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Episodic memories

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ABSTRACT

An account of episodic memories is developed that focuses on the types of knowledge they represent, their properties, and the functions they might serve. It is proposed that episodic memories consist of *episodic elements*, summary records of experience often in the form of visual images, associated to a *conceptual frame* that provides a conceptual context. Episodic memories are embedded in a more complex conceptual system in which they can become the basis of autobiographical memories. However, the function of episodic memories is to keep a record of progress with short-term goals and access to most episodic memories is lost soon after their formation. Finally, it is suggested that developmentally episodic memories form the basis of the conceptual system and it is from sets of episodic memories that early non-verbal conceptual knowledge is abstracted.

Tulving's concept of *episodic memory* is principally about a type of *memory system* (Tulving, 1983, 1985a). Understanding episodic memory as a system is unquestionably important (Schacter & Tulving, 1994). There are, however, other valuable questions that can be asked here too and some of these relate to episodic memories *as memories*. That is, as mental representations with distinct properties, organization in long-term memory, and which are manifest in particular brain circuits. These features are considered in the sections that follow, in the spirit of Tulving (1983), and they lead to proposals about the ontogeny and phylogeny of episodic memory more generally.

1. Properties of episodic memories

Table 1 lists nine properties of episodic memories that collectively distinguish them from other types of memory representations. Note that, it is the combination of these features that are proposed as defining. Other types of long-term memory representations may feature one or several of the properties but only episodic memories have all nine properties. These properties are now considered in further detail, as are some of the issues they raise for the study of episodic memories.

The first property in Table 1 captures the idea that episodic memories are *summary* records of experience. That is to say that they are experience-near and correspond to experience but they are not literal records of experience. In certain special cases, memory for highly self-relevant self-defining moments for instance, they may contain fragments that are close to being literal, veridical, records of experience. Something like this appears to occur in, for example, memory for trauma, (see Holmes, Grey, & Young, 2005) when highly specific details are retained. These can take various forms, for example a vivid recollection of the texture of the material on a car door that a road traffic accident victim looked down on to avoid witnessing the head on impact of an oncoming vehicle, a blue flash of light when an electric cable snapped as a train derailed, the thought a person had during a traffic accident, and so on (see Conway, Meares, & Standart, 2004). Some caution must be exercised here as it is also the case where such details can be incorrect too – the only point is that some are correct and appear to be very close to actual experience, they can also cause an intense feeling of reliving when brought into consciousness. Vivid details like these are also often reported for less traumatic but nonetheless highly personally important self-defining experiences and for memories of significant public events, so called 'flashbulb' memories (see Conway, 2005; Conway & Pleydell-Pearce, 2000; Conway, Singer, & Tagini, 2004, for reviews). Again, these too may not always derive from external experience and, as with all episodic memories, they are also associated with more conceptual knowledge. In general, however, it is suggested that episodic information is more summarized and generic, more *representative* of an experience than it is a literal record. This proposal raises interesting questions that research has yet to address. For instance, how is experiential processing transformed into episodic information? I think it fair to note that currently we have very little idea, and even less evidence, about how this transformation takes place. Baddeley's (2001) notion of an episodic buffer in working memory constitutes one promising approach to this question. Another thinking about the role of hippocampal processes in configuring knowledge and generating

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Table 1
Nine properties of episodic memories.

1. Contain summary records of sensory-perceptual-conceptual-affective processing.
2. Retain patterns of activation/inhibition over long periods.
3. Often represented in the form of (visual) images.
4. They always have a perspective (field or observer).
5. Represent short time slices of experience.
6. They are represented on a temporal dimension roughly in order of occurrence.
7. They are subject to rapid forgetting.
8. They make autobiographical remembering specific.
9. They are recollectively experienced when accessed.

associations (Squire, 1992) is also highly relevant. Nevertheless exactly how knowledge is extracted from experience and represented in an episodic memory is unknown (but see Moscovitch, 1995, for an particularly interesting account). Although it seems that in everyday experience this is a largely non-conscious process and not within intentional control.

Interestingly, much the same might be said about property two in Table 1 which focuses on the fact that once an episodic memory is formed, episodic information (episodic detail) within the memory is differentially accessible. Racsmany and Conway (2006) developed this idea in a series of experiments that showed that items that were inhibited and therefore difficult to access were only inhibited in an episodic memory of their acquisition. The same items if accessed in conceptual, non-episodic, representations were either not inhibited or were primed. Thus, somewhat paradoxically the same item can be simultaneously inhibited (in it's representation in an episodic memory) and primed (in it's representation in conceptual knowledge structures). This pattern was termed *episodic inhibition*. Episodic inhibition captures the idea that in any episodic memory there is a pattern of activation/inhibition over the contents of the memory and it is this pattern that determines the accessibility of episodic details: inhibited details are difficult to access and activated details have their access facilitated. The activation/inhibition levels of details in an episodic memory are probably determined by many factors, although we have suggested that the goal structure of an experience may be critical in that it drives attention, action, and affect, and must thereby influence encoding processes, cf. Conway (2005). Indeed, one of the main functions of episodic memories might be to keep a highly specific record of aspects of experience relevant to recent goal processing (Brewer & Dupree, 1983; Lichtenstein & Brewer, 1980; Williams, Conway, & Baddeley, 2008). Being able to remember in a relevant way, rather than literally, what has been recently said and/or done is critical to focussed and fluent everyday cognition and action: exactly the type of relatively routine daily behaviour that patients with, for example, anterograde amnesia can find so difficult. Details in an episodic memory are then at different levels of accessibility. Some of these levels will be preset by encoding others will emerge over repeated episodes of accessing a memory and yet others will be determined the nature of the search and cues that feature in it. A question of considerable interest here is: What in memory represents the boundaries of an episodic memory? Indeed, boundaries must be especially important as they separate memories into discrete entities and because of that are, presumably, highly available. Unfortunately relatively little is known about this (see Williams et al., 2008, for some recent findings).

