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Prospective memory and mesial temporal epilepsy associated with hippocampal sclerosis

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Abstract

Episodic memory impairment is commonly observed in patients with epilepsy associated with mesial temporal sclerosis (MTS). Prospective memory (PM) is a set cognitive abilities that allow future performance of a present intention, in response to time- or event-based evocation cues, that trigger the intended action at the appropriate time. PM has not been evaluated in mesial temporal sclerosis. We evaluated the role of right and left hippocampal lesions on performance in both the retrospective and prospective PM components in patients with epilepsy secondary to mesial temporal sclerosis and correlated with performance in traditional neuropsychological tests, as well as with self-perception of memory impairment. We tested the hypotheses that a hippocampal lesion impacts on the prospective components of PM, and that a left-sided lesion had a greater impact on performance in the prospective component of PM than a right-sided lesion. We evaluated PM in 26 patients with right MTS, 22 left MTS patients, and 26 age–gender and education matched controls. The prospective component of PM was impaired in both patient groups, with both a lesion (patients performed significantly worse in the PM battery) and laterality effect (left MTS patients performed significantly worse than right MTS patients in the PM battery). Performance in the prospective component of the PM battery correlated with long-term delay performance in episodic verbal memory and self-perception of memory impairment in the left MTS group. The retrospective component was impaired in left MTS patients. Impaired performance was not accounted for solely by depression, anxiety or an antiepileptic drug effect. We conclude that mesial temporal lobe structures, including the hippocampus, play an important role in both the prospective and retrospective components of PM processes in tasks involving long delay intervals.
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1. Introduction

Prospective memory (PM) is a set cognitive abilities that allow future performance of a present intention, in response to time- or event-based evocation cues that trigger the intended action, at the appropriate time. PM plays a role in short-term tasks, such as boiling water for tea, in long-term episodic tasks, such as remembering to give someone a message on a future occasion, as well as in repetitive routine activities, such as daily remembering to take medications at night before going to sleep. PM tasks require cessation of ongoing activities to allow accomplishment of the desired task (Graf & Uttl, 2001).

The evocation context consists of both a series of representations (places, people, objects, etc.) and their relation in a precise context, such as remembering to post a letter in the mailbox (object), the following morning (time), near one's office (place). The specific evocation context is determined by the previously determined combined set. Evocation can be triggered by any of elements. Evocation cues are determined when future intentions are created and are required for accomplishment of a non-routine action. The initial planning process determines number and strength of cues (Burgess & Shallice, 1997; Shallice, 1996).

Successful accomplishment of the desired task depends on both a prospective and a retrospective components, or, remembering that one needs to do something, at the appropriate time, in response to a precise stimulus (prospective component), and to remember what to do (retrospective component) (Burgess & Shallice, 1997). The prospective component relies

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heavily on attentional-executive processes, dependent on a large subcortical–frontal network, while the retrospective component relies on long-term memory processes, which depend on mesial temporal and other limbic structures. Contrary to episodic memory testing, PM tasks require the action be carried out spontaneously. The action cannot be set at an "evocation mode" by the examiner (Einstein et al., 2005). Although in usual daily activities, both prospective and retrospective components can affect PM performance, in testing conditions the role of each component in performance can, to a certain extent, be teased out (McDaniel & Einstein, 2007).

PM memory performance may be influenced by event or time-based processes. These processes are mediated by both a subcortical–frontal–parietal network (that regulates attentional-executive functions), as well as by a limbic-hippocampal memory network.

Event-based recall depends on the association between the desired action and a trigger target event. The future identification of a target event or a sense of familiarity will serve as a trigger to activate the original plan that leads to initiation of the desired action, in a fast and automatic process that requires few cognitive resources. The recall degree will depend on the extent and strength of the initial processing. This process should depend more heavily on the limbic-hippocampal memory network (spontaneous recall model) (Einstein & McDaniel, 1996; Einstein et al., 2005; Kliegel, Guynn, & Zimmer, 2007; McDaniel & Einstein, 2000; McDaniel, Guynn, Einstein, & Breneiser, 2004).

