm went off) and almost never mentioned the real cause of the whole accident (the popcorn). The older children, in contrast, typically included both.

Seven years later, most of the children were located and interviewed again. Those who had been 4.5 years old at the time of the event (and were now about 11) still remembered it fairly well; nearly a third of them were able to give what Pillemer et al. call "an intact narrative account." In contrast, none of the 3.5-year-old group could produce such an account. Many of them seemed to remember nothing at all, and were at chance level on forced-choice questions. How can we explain this difference? The difference in recall is not due to erased memories of younger children, rather it is due to 4.5 year olds capacity to understand the events while they are happening in a way that 3.5 year olds cannot (Neisser 2004). In other words, the quality of the child's narrative processing immediately following a momentous event can influence long-term memory accessibility. In the fire alarm study, 4.5 year olds had originally understood the purpose for the alarm and evacuation and bound the events into a rudimentary narrative. This initial binding of the events improved their recall seven years later. However, 3.5 year olds' fleeting and fragmentary event memories were not bound even two weeks after the fire alarm, and were completely lost in the subsequent years.

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Perhaps another important factor for memorability is social rehearsal through storytelling. Talking about an episode provides overt rehearsal of the memory in question. Episodes are better recalled if they are socially rehearsed (Conway et al. 1994; Finkenauer et al. 1998; Hirst et al. 2009). From 3 to 5 years in age, children's narrations change from predominantly describing states and identifying objects to narrating actions and the goals and purposes for these actions (Berman 1988; Stein 1988; Trabasso and Nickels 1992). Being older, the 4.5 year olds in the fire alarm study had probably had more experience in describing events to their parents, and therefore had better narrative skills than the 3.5 year-olds. In all likelihood many of 4.5 year olds did tell their parents about the fire alarm later that day, thus rehearsing it and establishing its interpretation more firmly.

Narrative is not simply the way in which episodic memories are expressed, it is also instrumental in providing the organizational and phenomenological forms characteristic of episodic memory. Young children generally do not structure their experience in memorable ways, since they are less skilled in narrative construction than adults. As children's developing narrative skills allow them to enter into dialogue with others about their past experiences, children become more skillful in forming temporally and causally organized representations of past experiences centered on their goals (Nelson and Fivush 2004) and they can socially rehearse their memories. Experience with different forms of narrative, in play, in stories, and especially in talk about personal episodes, provides a model for organizing one's event memories.

Narratives provide a useful cognitive framework or format for remembering a sequence of events. All these elements of binding process bear the mark of a system for retaining unique and important experiences through overt social rehearsal. With this claim, the second part of the dual systems thesis is now in place: the explanation of the features of the second component of the personally experienced memories is to be found in our storytelling capacity and the conversations in which narrative exchanges take place. For short, I will call this the *narrative binding process*.

4 The dual memory systems

According to the dual systems thesis, two different processes underlie personally experienced memories. Table 1 provides a summary of the characteristics of the two systems. On the one hand, the event segmentation process is a perceptual process specialized for breaking apart continuous flux of activity into discrete events. It retains perceptual representations from event boundaries predominantly in the form of visual images. These perceptual representations are highly accurate but short-lived. On the other hand, the narrative binding process binds event memories into a retrievable episode that is temporally and causally organized around subject's goals. It retains narrative episodes that are low in accuracy but spans larger time scales.

The event segmentation process does not require conscious attention, and hence encoding is relatively fast. Moreover, event memories are activated by task-based cues from working memory, hence their retrieval is relatively fast as well. The narrative binding process requires conscious recollection of events. Although episodic memories can be activated by cues as well, they are also addressable through conscious,

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Table 1 Characteristics of event and episodic memories

Event memory	Episodic memory
1. Retain records of event segmentation	1. Retain records of narrative binding
2. Represent time slices determined by event boundaries	2. Represent longer time scales determined by plot (e.g. goal-attempt-outcome structures)
3. Events are represented predominantly in the form of visual images with high accuracy	3. Episodes are represented in the form of narratives with lower accuracy
4. Object-based representations	4. Goal-based representations
5. Encoding is unconscious, recall is cue driven and fast	5. Encoding is conscious, recall can be cue driven or voluntary
6. They are only retained in a durable form if a script is formed for the event category due to repeated experience or they become linked to other events within a narrative. Otherwise they are rapidly forgotten	6. They are retained for longer periods especially if they are socially rehearsed
7. When included as part of an episodic memory construction they provide specificity	7. Episodes terminate at event memories
8. Their main function is to provide a short-term record of progress in current goal processing and learning for routine events	8. Their main function is debated. Alternative proposals range from prospection to social bonding

purposeful recall, and they can be called up in situations remote from the original learning context. As such episodic recall can be relatively slow.