Properties 3, 4, and 5 in Table 1 concern the nature of episodic memories. It has long been known that episodic memories are dominated by imagery and particularly by visual imagery (Brewer, 1988; Galton, 1883). Indeed, brain damage that leads to the loss of the ability to generate visual images may as a secondary consequence give rise to retrograde amnesia (Conway, 1996, 2005; Rubin & Greenberg, 1998). This type of retrograde amnesia is marked by a lack of specificity in memory although more general knowledge of the patient's life is often retained (Conway, 1996, 2005). Visual images contain information that is configural. That is to say that the objects represented in a visual image are represented in relation to each other and because of this visual images may maximize the amount of information they contain (Conway, 1988). The contents of a visual episodic image may be highly sensitive to visual cues that can activate the image, either by some direct mapping from cue to image content or, perhaps, by some mapping onto relations configured in the image. As visual processing is so central to human cognition it follows that visual episodic images are probably being accessed a great deal of the time (although they do not necessarily enter conscious awareness) and are generally highly responsive to visual cues.

Interestingly, it seems that visual episodic memories always have a perspective. This was first noticed by Henri and Henri (1898), further developed by Freud (1915), and reintroduced into modern memory research by Nigro and Neisser (1983); see too (McIsaac & Eich, 2002; Robinson & Swanson, 1993). In the modern parlance memories are said to have a 'field' or an 'observer' perspective (Nigro & Neisser, 1983). A visual episodic memory with a field perspective is considered to preserve a person's original perspective or something approximating to that perspective. In contrast in a visual episodic memory with an observer perspective the rememberer looks into the memory and sees themselves in the memory. Although systematic properties of field and observer memories have been investigated, for example field memories have been found to be more strongly associated with recollective experience than observer memories (Libby & Eibach, 2002; McIsaac & Eich, 2002), and recent memories are more likely than older memories to be retrieved with a field perspective (Robinson & Swanson, 1993), there remain interesting aspects of episodic perspective yet to be investigated. In our laboratory for instance we have often asked our participants when they reported observer memories: what do you look like? The answers are surprisingly varied. For memories from childhood a representation of themselves from a photograph is often reported or a sort of stereotyped image is described. For memories some years old but not from childhood the image of the self in observer memories is frequently a generic image rather than a specific image from a unique moment. For more recent memories the images of the self in a memory are more frequently episodic than generic. In contrast we found field perspective to be less varied. It seems, as Freud (1915) originally noted, that the observer perspective in an episodic memory indicates more memory construction and the incorporation of other knowledge into an episodic memory. That this appears to occur for older compared to recent memories perhaps indicates a slow integration of episodic memories with more generic and conceptual autobiographical knowledge.

Episodic memories, especially visual episodic memories, represent short time slices of experience (Anderson & Conway, 1993; Neisser & Harsch, 1992; Williams et al., 2008). It is, however, neither known how this occurs nor what the nature of these time slices is. We have proposed that the boundaries of episodic memories are marked at the opening boundary by information about actions and at the closing boundary by facts that are often details about the outcomes of actions (Williams et al., 2008). This is consistent with our more general view that episodic memory and autobiographical knowledge are about goals. That is to say they preserve information that is highly relevant to goal processing including goal generation, plan execution, outcomes and evaluations (for related views see Brewer & Dupree, 1983; Lichtenstein & Brewer, 1980). We have suggested that one function of episodic memories is to provide a means to accurately check on recent progress with current goals, i.e. in the preceding few minutes, hours, days, or last few days. In providing this detailed record of progress with very specific goals episodic memory also forms the basis for future goals and plan-implementation. Tulving (2002) has pointed to the impor-

tant role of episodic memory in underpinning goals and plans for the future and how these fail in anterograde amnesics who cannot retain episodic memories. It is an aspect of episodic memory generally and specific episodic memories in particular that remains under-investigated.

Finally, and briefly, consider the last four properties in Table 1. The notion of temporal order is hardly a new one in the study of episodic memory and indeed an early and simple model of random access memory was able to show how temporal order can be retrieved even from a relatively unsophisticated system (Landauer, 1975; see Kahana, Howard, & Polyn, 2008 for a recent review). The ability to recall the day's events, in backward and/or forward order, may well be a key cognitive ability that underlies coherent planning and goal pursuit. The preservation of temporal order in episodic memory may then be especially important. One aspect of this that has not been investigated is the feelings of beforeness and afterness that preservation of temporal order may support. Feelings ultimately about the direction of time that must also include at least an anticipatory sense of the immediate future. It is interesting that patients with, for instance, closed head injuries and wide spread brain damage often complain of losing feelings like these (we refer to them as *cognitive feelings* see Conway, 2005) and because of that are disoriented in time.

