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Slow wave sleep and recollection in recognition memory

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Abstract

Recognition memory performance reflects two distinct memory processes: a conscious process of recollection, which allows remembering specific details of a previous event, and familiarity, which emerges in the absence of any conscious information about the context in which the event occurred. Slow wave sleep (SWS) and rapid eye movement (REM) sleep are differentially involved in the consolidation of different types of memory. The study assessed the effects of SWS and REM sleep on recollection, by means of the "remember"/"know" paradigm. Subjects studied three blocks of 12 words before a 3-h retention interval filled with SWS, REM sleep or wakefulness, placed between 3 a.m. and 6 a.m. Afterwards, recognition and recollection were tested. Recollection was higher after a retention interval rich in SWS than after a retention interval rich in REM sleep or filled with wakefulness. The results suggest that SWS facilitates the process of recollection in recognition memory.

Keywords: Slow wave sleep; REM sleep; Recognition memory; Recollection

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1. Introduction

Numerous experiments involving animals and humans have shown that REM sleep is involved in learning and memory consolidation (Maquet et al., 2003; Peigneux, Laureys, Delbeuck, & Maquet, 2001 for reviews). Recent studies have revealed that SWS may also play a role in memory. In humans, behavioural studies have suggested that declarative memory consolidation is SWS-dependent (Peigneux et al., 2001; Rauchs, Desgranges, Foret, & Eustache, 2005; Smith, 2001 for reviews).

Ekstrand and colleagues introduced a technique for analyzing the effects of specific types of sleep on memory processes (Barrett & Ekstrand, 1972; Ekstrand, Barrett, West, & Maier, 1977; Yaroush, Sullivan, & Ekstrand, 1971) by comparing retention rates following a sleep episode in the early part of nocturnal sleep and a sleep episode placed in the latter part of sleep. Indeed, it is well known that SWS dominates the first

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half of the night ("early" sleep) while REM sleep is predominant in the second half of the night ("late" sleep). More recently, Plihal and Born (1997, 1999a) used this technique to study the effects of sleep on declarative and non-declarative memory. They showed that episodic recall of paired-associate word lists and spatial memory were improved by "early sleep" which contains an important proportion of SWS whereas procedural memory was improved by "late sleep" which contains an important proportion of REM sleep. Using the same paradigm than Plihal and Born (1997, 1999a), Drosopoulos, Wagner, and Born (2005) found that "early sleep" improved temporal episodic memory. However, some old studies found a beneficial of REM sleep for the recall of short stories (Tilley & Empson, 1978) or of words belonging to different semantic categories (Tilley, 1981) as well as for consolidation of declarative memory for highly emotional material (Wagner, Gais, & Born, 2001). In contrast, some studies found no differential effect of SWS and REM sleep on declarative memory (Cipolli & Salzarulo, 1979). More recently, Ficca, Lombardo, Rossi, and Salzarulo (2000) showed that recall of pairs of unrelated words is impaired after fragmented sleep leading to sleep cycle disorganisation but not after fragmented sleep without sleep cycles disorganisation. These data suggest that the role of sleep cycle organisation, i.e., the NREM-REM alternation, is critical for recall of verbal material, rather than of a specific sleep state. In the same way, some studies indicate that procedural visual discrimination learning depends on the contribution of both SWS and REM sleep (Gais, Plihal, Wagner, & Born, 2000; Stickgold, Whidbee, Schirmer, Patel, & Hobson, 2000). In addition some studies pointed to the correlation between motor skill learning and stage 2 amount, which is a direct function of total sleep time and, to a larger extent, reflects the global quality of sleep, particularly a regular alternation of deep sleep and REM sleep (Smith & McNeill, 1994; Walker, Brakefield, Morgan, Hobson, & Stickgold, 2002). In this study, we were interested in the role of SWS on recollection.

Memory consists of several systems and processes. In the case of declarative memory, it has been shown that recognition reflects two distinct memory processes, known as recollection and familiarity, as attested by numerous cognitive, neuropsychological, and neuroimaging studies (Düzel, Yonelinas, & Mangun, 1997; Tulving, 1995; Yonelinas, Shaw, & Rugg, 2005; for a review see Yonelinas, 2002). Recollection allows us to remember specific details of the context in which stimuli were experienced previously. On the other hand, memory performance is said to rely on familiarity if stimuli thought to have been experienced previously do not evoke any recollection of specific details about the processing episode. These two processes depend on distinct neural substrates. Recollection requires the involvement of the hippocampus to access specific information, such as spatial and temporal information associated with the presentation of the item during learning. Familiarity relies on regions surrounding the hippocampus, such as the parahippocampus gyrus (Aggleton & Brown, 1999; Eldridge, Knowlton, Furmanski, Bookheimer, & Engel, 2000; Knowlton, 1998; Tulving & Markowitsch, 1998; Yonelinas et al., 2005). Some authors (Tulving, 1985) argue that the distinction between recollection and familiarity reflects the episodic (recollection) vs. semantic (familiarity) distinction in declarative memory, although other interpretations exist (for review, see Yonelinas, 2002). Thus, if SWS facilitates episodic memory, one can predict that recollection will be improved by SWS.

In order to assess the effects of SWS and REM sleep on memory, we placed the learning and test phases before and after either a wakefulness period or a period dominated by SWS or REM sleep, in line with Yaroush et al. (1971). In the latter's design, the SWS retention interval was located at 11 p.m.–2 a.m. and the REM retention interval at 3 a.m.–6 a.m., i.e., at different circadian phases (Ekstrand et al., 1977; Plihal & Born, 1997, 1999a). To control for the circadian influence on learning, recall, and retention, we decided to place the learning and recall phases at the same circadian times—the late part of the night, as suggested by Barrett and Ekstrand (1972). The retention interval was 2.50 a.m.–6.50 a.m. in all experimental conditions and was filled with wakefulness, SWS or REM sleep.

2. Materials and methods

2.1. Subjects

Thirty-two healthy young subjects (20–30 years; 9 men, 23 women) took part to the study. They were all good sleepers with no history of sleep disturbance or shift-working. They were free from medication and drugs. There were no pronounced morning or evening types (mean 50 ± 1.5; Horne & Östberg, 1976). During