Event-based performance may be also influenced by attentional-executive function, related to subcortical–frontal–parietal network, that plays a role on environmental monitoring for target events (monitoring model) (Smith, 2003). Due to multiple demands, prospective memory must rely on a flexible recall system and both monitoring and spontaneous recall may trigger prospective remembering (multiple processes theory) (Einstein et al., 2005; McDaniel & Einstein, 2000, 2007; McDaniel et al., 2004; McGann, Ellis, & Milne, 2002).

Time-based recall relies on an internally generated task to be carried out in the appropriate context. Time-based involves active monitoring of time, environment and the plan (Henry, MacLeod, Phillips, & Crawford, 2004). This process depends on the attentional-executive function, related to subcortical–frontal–parietal network, especially in short intervals that rely more heavily on working memory processes (Brown, 1990; Mimura, Kinsbourne, & O'Connor, 2000). Also, both right and left mesial temporal structures have been shown to play a role in the accuracy of prospective temporal judgments, in intervals exceeding working memory function (Noulhiane, Pouthas, Hasboun, Baulac, & Samson, 2007). Thus, longer time intervals may place a stronger burden on the limbic-hippocampal memory network, in time- and event-based tasks.

Functional neuroimaging studies have shown consistent activation of the prefrontal and parietal cortices, as well as of the hippocampal formation, in episodic memory tasks (Vincent et al., 2006), and also in short-term PM tasks. Functional neuroimaging studies in PM show that maintenance of the intention depends on prefrontal, lateral frontal and inferior parietal cortex activation (Burgess, Scott, & Frith, 2003; Okuda et al., 2007; Simons, Schölvinck, Gilbert, Frith, & Burgess, 2006). Left parahippocampal gyrus activation relates to stimulus novelty. Midline frontal activation may be involved in divided attention between carrying out the intended plan and interruption of an ongoing activity (Okuda et al., 1998). Precuneus activation occurs in expectation to a PM task and thalamic activation occurs as the action is carried out (Burgess, Quayle, & Frith, 2001).

Functional neuroimaging studies of PM provide limited information, since they fail to evaluate PM long-term tasks, more representative of usual daily activities (Burgess et al., 2003; Einstein, McDaniel, Smith, & Shaw, 1998; Okuda et al., 2007; Simons et al., 2006).

PM mechanisms have been studied in young and older healthy subjects, as well as in Alzheimer's, head trauma and multiple sclerosis patients (Dricoll, McDaniel, & Guynn, 2005; Fortin, Godbout, & Braun, 2002; Groot, Wilson, Evans, & Watson, 2002; Maylor, Smith, Della Salla, & Logie, 2002; Rendell, Jensen, & Henry, 2007). Temporal lobe structures are required to recall the content of the PM task (retrospective component) (Umeda, Nagumo, & Kato, 2006), but the role of these structures in the prospective PM component is still poorly understood. Bilateral 20–30% hippocampus volume reduction determined impaired performance in both episodic and PM testing, while 8–9% hippocampal volume loss was associated with PM impairment and route planning difficulty (Isaacs et al., 2003).

Hippocampal sclerosis refers to a relatively homogeneous lesion, that involves variable degrees of selective neuronal loss in the CA1, CA3 and CA4 hippocampal regions, with variable involvement of the amygdala and parahippocampal gyrus. Hippocampal or mesial temporal sclerosis is diagnosed by typical MRI findings of hippocampal volume loss on T1 weighted images and increased signal in the hippocampus on T2 weighted and FLAIR images, with a variable degree of involvement of the amygdala and parahippocampal gyrus. It is associated with an early precipitating insult, such as a complicated febrile seizure, usually before age three. This is followed by a silent period, during which histologic and functional changes occur in these structures, leading to a complex neurobehavioral syndrome that usually manifests later in childhood or adolescence. Temporal lobe epilepsy usually presents with medically refractory complex partial seizures, refractory to polytherapy with antiepileptic drugs. Cognitive impairment involving episodic and semantic memory, and, to a lesser extent executive functions is commonly observed in this patient population. Episodic and semantic memory impairment is more pronounced in dominant hemisphere hippocampal sclerosis lesions (Alessio et al., 2006; Engel & Pedley, 1998).

Based on the following assumptions:

(A) both left and right hippocampi play a role in time-based prospective memory tasks exceeding working memory function;

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