The temporal dimension in episodic memory extends then both backward and forward in time and we have recently termed this the *remembering-imaging window* (Conway, in press). The idea partly derives from the observation that in terms of brain activations remembering and imaging barely differ (Conway, Pleydell-Pearce, Whitecross, & Sharpe, 2003; Schacter & Addis, 2007). Thus, remembering the past and imaging the future take place in the same system, a system we might call the *remembering-imaging system.* The notion of a remembering-imaging 'window' relates to work currently ongoing in our laboratory in which participants list as many specific memories as they can for yesterday, 2 days ago, 3 days ago, and so on for several more days. There is a steady decrease in the number of memories listed with increasing retention interval and, interestingly, at about the 3-day retention interval and further back memories appear that are not specific but instead are more general, more generic, and much more concerned with routines and schema than with specific episodic memories although, of course, some of these persist. The same participants then also list, day-by-day, specific events they plausibly expect to occur in their lives over the next 5-day period. A similar pattern is observed and the number of specific events listed decreases day-by-day and after about the 2/3 day mark there is a sharp rise in listings of routine schematic events. Some specific anticipated events do of course appear at later points but these are not numerous. This then is the remembering-imaging window in which specific memories for recent experiences and anticipated future experiences constitute a window of episodic consciousness that functions to keep us tightly connected to our current goals and plans.

Despite the importance of episodic memories in preserving temporal order and, possibly, supporting our feelings of beforeness, afterness, nowness, and anticipation of the future, episodic memories do not endure for lengthy periods of time in long-term memory. It is clear that many episodic memories from a single day can be recalled at the end of the day. But as the retention interval increases access to many of these memories is rapidly lost. Few episodic memories can be recalled, even of a distinctive day, at a retention interval of one week and of a mundane routine day virtually none (Williams et al., 2008). This process of rapid forgetting, although first reported over a century ago by Ebbinghaus (1885/1964) is one of the under-investigated properties for episodic memories of everyday events. Recent work in our laboratory using a portable camera worn around the neck that automatically takes photographs in response to sensory changes, e.g. in movement, luminance, etc., suggests that the many episodic memories formed in a typical day are not themselves lost and can often be accessed using sequences of photographs from the camera (Berry et al., 2007; Loveday & Conway, 2008; St.Jacques, Conway, Lowder, & Cabeza, 2009). This raises the fascinating prospect of large numbers of long-lasting but inaccessible episodic memories enduring in long-term memory, perhaps across the full lifespan. The potential of such large sets of inaccessible, but available, episodic memories to have what might be quite powerful implicit effects, is intriguing. It perhaps suggests too, that give sufficiently effective cues it might be possible reinstate, at least partly, a previous window of remembering-imaging.

Finally with respect to Table 1 consider the role of episodic memories in providing memory specificity and in triggering recollective experience (properties 8 and 9). Memory specificity is interesting. Why should we have specific memories when surely a general knowledge of the world and some generic recollection of the past would almost certainly be sufficient to ensure survival? If one function of episodic memories is to keep an adaptive record of recent goal processing so that progress with goals can be readily assessed then clearly episodic memories need to be specific enough to provide the appropriate information. Hence, perhaps, the high degree of specificity that they have in the short-term at least. I suggested that only a relatively small proportion of episodic memories remains accessible in long-term memory and perhaps this is because of their relevance to longer-term goals and consequently to the future. It is particularly noteworthy that clinically depressed patients who have over-general memories (lack of normal access to specific episodic memories) also have over-general futures that lack specificity in plans and goals (see Williams et al., 2007, for a review). It may be that for plans and goals to be specific they have to be grounded in specific episodic memories of both the past and the future.

A further factor driving the long-term retention of specific episodic memories relates to their role in learning and the acquisition of knowledge. In the main anterograde amnesics who apparently no longer have accessible episodic memories also show major impairments in learning and especially in the acquisition of new knowledge. Although it appears that some greatly reduced acquisition of new knowledge, for example new words does take place it is, nonetheless, not even remotely close to the levels and extent of acquisition of new knowledge present when episodic memory is intact. To-be-sure, there are certain individuals with extensively reduced hippocampal volume and abnormal episodic memory whose learning can approach normal levels (Vargha-Khadem et al., 1997). In all these cases it seems likely that there is residual functioning hippocampal circuitry that supports some, usually very little, knowledge acquisition (Squire, 1992). Or possibly these low levels of learning are mediated by other areas of brain that can support in a minor way some hippocampal functions. There is, however, evidence that episodic memories are crucial in the acquisition of new knowledge and learners may pass through a phase during which knowledge is gradually abstracted from episodic memories in the process of becoming part of more general long-term conceptual knowledge (Conway, Gardiner, Perfect, Anderson, & Cohen, 1997). Indeed, episodic memories may remain closely associated with some long-term conceptual knowledge (Conway, 1990; Westmacott & Moscovitch, 2003), although the more usual case is that as conceptual knowledge is acquired access to memories of moments when the knowledge was first processed is rapidly lost. The suggestion is then that episodic memories are the basis of concept acquisition and may be especially critical when new knowledge is to be acquired. This proposal raises interesting questions about the development of memory and these are returned to later.