According to the dual systems thesis, the narrative binding system does not replace the event segmentation system; rather they coexist and interact throughout life. The event segmentation and narrative binding processes work as opposing forces. On the one hand, experiences are constantly being broken up into their component pieces and are being added to generic knowledge base about the world. On the other hand, the component pieces of novel experiences are combined back and socially rehearsed. If we liken events to words and scripts to sentences, then narrative is like a paragraph. The narrative binding process takes event memories and scripts as inputs and organizes them into a goal plan hierarchy.

Consider an example. When a person goes to a bar for the first time, the event segmentation process breaks apart the experience into discrete events such as getting in, sitting at a table, ordering drinks, drinking, paying your bill and leaving. These events are identified on the basis of perceptual characteristics such as points of maximal change in physical features, and top down influence from similar scripts such as going to a restaurant. Through repeated experience, these events form a bar script that specifies the expected temporal and causal order events. The script provides generic knowledge detached from the particular experience that can then be used in subsequent occasions and at different locations. The specific details of the original experience will be forgotten over time.

The narrative binding process, however, takes a particular instance of going to a bar when things do not go according to the script such as being hassled by a drunken person. It binds the events in this novel instance into a narrative about a drunken

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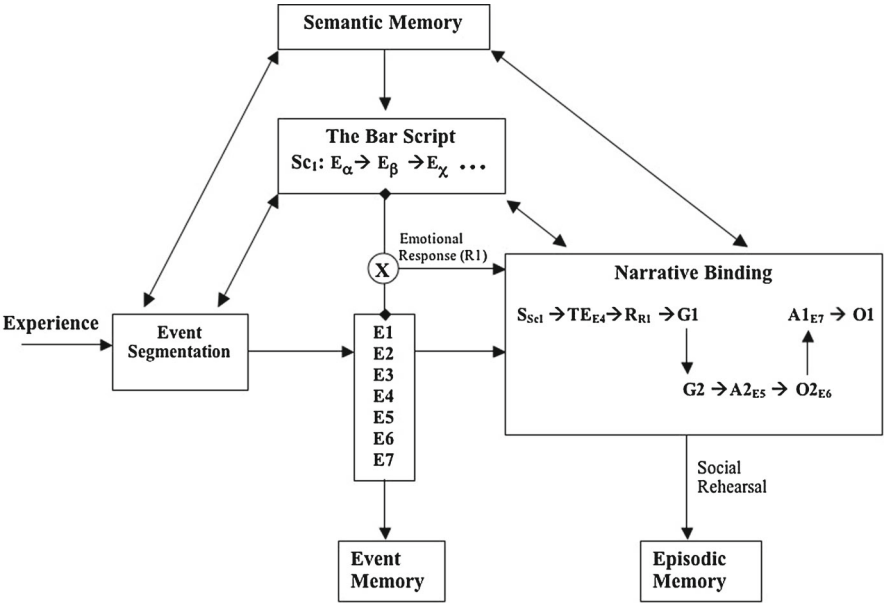

Fig. 1 Narrative binding of the events in the bar example. The narrator goes to a bar (*E1*), sits on a table at the corner (*E2*) and orders a beer (*E3*), a drunken Norwegian sailor hassles him (*E4*), the person calls his friends for help (*E5*), his friends come (*E6*) and save him just in time before being attacked (*E7*). In the construction of a narrative, the narrative elements of setting (*S*), triggering event (*TE*), the narrator's emotional response (*R*), and goal (*G*), attempt (*A*) and outcome (*O*) structures are used. The sailor's threats frighten the narrator (*R1*), which initiates the goal of preservation of personal safety (*G1*). The narrator satisfies this goal by a secondary goal of getting help (*G2*). Note that instead of actual events E1, E2 and E3, a generic bar script (*Sc1*) is used as the setting of this narrative, and hence those specific details are likely to be forgotten over time

