



Episodic autobiographical memories over the course of time: Cognitive, neuropsychological and neuroimaging findings

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ABSTRACT

The critical attributes of episodic memory are self, auto-noetic consciousness and subjectively sensed time. The aim of this paper is to present a theoretical overview of our already published researches into the nature of episodic memory over the course of time. We have developed a new method of assessing *autobiographical* memory (TEMPau task), which is specially designed to measure these specific aspects, based on the sense of re-experiencing events from across the entire lifespan. Based on our findings of cognitive, neuropsychological and neuroimaging studies, new insights into episodic autobiographical memories are presented, focusing on the effects of age of the subjects interacting with time interval in healthy subjects and lesioned patients. The multifaceted and complex nature of episodic memory is emphasized and it is suggested that mental time travel through subjective time, which allows individuals to re-experience specific past events through a feeling of self-awareness, is the last feature of autobiographical memory to become fully operational in development and the first feature to go in aging and most amnesias. Our findings highlight the critical role of frontotemporal areas in constructive autobiographical memory processes, and especially hippocampus, in re-experiencing episodic details from the recent or more distant past.

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“Yesterday evening, as I was taking a solitary walk . . . ; I was roused from my thoughts by the warbling of a thrush perched on the uppermost branch of a birch. At that very instant, its magic notes conjured up images of the family estate . . . suddenly transported back into the past, I gazed once more upon the countryside where I had so often heard the thrush’s song. When I listened to it then, I was as sad as I am now.” (Chateaubriand, *Mémoire d’outre tombe* [Memoirs from beyond the tomb], 1848)

1. The concept of lifelong episodic autobiographical memory

In previous centuries, philosophers and psychologists regarded memory as a power of the mind responsible for our self-identity (e.g. James, 1890; Locke, 1690). It was a unique property, as illustrated by Théodule Ribot (1881): “I have made the journey from Paris to Brest a hundred times. All these images overlap to form an unclear mass—a single, vague state, if the truth be told. Of all these journeys, only those connected to some important event, be

it happy or unfortunate, appear to me as memories: only those that arouse secondary states of consciousness are situated in time.” In the same vein, James (1890) emphasized that “memory requires more than mere dating of a fact in the past. It must be dated in *my* past. In other words, I must think that I directly experienced its occurrence. It must have that “warmth and intimacy” . . . as characterizing all experiences “appropriated” by the thinker as his own” (volume I, p. 650). This view closely parallels current conceptions of episodic memory, placing an emphasis on the subjective recollective experience and on pastness. The ambition of this paper is to present a theoretical overview into the multifaceted and complex nature of episodic memory emphasizing its temporal complexity, i.e. changes with the age of subjects, interacting with the age of memories, based on our already published researches in terms of cognitive, neuropsychological, and functional neuroimaging approaches.

According to its most recent definition, episodic memory refers to personal events recollected in the context of a particular time and place – the “what”, “where” and “when” – and with some reference to oneself as a participant in the episode (Tulving, 1985, 2001, 2002). With the development of the theory of episodic memory, the essence of this memory system has shifted away from specificity and towards the phenomenal experience of remembering (Brewer, 1996; Baddeley, 2001; Gardiner, 2001; Tulving, 2001,

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2002; Wheeler, Stuss, & Tulving, 1997). As such, it encompasses perceptual, affective and spatiotemporal contextual details, and gives the rememberer the feeling that a representation is the recollection of an event belonging to his or her personal past. Although this memory system contrasts with semantic memory, its operations rely on, but go beyond, the semantic memory system. Episodic and semantic memory systems are associated with two distinct states of consciousness: auto-noetic and noetic consciousness. Auto-noetic consciousness, which is a *sine qua non* of episodic memory, is defined by a sense of self in time and the mental reliving of subjective experiences arising from the encoding context. Hence, based on a combination of self, auto-noetic consciousness and subjectively sensed time, episodic memory makes it possible to travel mentally through subjective time, from present to past, and thus to recollect, one's own previous experiences via auto-noetic consciousness. The central tenet of this theory therefore revolves around phenomenological re-experiencing and the sense of self in time. The neural bases of episodic memory and auto-noetic consciousness are thought to be subserved primarily by the prefrontal cortex, but also by the medial temporal lobe (Tulving & Markowitsch, 1998; Vargha-Khadem et al., 1997). By contrast, semantic memory is associated with noetic consciousness, which denotes the subject's ability to be aware of information about the world in the absence of any remembering, and is subserved by a broad set of neocortical areas (including frontal, temporal and occipital cortices).