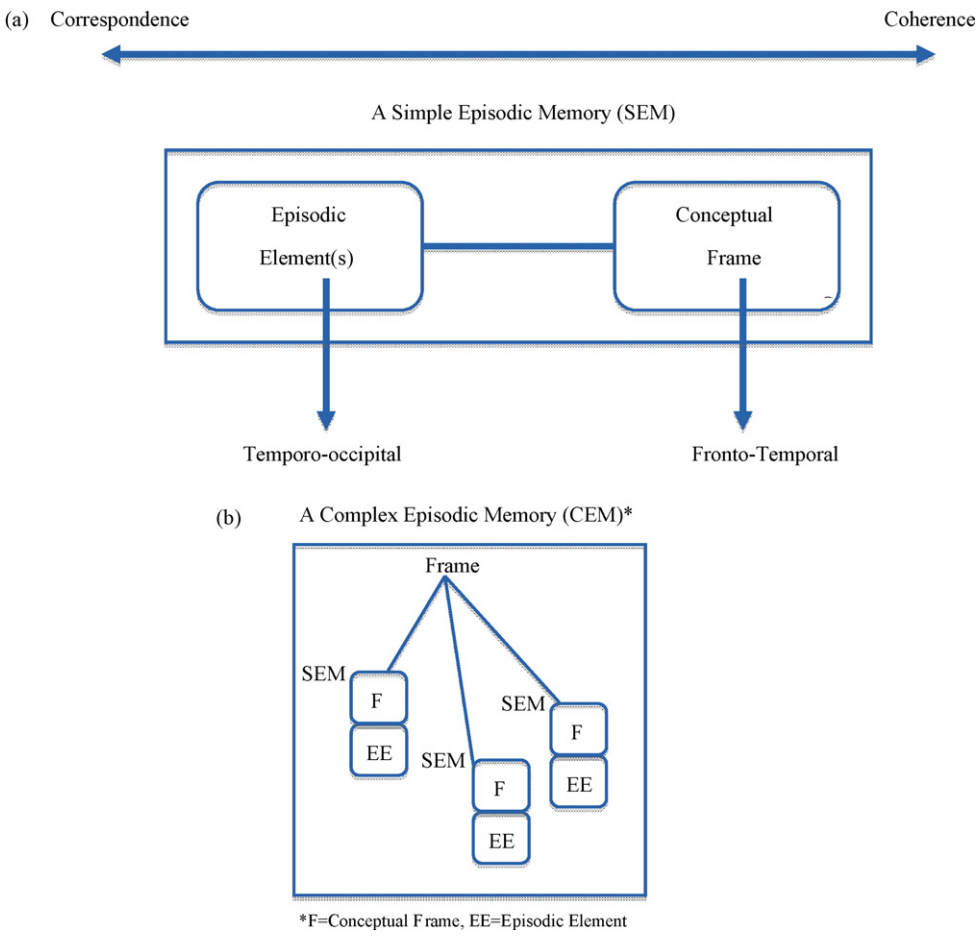


Fig. 1. Simple and complex episodic memories.

2. Organization of episodic memories

The idea that episodic memories are stored in memory in a way that preserves the temporal dimension was introduced above. But this temporal organization cannot be long-lasting, especially as access to so many initially formed episodic memories is lost within a few days of formation. Moreover, there is little evidence of the retention of detailed and specific temporal organization of episodic memories in long-term memory. Instead, the organization of those episodic memories access to which is maintained appears to be conceptual and reflect their integration with long-term autobiographical knowledge structures. In this section I propose one way in which episodic memories might be organized in long-term memory, after they have been successfully integrated with existing knowledge structures or have formed the basis of the generation of new knowledge structures. In this scheme there are three types of representations: *episodic elements*[1] *(EEs), simple episodic memories (SEMs),* and *complex episodic memories (CEMs).*

Episodic elements are the most event-specific, most experience-near representations in long-term memory. They are often in the form of visual images (which may be the main representational format of episodic memories) and they represent moments of experience or summaries of moments of experience, particularly and perhaps exclusively moments of conscious experience (see Moscovitch, 1995) or moments of 'now' (Stern, 2004). Importantly, EEs are usually in a *frame*.[2] A frame is conceived of as conceptual contextualizing knowledge that organizes either a single EE or more usually a set of EEs. Fig. 1, top panel 1a, depicts this basic organizational unit which according to the present account, constitutes a *simple episodic memory*. Thus, SEMs are EEs plus a frame. According to this view there are two ways to access a SEM, either by a cue that corresponds in some way to the content of EEs or by a cue that accesses the frame. Intentional access of a SEM will usually be through the frame, incidental access usually through EEs, although given an effective cue access, intentionally or incidentally could be through either type of episodic knowledge or, perhaps, both in parallel.[3]

Episodic elements without a frame may correspond to what Tulving (1983), termed 'free radicals' in memory, memory for jokes for example. Images and very early memories from childhood may also consist of EEs that have no frames or very simplified frames, e.g. "my first memory". More importantly, in psychological illnesses dysfunctional memory processes may lead to SEMs in which access to the SEM frame is lost but the EEs remain highly activated and intrude into consciousness. Indeed, something like this may lie at the heart of memory dysfunction in posttraumatic stress disorder, PTSD, (see Brewin & Holmes, 2003, for a recent review). Morrison

[1] A term deliberately chosen because of its reference to Tulving's seminal book, *Elements of Episodic Memory* (1983). But note that Tulving's concern was with the elements of an episodic *memory system* and not, as here, with elements of episodic representations.

[2] The term 'frame' is similar in conception to the notion of a 'frame' introduced by Minsky (1975).

[3] Note the parallel here between the proposed architecture of SEMs and the Headed Records Framework of Morton, Hammersley, and Bekerian (1985). SEMs can be thought of as a type of headed record.

(2004) described the interesting case of a patient with a morbid fear of white vans and a psychotic belief that he would be abducted and assaulted in such a vehicle. His delusion included intrusive and intense visual images of the feared event. In treatment it became evident that he had in fact experienced such an event and that his images most probably derived from a memory of the assault. The patient himself was unable to comprehend that his images were in fact memories. In a similar manner Day, Holmes, and Hackmann (2004), describe an agrophobic patient who feared being somehow sucked into the open bench freezers in supermarkets and dragged under the bags of frozen foods. This patient too was unable to connect her phobic imagery with a vivid memory of a drowning incident from her youth.