Norwegian sailor hassling the narrator claiming that the narrator was sitting with his woman, and how the narrator's friends save him just in time before being attacked (Labov 2008). The binding process takes a generic bar script as the setting of this narrative, the Norwegian sailor's threats as the triggering event, and being frighten as the emotional response of the narrator. The subsequent events are interpreted within a goal plan hierarchy. The narrator devises a plan *in order to* preserve his safety, and the plan is to call his friends for help. The plan works, his friends come just in time before being attacked and save him. Figure 1 provides an illustration of segmentation and narrative binding of events in the bar example.

Event memory and episodic memory help us deal with different tasks in time. Event memory is specialized to assist short-term record of progress in current context and tasks and learning from repeated experiences. Event segmentation allows most species including humans to operate effectively in their environment day-to-day. Using what has happened as a basis for anticipating what will happen next provides a useful heuristic for guiding action. Once events have been individuated, one can recognize sequences of events, and based on such sequences anticipate what will happen next and select appropriate future actions. This allows selection of responses ahead of

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the realization of an (anticipated) event and therefore, it is indispensable to adapt to situations and successfully interact with the environment (Schütz-Bosbach and Prinz 2007).

Episodic memory affords learning for one-time novel experiences through social rehearsal. The function of episodic memory, or the function of these one-time novel experiences in particular, is currently debated (see Boyer 2008 for a discussion). Memories for routines are useful as they provide us with an ability to anticipate the sequence and content of the routine event and perform better at each encounter. But a novel experience does not have the same functional value, unless it is repeated. So, why a system would retain information about an experience that would not be encountered again is a much harder question to answer. Alternative proposals range from cognitive accounts, in which episodes are taken to provide a store of possible scenarios whose combination allows sophisticated prospection and flexible planning (Suddendorf and Corballis 2007; Blank et al. 2007; Boyer 2008), to social interactionist accounts, in which sharing episodes is seen as a means to effectively manage social dynamics and socially bond with others (Nelson 1993; Nelson and Fivush 2004; Reese 2002). At present there is no single received view, accepted by all interested parties.

The event and episodic memory distinction is a *functional* one that contrasts two different processes for personally experienced memories; it does not refer to, or necessarily imply the existence of, distinct underlying memory systems. However, the distinction seems to be consistent with recent neuroimaging evidence. On the one hand, event segmentation processes have been shown to involve a network of brain regions that include right posterior frontal cortex and a collection of regions in extrastriate visual cortex, including temporal, occipital, and parietal areas (Zacks and Swallow 2007; Zacks et al. 2001). On the other hand, episodic recall seem to involve a core set of brain regions within the default network that includes medial prefrontal, medial-temporal, parietal regions, the lateral prefrontal cortex and the occipital cortex (Buckner and Carroll 2007; Hassabis and Maguire 2007; Spreng et al. 2009). It is an open empirical question how distinct these two systems are and how much they overlap.

5 Solving the puzzle

This paper began with a puzzle that arose from a tension between two views about the status of episodic memory when considered from the comparative perspective. One of these, the WWW view, held that clear analogies to episodic memory exist in primates and other species. The other, mental time travel theory, held that episodic memory is a uniquely human capacity with no counterpart in other animals.

The dual systems thesis provides a solution to this puzzle. It shows that both views contain a kernel of truth, when we carefully distinguish two components of the memory system at issue. Consider the two comparative questions posed earlier. First, are there analogies of episodic memory in primates and other animals, as supposed by the WWW view? According to the dual systems thesis, the answer to this question is, indeed, yes. Event segmentation capacities dedicated to short-term record of progress in current context and tasks, including processes for learning from repeated experi-

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ences, are likely to be found in other animals. Even though event segmentation tasks have not been employed in other animals yet, there is good evidence that other animals have memories of events in context (Gaffan 1994; Mercado et al. 1999; Schwartz et al. 2003). However, the similarity ends with event memory : the other process involved in personally experienced memories is missing in other species. Thus other animals lack a narrative binding process that fits the description of episodic memory, which contains organizational components such as to link multiple events into a temporal sequence, to establish causal relations between pairs of events, and to ascribe goal status to a particular event, and use this as the focal point of the memory representation.[3] Although some nonhuman animals show sensitivity to temporal information (e.g. Clayton and Dickinson 1998; Babb and Crystal 2006), it is debated whether this amounts to an ability to temporally sequence events into before/after relations (McCormack and Hoerl 2011; Roberts and Feeney 2009). Moreover, even our primate cousins have very limited causal understanding and none seem to understand the behavior of others in terms of intentions or goals (Povinelli 2000; Penn and Povinelli 2007; Penn et al. 2008; Visalberghi and Tomasello 1998; Tomasello et al. 2005).