As episodic memory refers to events recollected in the context of a particular time and place, and with a degree of autobiographical reference, autobiographical memory (AM) has long been regarded as being episodic in nature. Moreover, autobiographical memory gives researchers the opportunity to study episodic memory using self-relevant material that is more closely related to the current definition of episodic memory (Tulving, 2001, 2002) than that used in most standard tests of episodic memory (Piolino, 2008). The latter rarely make a distinction between the different components (content and context) of episodic memory and do not measure very lengthy retention intervals, autobiographical references or rich phenomenological and idiosyncratic aspects of memory. Interestingly, the assessment of autobiographical memory makes it possible to investigate not only the ability to recall a specific and meaningful personal event, locating it in time and space, but also the ability to travel back into the past and relive specific details of that event which distinguish it from any similar ones. However, as has so often happened in the history of memory conceptions (Baddeley, 2001; Scoville & Milner, 1957), neuropsychological examinations of patients have proved to be an additional source of evidence. Drawing on their pioneering study of the amnesic patient KC, Tulving, Schacter, McLachlan and Moscovitch (Tulving, Schacter, McLachlan, & Moscovitch, 1988; see Rosenbaum et al., 2005, for a review) were among the first to propose a clear distinction between the episodic component of AM (disturbed in KC), containing personal specific events situated in time and space, and a semantic component (preserved in KC), storing general knowledge about one's past, such as the names of acquaintances, personal addresses, generic events and self-concept (Tulving, 1993). This study provided evidence that people can gain mental access to their personal past not only through auto-noetic remembering but also through just knowing. Accordingly, semantic memory includes not only general information about the world, but also knowledge about previous personal events and experiences that one can no longer remember. More recently, Conway, Singer, and Tagini (2004) claimed that the retrieval of autobiographical memories depends on a complex, self-driven set of control processes and involves the episodic memory system, which contains event-specific sensory-perceptual-cognitive-affective details, and the long-term semantic self, which contains more abstract autobiographical knowledge (i.e. generic events and conceptual

knowledge). Therefore, autobiographical memory is now recognized as being multifaceted, containing a body of general knowledge, as well as unique experiences specific to an individual, which have been accumulated since childhood, and which allow him/her to construct a feeling of identity and continuity (Conway & Pleydell-Pearce, 2000; Piolino, Desgranges, & Eustache, 2000; Wilson & Ross, 2003). When it comes to the relationship between self and memory, Tulving's conception emphasizes the episodic aspects of the self, defending the role of a phenomenological self in the construction and maintenance of subjective continuity in time and personal identity.

The episodic component of AM contains specific personal events, with phenomenological details situated in time and space pertaining to one's self, and presupposes very lengthy retention intervals. Its essence lies in the auto-noetic state of consciousness, which enables a personal event to be consciously recollected in its original encoding context and implies mental time travel. Episodic AMs have several core characteristics: they not only concern unique, personal events situated in time and space, but also presuppose phenomenological details (i.e. perceptual, cognitive, affective internal contextual details), self-relevance, the conscious recollection of these events and the rememberer's personal perspective (Brewer, 1996). Visual mental imagery and emotional experience are critical phenomenological characteristics of episodic AM retrieval. Hence, the subjective sense of remembering almost invariably involves some sort of visual (Greenberg & Rubin, 2003) and emotional (Rubin & Berntsen, 2003) re-experiencing of an event. Unlike episodic AM, the semantic component of AM is characterized by a noetic state of consciousness, in which one is capable of retrieving general facts about personal events, but not of re-experiencing specific contexts. Therefore, not all memories that are autobiographical have an auto-noetic character mediated by the episodic memory system.

One of the most interesting current debates about episodic memory revolves around whether and how memories change over time. One of the merits of AM studies is that they have painted a much more dynamic picture of memory consolidation, storage and retrieval than strictly "experimental" studies, i.e. those in the Ebbinghaus tradition. There is a strong body of evidence that, rather than being only determined by the length of the retention interval, the distribution of episodic AMs across a long lifespan reflects the survival of vivid memories from late adolescence and early adulthood compared with other remote periods – the so-called reminiscence bump (Rubin, Wetzler, & Nebes, 1986; Rubin & Schulkind, 1997; Rubin, Rahhal, & Poon, 1998) – which represents a potent landmark for the current self (Conway & Pleydell-Pearce, 2000), serving to maintain a sense of identity and continuity in the present. Furthermore, with the passage of time and the repetition of similar events in the phenomenal experience of remembering real-world events, there is a shift away from auto-noetic consciousness and towards noetic consciousness, i.e. from episodic to semantic memory (Conway, Gardiner, Perfect, Anderson, & Cohen, 1997; Robinson & Swanson, 1993). This shift is in line with the idea that most features of very long-term memories become semanticized over time (Cermak, 1984), becoming a mixture of semantic knowledge and specific experiences (see also Piolino, Lamidey, Desgranges, & Eustache, 2007; Westmacott & Moscovitch, 2003 for an illustration of this concept in the recollection of names of contemporary celebrities). The nature of AM retrieval and conscious experience depends on the ratio of episodic to semantic elements (see Cabeza & St Jacques, 2007, for a similar view). It has been postulated that the loss of episodic details and the emergence of a conceptual organization cause a "Remember-to-Know" shift over time, as a result of repeated encounters with similar events. It is worth noting that repetition has been shown to influence autobiographical recollection, whether it be "internal" repetition (thinking

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