Images in psychological illness and, perhaps, more generally in cognition clearly must have a source and one possibility is that some images are in fact EEs although the individual may be unaware of this, because the SEM frame has not been accessed. More generally, however, attenuated access occurs for EEs rather than for the SEM frame that may remain accessible long after access to the EEs it contextualizes has been lost. The over-general memories of depressed patients are one extreme example of this but the same may occur over long retention intervals and more widely in old age, cf. Levine, Svoboda, Hay, Winocur, and Moscovitch (2002). Loss of specificity in memory is loss of access to EEs *with* retention of access to a SEM frame. A common example in our laboratory is the participant who recalls taking part in an experiment last year but cannot recall any more about it.

Fig. 1a also depicts the relation of SEM content to the correspondence-coherence dimension (see Conway, 2005). Episodic elements correspond to experience more or less directly, whereas the conceptual frame locates the EEs in a particular memory structure and is, therefore, more concerned with coherence than correspondence. The conceptual frame is then a type of *interpretation* of the EEs that provides them with a personal meaning. Because of this the conceptual frame is viewed as originating from conceptual processing systems in fronto-temporal regions of the brain. Episodic elements are viewed as the product of temporo-occipital networks. Some intriguing evidence suggests that EEs may be stored in these more posterior regions and conceptual frames in the more anterior networks. It has been found for example that patients with damage to posterior regions who lose the ability to generate visual images may as a secondary consequence develop amnesia in which general personal conceptual knowledge is retained while access to EEs is lost (Conway, 1996; Conway & Fthenaki, 2000; Rubin & Greenberg, 1998). Amnesia resulting from other types of brain injury, e.g. to limbic system structures, may also lead to the loss of access to EEs with preservation of access to some general personal knowledge. Taken together these data suggest that SEMs are distributed in fairly complex ways over anterior-posterior memory networks – a finding further supported by many neuroimaging studies (see Cabeza & St Jacques, 2007, for a review, note that the temporal pole may be a particularly significant site for this type of personal conceptual knowledge).

One important property of SEMs is that they represent comparatively short time slices (see Table 1) and any SEM will only feature a limited number of EEs. Just how many EEs will feature on average in a typical SEM is unknown but some evidence is suggestive. For instance, memories of single occurrence traumatic events have been found to feature only about three to five highly vivid details (Holmes et al., 2005). On the other hand memory for one's journey to work, sampled on arrival at work, contains about 7–9 details on average (Williams et al., 2008). Clearly, the number of EEs in a SEM will vary with the nature of the experience, it's self-relevance, and other factors too. Nonetheless, it is proposed that SEMs organize a limited number of EEs, possibly numbered in single figures for many everyday events. Memory for experience is, however, more complicated than this and consequently SEMs themselves may be organized into *complex episodic memories* or CEMs. Complex episodic memories consist of one or more SEMs associated with a common higher order conceptual frame as shown in Fig. 1b. Thus, an everyday event such as a *day at work* will be represented by several SEMs, e.g. images of a project meeting, talking with colleagues at coffee, organizing a meeting, lunch, etc.

Episodic memory as a memory system contains then a variety of representations. Very specific representations of moments of experience, EEs, are records of sensory-perceptual-conceptual-affective processing that are featured in an experience (see Racsmany & Conway, 2006, for further discussion). These EEs may be summary or representative samples of experience. For instance, a person who studied a categorized list of words might subsequently retain some summary information, *some of the words named fruits*, and perhaps the activation levels of the names of specific fruits would in the EE be determined by processes occurring during study. Added to this might be the conceptual frame *studying words I have to remember* and the EE with frame would then form a SEM. Several SEMs associated with this experience might have been constructed, possibly related to points in goal processing, e.g., switching from learning to remembering and these might be associated with a common higher order conceptual frame or CEM which in this example might be *when I was in Mihaly and Martin's experiment*. Importantly uncontextualized EEs are also possible as are conceptual frames with no accessible EEs or SEMs.

The foregoing discussion presented what is essentially an encoding account of the formation of episodic memories and there can be no doubt that encoding and the environment in which it takes place is critical to the formation of episodic memories – after all this is just what anterograde amnesic cannot do. Nonetheless, retrieval too may help shape episodic memories and influence their integration with long-term autobiographical memory knowledge structures. Accessing SEMs and CEMs may raise their accessibility and accessing their content may act to make some details more accessible than others. Another consequence of accessing some EEs in, for example, a SEM may be (episodic) inhibition of associated EEs that compete for retrieval and in this way a pattern of activation/inhibition over the content of a SEM may be shaped by retrieval/rehearsal. The same process of episodic inhibition could, of course, function at higher levels making some SEMs, CEMs, and other autobiographical knowledge structures differentially accessible. Racsmany and Conway (2006) propose that over time the pattern of activation in a SEM becomes fixed and difficult to change. A potent cue corresponding to some aspect of an EE in a SEM might overcome lowered accessibility and lead to what might be termed a 'Proustian moment'. In general, however, as the retention interval lengthens and as selective rehearsal continues, driven by the stable pattern of activation/inhibition over the contents of a SEM or CEM, the probability of finding a sufficiently specific cue, one that could perhaps reinstate some previous processing state, decreases even possibly to asymptotic levels. By this view although some, may be many, EEs and other types of knowledge become in effect inaccessible they are not lost from long-term memory and remain, in theory at least, available. The effects of retrieval, especially repeated retrieval (rehearsal) are then to shape episodic memory and autobiographical knowledge into patterns of accessibility, ranging from the highly accessible to the inaccessible (but still available).

