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Hippocampus and epilepsy

The hippocampus: A central node in a large-scale brain network for memory

L'hippocampe : au centre d'un large réseau cérébral pour la mémoire

J. Huijgen [a,b,c], *S. Samson* [a,d,*]

[a] *EA 4072, laboratoire PSITEC, équipe « Neuropsychologie: Audition, Cognition, Action », université de Lille, rue Émile-Laine, 59037 Lille, France*
[b] *Centre de neuro-imagerie de recherche (CENIR), groupe hospitalier de la Pitié-Salpêtrière, 47, boulevard de l'Hôpital, 75013 Paris, France*
[c] *Centre de recherche de l'institut du cerveau et de la moelle épinière (CRICM), UPMC-UMR 7225 CNRS – UMRS 975 Inserm, 47, boulevard de l'Hôpital, 75013 Paris, France*
[d] *Unité d'épilepsie, groupe hospitalier de la Pitié-Salpêtrière, 47-83, boulevard de l'Hôpital, 75013 Paris, France*

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ABSTRACT

The medial temporal lobe is a key region in the formation and consolidation of conscious or declarative memories. In this review, we will first consider the role of the hippocampus and its surrounding medial temporal lobe structures in recognition memory from a historical perspective. According to the dual process model of recognition memory, recognition judgments can be based on the recollection of details about previous presented stimuli or on the feeling of familiarity. Studies in humans, primates and rodents suggest that the hippocampus, the parahippocampal cortex and the perirhinal cortex play different roles in recollection and familiarity. Then, we will describe the role of the hippocampus and neocortex in memory consolidation: a process in which novel memories become integrated into long-term memory. After presenting possible mechanisms underlying sleep-dependent declarative memory consolidation, we will discuss the phenomenon of accelerated long-term forgetting. This type of memory deficit is often observed in epileptic patients with a hippocampal lesion, and provides a novel opportunity to investigate post-encoding and memory consolidation processes.

RÉSUMÉ

Le lobe temporal médial est une région essentielle à la formation et à la consolidation des souvenirs conscients ou déclaratifs. Dans cette revue, nous allons d'abord retracer le rôle de l'hippocampe et des structures adjacentes du lobe temporal médian dans la reconnaissance

* *Corresponding author.* Département de psychologie, université de Lille (EA4559), BP 60149, 59653 Villeneuve-d'Ascq cedex, France.
E-mail address: severine.samson@univ-lille3.fr (S. Samson).
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selon une perspective historique. Selon le modèle à double processus de la mémoire, les jugements de reconnaissance peuvent être basés sur le souvenir des détails de l'évènement précédemment vécu ou sur un sentiment de familiarité. Les études menées chez l'humain, le primate et le rongeur suggèrent que l'hippocampe, le cortex parahippocampique et le cortex périrhinal seraient différemment impliqués dans la récollection et la familiarité. Puis, nous décrirons le rôle de l'hippocampe et du néocortex dans la consolidation mnésique, processus par lequel les nouveaux souvenirs sont intégrés en mémoire à long terme. Après avoir présenté les mécanismes possibles de la consolidation en mémoire déclarative dépendant du sommeil, nous discuterons de l'oubli accéléré à long terme. Ce type de déficit mnésique, souvent observé chez les patients épileptiques présentant une lésion de l'hippocampe, fournit l'opportunité d'examiner les processus post-encodages de consolidation en mémoire.

The medial temporal lobe (MTL) is an essential structure in the formation of long-term declarative memory [1,2]. This memory circuitry comprises multiple regions, including the hippocampus and the parahippocampal gyrus, which is composed of the parahippocampal, perirhinal and the entorhinal cortex [3–6] (Fig. 1). This latter cortical region is the main relay between hippocampus and neocortex [4,7–9]. According to Tulving [10], declarative long-term memory can be divided into memories of general facts (i.e. semantic memory) and memories related to specific personal experiences or events (i.e. episodic memory). This type of memory can be contrasted with non-declarative memory abilities such as procedural or skill learning, perceptual memory (i.e. priming) and simple forms of conditioning [11]. In human neuropsychology, declarative memory has typically been tested with recall or recognition memory paradigms. Whereas recall requires the generation of a verbal or non-verbal response to retrieve information that has been previously encoded, recognition is based on a judgment to determine whether or not a particular stimulus (i.e. word, object, spatial location) has been presented before (yes/no response). Retrieval processes involved in recognition memory paradigms are less contaminated by executive frontal lobe functions (i.e. strategy elaboration, initiation of a response) than retrieval processes involved in recall memory. Therefore, recent advances in our understanding of the role of the MTL structures in declarative memory have resulted from studies using recognition memory paradigms.

According to the dual process model of recognition memory, two types of retrieval processes can support recognition judgments: familiarity and recollection. The distinction can be illustrated with the common experience of recognizing a song on the radio but not being able to recollect specific information about the artist, the title of the song or where you heard it before. On the other hand, some songs may have a particular meaning for the listener and can elicit a full explicit recollection including vivid images of when you heard the song on the day of your marriage together with detailed information about the band, such as the name of the band members and where they come from. This example demonstrates that memory judgments can be based either on recollection of specific information about a previous event or on assessment of stimulus familiarity [12]. Currently, there is a debate about how the MTL contributes to recollection or familiarity processes, with some scientists claiming that the different MTL regions are equally important for both processes [13] and others suggesting that specific and distinct MTL regions contribute to a particular retrieval process [14]. To investigate the role of the hippocampus and its surrounding regions in memory, we will first present a short overview on the role of the MTL in recognition memory (see [15] for an extensive recent review). We will then discuss the cerebral bases of memory consolidation and the contribution of sleep to hippocampal-dependent declarative memory consolidation, a mechanism allowing fresh memories to become integrated into long-term memory [16]. Finally, we will present the recently described phenomenon of accelerated long-term forgetting (ALF), which is characterized by abnormal rapid forgetting over hours to weeks despite apparent normal learning and initial retention at short delays. This type of memory deficit, which often goes undetected in patients with MTL dysfunction (temporal lobe epilepsy, early stage of Alzheimer disease), provides a novel opportunity to investigate post-encoding or memory consolidation processes.

1. Recognition memory and the medial temporal lobe: a historical perspective

In 1950, Karl Lashley wrote an influential paper in which he concluded that learning and memory were equally supported by all parts of the brain [17]. A few years later, this vision was drastically changed based on Milner's seminal work in patients who had undergone unilateral anterior temporal lobe removal for the surgical treatment of pharmacologically intractable temporal lobe epilepsy. By comparing patients with a ''small'' (in which the hippocampus was spared or slightly removed), or a ''large'' MTL resection (in which most of the hippocampus was removed), Brenda Milner and her team showed that both the lateralization and the size of the hippocampal lesion influence memory abilities. These findings illustrated material-specific memory disorders that vary as a function of the side of hippocampal lesion [18–20]. They found that anterior temporal lobe resection, in the dominant hemisphere for speech (generally the left), selectively impairs memory for verbal material (i.e. word list, story, easily labelled objects). Conversely, a corresponding removal from the non-dominant hemisphere (generally the right) impairs memory