This leads to the second comparative question: is episodic memory unique to human beings, as supposed by mental time travel theory? According to the dual systems thesis, the answer to this question is, again, yes. Only humans have the narrative binding capacity to bind event segments into a retrievable whole to form this particular type of memory. However, those who subscribe to mental time travel theory see episodic memory as a specifically human guidance system. This is only half the story, given event memories also allow most species including humans to operate effectively in their environment day-by-day. Moreover, proponents of mental time travel theory also see a major role for episodic memory in prospection by mentally traveling into the past and into the future and planning accordingly. There is no basis to rule out the role of event memory and scripts in short term action guidance. Although this type of guidance does not require mental time travel or even conscious attention, it nonetheless provides perhaps the most useful means to effectively deal with day-to-day tasks and frequently repeated events. Furthermore, once we recognize the role of narratives in episodic memory, there is an array of socio-cognitive functions that episodic memory can serve, besides prospection.

The dual systems thesis can also offer new insights into the phenomenological aspects of episodic memory. According to the mental time travel theory, the defining feature of episodic recollection is autonoetic consciousness (Tulving 1985), the ability to relive subjective experiences with a sense of self that is extended in time. Only autonoetic experience is assumed to be capable of providing the subjective requirements for mental time travel (Suddendorf and Corballis 1997; Tulving 2005). According to Klein (2013, 2014), autonoetic awareness is distinct from the memory content and comes into play during retrieval. In his view, the connection of a current mental state with a past experience gives rise to autonoetic awareness during retrieval.

[3] Even though narrative capacities are closely related to linguistic capacities in humans, a narrative need not be based on language. Silent movies, picture books, comic strips are all examples of non-linguistic narratives. Testing narrative skills need not require linguistic skills either. Picture sequencing or re-enactment tasks are used to test narrative skills of young children.

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A number of prominent philosophers argue that the portions of human consciousness beyond the purely somatic—self-awareness, self-understanding, and self-knowledge—are products of personal narratives (e.g., Dennett 1992; Flanagan 1992; Schechtman 1996; Velleman 2005). Human beings unify and organize their experiences by situating actions, motivations, desires, goals, values, character traits so on and so forth in narratives that trace their origins and plot their development. These narrative constructions allow a new type of consciousness to emerge, i.e. an awareness of the narrative self extended over time. The narrative self maintains coherence in the present and provides a continuous mental representation of the self over time. It is an open question whether autonoetic consciousness involved in episodic recall is the awareness of the narrative self that results from unifying and organizing experiences in a life narrative.

The ability to construct and relive narratives could well be the vehicle for mental time travel. Narrative, like mental time travel, is a re-experience device. In narratives, people experience a simulated reality and feel real emotions in response to the conflicts and relationships of story characters (Oatley 1995). This vicarious form of involvement has been referred to as *absorption* (Graesser 1981) or *transportation* (Green and Brock 2000). Transportation is characterized by a nearly complete focusing of attention, vicariously experiencing the narrator's emotions, and an automaticity that reflects our propensity for processing narratives (Bower et al. 1979; Graesser 1981; Mandler and Johnson 1977). In the case of episodic recall, narrative transports one to a past experience rather than a fictional world and thereby provides one the ability to mentally travel back in time.

6 Conclusion

The dual systems thesis provides a resolution to the controversy between the WWW view and mental time travel theory by offering a dual systems model for personally experienced memories. Each view gets half the story right, but needs to acknowledge the other half. The dual systems thesis also supports the controversial claim that episodic memory is uniquely human, but provides new grounds on which to rest that claim.

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Compliance with ethical standards

Conflict of Interest The author declares that he has no conflict of interest.

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