Episodic knowledge has also, however, to become integrated with autobiographical knowledge if intentionally driven access to it is to be established and subsequently maintained. Episodic knowledge that does not become integrated, 'free radicals' for instance, can only be accessed by a cue that corresponds in some way to the content or features of the episodic knowledge, e.g. a cue that maps onto the content of an EE. Fig. 2 illustrates the integration of episodic memory with autobiographical memory and the self (see Conway,

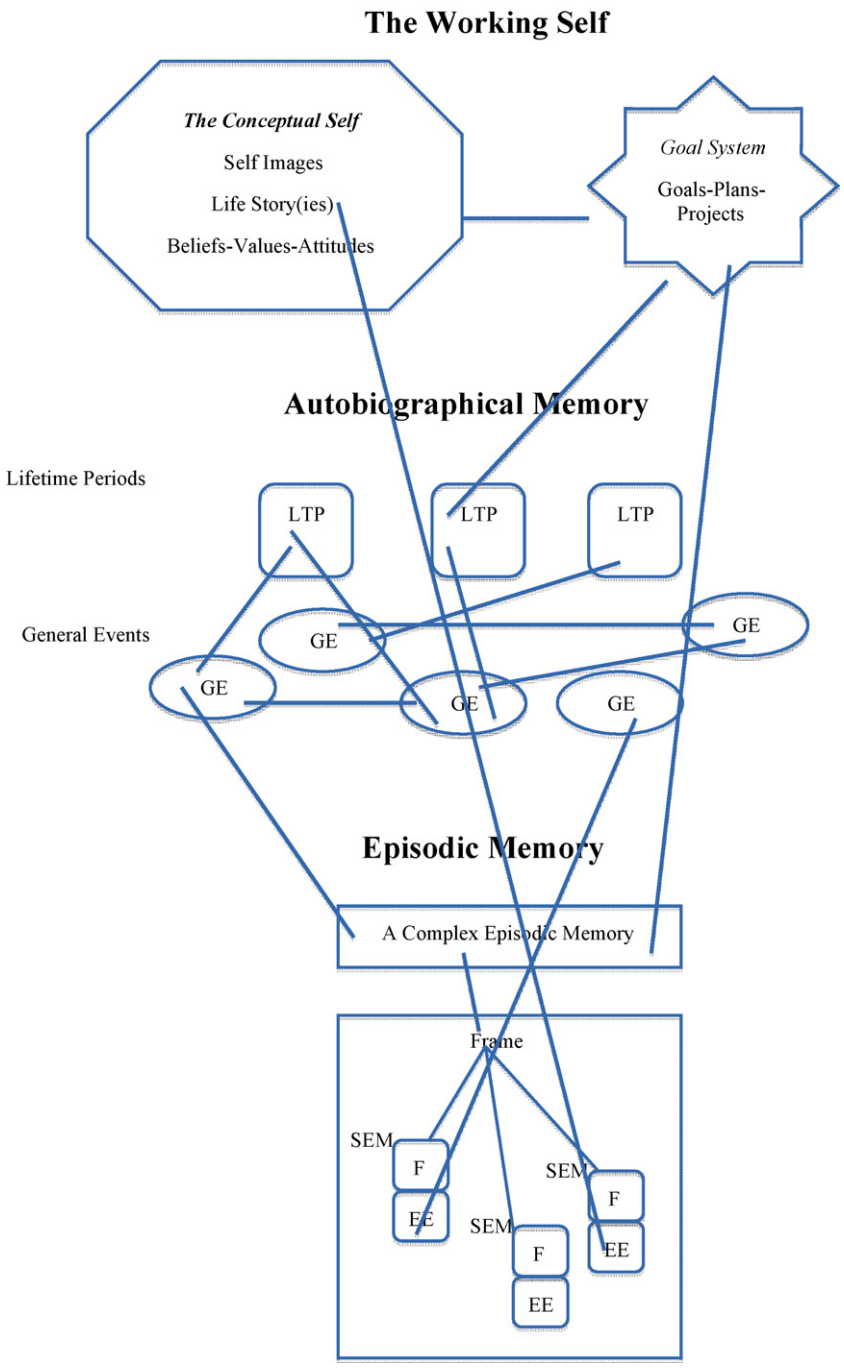
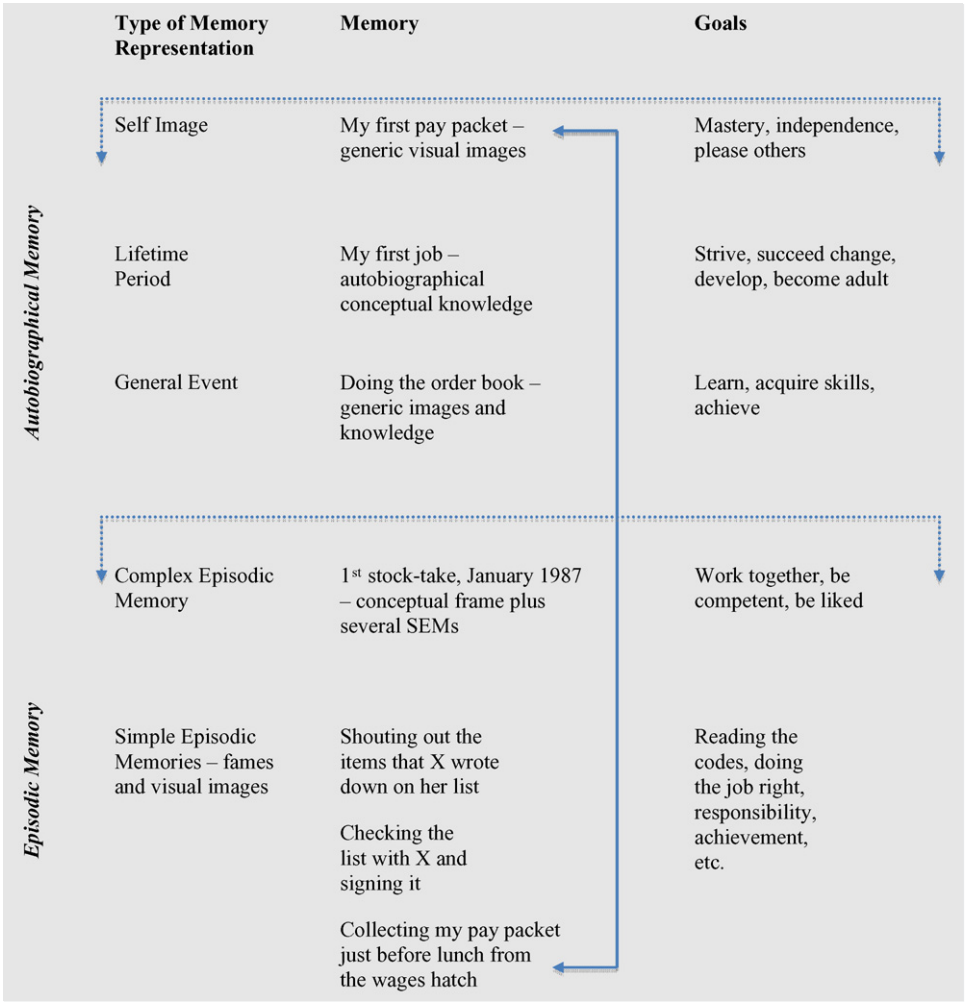


Fig. 2. The embedding of episodic memories in autobiographical memory knowledge structures.

2005, for a more detailed overview of this model and also Conway & Pleydell-Pearce, 2000, and Conway, Singer, et al., 2004; and for related views on the integration of memory and the self see Levine et al., 1998; Rosenbaum, McKinnon, Levine, & Moscovitch, 2004). The central idea behind Fig. 2 is that autobiographical knowledge (depicted under the title 'autobiographical memory' in Fig. 2) forms the conceptual context for episodic memories. While, in turn, the conceptual self forms the conceptual context for autobiographical knowledge. These knowledge domains are hierarchical and nested within each other by 'part-of' relations. A SEM is part-of a CEM, which is part-of a general event which is part-of a lifetime period, which is part-of the conceptual self. Knowledge structures in the autobiographical knowledge base are *partonomic knowledge hierarchies* (Barsalou, 1988; Conway & Bekerian, 1987). There are two principle forms of access to representations in this system: either by activation traversing the part-of indices of the autobiographical knowledge structures or by a cue directly activating the content of a representation (generative and direct access – Conway, 1992, 1996; Moscovitch, 1995).

Also shown in Fig. 2 is a depiction of the goal system. Conway, Meares, et al. (2004) and Conway, Singer, et al. (2004) review this aspect of the autobiographical memory framework in detail. The goal system is considered to influence all aspects of autobiographical memory and, indeed, autobiographical memory as a whole can be thought of as a record of the goal system and a basis for further goal generation. Episodic memories (SEMs and CEMs) are initially a record of short-term goal processing or rather the effects or outcomes of short-term goal processing. As consolidation takes

Table 2
Autobiographical representations, memories (SEMs and CEMs), and goals.



place, perhaps in part stimulated by retrieval, some episodic memories become integrated with autobiographical memory knowledge structures and access to them then becomes long-term. Autobiographical memory knowledge structures are essentially about long-term goals and they provide a basis for the generation of coherent long-term goals and plans, goals and plans that extend beyond a few days. Episodic memories are particularly important because they provide the most specific evidence (images derived from experience) about recent goal processing and because of this specificity they can constrain and channel subsequent goals. A specific visual image of sending off a recently completed piece of writing may be part-of the complex long-term goal of *writing a book*. This image provides the evidence, the data, that certain sub-goals have been completed or satisfied.

Episodic images and the memories they form are in a sense part of the language of goals. However, as sub-goals are completed access to the EEs contained in goal-associated episodic memories may be gradually lost leaving, perhaps, only access to the conceptual frame. Similarly as higher order goals are completed access to SEMs and CEMs may too be gradually lost. In contrast, some EEs may have a special status and provide specificity for self-images. This is shown in Fig. 2 and also Table 2 in which a SEM provides visual images that form the basis of a self-image. Self-images are images of the self in the past and/or future and they serve to provide specific content to more abstract summary aspects of the goals of the self. In Table 2 EEs from a SEM become directly associated with a self-image representing complex and fundamental goals of the self. Episodic elements have then as a key property the ability to attach to and provide specificity, for conceptual frames. By this view they are fundamental memory representations. Indeed, they may be one of the fundamental units of the cognitive system as a whole.

3. The development of episodic remembering

Episodic elements are formed outside conscious awareness and their formation is not within intentional control. One possibility is that hippocampal networks mediate the formation of episodic elements and their connection to a conceptual frame, although networks in other brains regions, fronto-temporal for example, may also influence the establishment of conceptual frames. An interesting question that then arises is: how can EEs be associated with conceptual frames in an infant's memory? One answer to this is that the ability to form EEs is hard-wired and functioning prior to birth. Conceptual knowledge is abstracted from EEs. By this view, which admittedly runs counter to one current view of the development of memory (Fivush & Nelson, 2004), EEs which are non-verbal and sensory-perceptual-affective in nature form the basis of the conceptual system. Episodic elements formed close together in time and sharing some common content might be grouped together in memory and other processes may then generate a more abstract, conceptual, frame for these developmentally early sets of EEs (see

Singer & Conway, 2008). This view of the development of conceptual knowledge derives from a developmental theory originally proposed by Nelson (Nelson, 1974; 1974, see too Markman, 1991, for related suggestions). Nelson proposed that for the infant in the process of acquiring vocabulary, single words initially refer to events. For example, when the mother rolls the ball to the child and says 'ball' then the word 'ball' is taken by the infant to refer to the whole event and not just the object. In this way early episodic memories become associated with specific words. As memories accrue in which the same or similar words occur but the memories themselves differ, for example the ball rolled on the carpet versus the ball rolled on the grass, then the referent of the word narrows from whole episode to a detail of an episode. At some point the word itself must become attached to a conceptual, rather than episodic, representation in long-term memory. This shift from initial reliance on episodic memories to conceptual knowledge has been identified in adult learning too where it also appears to occur over a period measured in months, at least for complex sets of knowledge (Conway et al., 1997). It can occur more rapidly for simple lists of items (Dewhurst, Conway, & Brandt, 2008). The shift from episodic memory to conceptual knowledge may then be a general feature of the acquisition of new knowledge.

Exactly how conceptual knowledge is abstracted from episodic memories is not known but two possibilities mentioned earlier are as follows. The first is as stated above and in line with Nelson's (1974) original suggestion. Episodic elements are isolated and associated together to form a basic, non-episodic representation of the item. Language may play an important role in this. A second, and perhaps more fundamental and earlier process is that sensory-perceptual-affective EEs automatically formed by hippocampal processes are grouped together in long-term memory. This might be on the basis of, for example, temporal association, e.g. contiguity (Kahana et al., 2008) such that all the EEs formed in some set period of time are grouped together to form a proto-SEM lacking a conceptual frame (and for that reason not retrievable by the adult). Possibly another basic and additional form of grouping of these early preverbal EEs is in terms of similarity of sensory-perceptual-affective content. Contiguity and similarity might then lead to the formation of proto-SEMs that later, as language acquisition takes places and more delineated conceptual knowledge forms, begin to acquire their conceptual frames and become full SEMs and, later, CEMs.

In this way conceptual knowledge might gradually emerge from what are in essence non-conceptual episodic memories. But as conceptual knowledge emerges it will, of course, in turn be represented in episodic memories in both EEs and as conceptual frames. Thus, episodic memories develop from sensory-perceptual-affective representations to sensory-perceptual-affective-conceptual representations in the older child and adult. This developmental change must occur throughout infancy but possibly accelerates with what has been termed the formation of the *cognitive self* at about 24 months (Howe & Courage, 1997; Howe, Courage, & Rooksby, in press). A period that also features the emergence of language and, presumably, the emergence of more complex cognitive representations in the form of mental models that underlie increasingly complex linguistic processes. Indeed, SEMs and CEMs are types of mental models of the past.

Finally, consider an account of the evolution of episodic memories. It has been proposed that the main function of episodic memories is to keep a record of recent goal processing. In essence to allow a rememberer to easily recall where they currently are in goal space and so execute adaptive self-initiated actions. Episodic memories may have what Conway (2005) termed *adaptive correspondence*. That is, although episodic memories can only represent experience, and usually in a summary form, the knowledge episodic memories contain has to be to at least some extent of adaptive value i.e. it must some of the time correspond to reality.[4] Because of its adaptive value the ability to episodically remember may be species wide (note that this runs counter to Tulving, 2002, who argued that episodic memory is a uniquely human ability). It is proposed that sensory-perceptual-affective episodic memories (the sort of episodic memories that human neonates and young infants might have) are formed by many species, not just humans, and that episodic memory is itself an evolutionary solution to the problem of knowing where one is in current goal-space. However, the major difference between human episodic memory and episodic memory in other species is the embedding of episodic memory in a highly complex conceptual system. Other species may also develop some limited generic knowledge in which some of their episodic memories are embedded but they do not develop the complex conceptual network that constitutes an autobiographical memory (see Fig. 2). One prediction that follows from this reasoning is that in species where episodic memory is not embedded in a conceptual system access to many episodic memories will be lost soon after their formation (perhaps within 24 h) and further access will be highly cue-dependent.

4. Summary

I have presented a view of episodic memories that highlights their possible nature and functions. It is a view that proposes that episodic memories developmentally form the basis of the conceptual system in which they are embedded and which in turn they come to represent. The function of episodic memories is to provide a basis for the adaptive pursuit of short-term goals. Access to episodic memories is lost fairly quickly but if a memory or set of memories become integrated with the conceptual system, particularly that part of it that represents autobiographical knowledge (see Fig. 2), then access may be maintained over long periods of time. By this view episodic memory is a species wide adaptation and the main differentiating feature of human episodic memory is its embedding in a complex personal conceptual system (see Fig. 2). Essentially, we have autobiographical memories and other species do not. Some of these proposals run counter to those of Tulving; they were, however, inspired by his theoretical thinking (especially Tulving, 1983) which made them possible. I agree with Tulving (2002) that episodic memory, and episodic memories, are a 'marvel of nature' and they are a marvel that memory research must come to understand.

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[4] Perhaps another adaptive function is that of imaging, imaging, for example, what may occur in the future and what that might be like (from the past).

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