Evidence for a role of sleep in forgetting of irrelevant information: a fMRI study.

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Introduction: Numerous studies have shown that sleep favours memory consolidation [1]. However, some authors proposed that sleep may also help to forget irrelevant information [2]. To test this hypothesis, we investigated the effect of sleep and sleep deprivation on memory performance using the directed forgetting (DF) paradigm. DF refers to the ability to intentionally forget irrelevant information for the ongoing task.

Methods: 26 young healthy subjects (11 males, 15 females, mean age: 23.1 ± 2.7 years) performed an item procedure DF task. During the encoding phase, words were presented during 1 s and were immediately followed by the instruction "to be remembered (TBR)" or "to be forgotten (TBF)" during 3 s. At the end of learning, subjects were randomly divided in two groups whether they slept (Sleep group, n = 14) or not (Sleep-deprived group, n = 12) during the first post-learning night. Memory performance was assessed after two recovery nights using a recognition task, consisting in the presentation of words that subjects have to categorize as previously encountered (whatever the instruction furnished) or not. The DF effect is observed when performance for TBR items is better than for TBF ones. fMRI data were acquired during both encoding and recognition using a 3T scanner (Siemens Allegra; 32 slices, voxel size:3.4x3.4x3, TR:2130ms). Data were analyzed using SPM5.

Results: A repeated measures ANOVA (with group as between subject factor, and item type as repeated measure factor) conducted on the items categorized as previously encountered revealed significant effects of group (Figure 1; sleep-deprived > sleep participants, $p<0.001$) and of item type (TBR items > TBF items, $p<0.001$), as well as a significant interaction ($p<0.02$). Post-hoc analyses revealed that sleep-deprived subjects recognized as much TBR items as sleep subjects ($p>0.16$) but recognized significantly more TBF items ($p<0.001$), leading to a larger DF effect in the sleep group ($p<0.03$).

The analysis of fMRI data revealed higher hippocampal activity at encoding (1) for TBR than for TBF items in both groups, and (2) for TBR items that were later recognized as compared to TBR items that were later forgotten in the sleep group only (Figure 2). In addition, in the sleep group only, both TBR and TBF items considered as previously encountered were associated to common cerebral activity in the medial prefrontal cortex as well as in the hippocampus and parahippocampal gyrus (conjunction analysis, Figure 2).

Conclusions: Behavioural data indicate that sleep deprivation favours the consolidation of TBF items while sleep takes into account the instruction given at learning and favours the forgetting of irrelevant information. The analysis of fMRI data disclosed larger hippocampal responses at encoding for TBR items subsequently consolidated during sleep. In line with Albouy et al. [3], these results suggest that hippocampal activation at learning might act as a tag for the neuronal populations that would participate in the offline replay of memories during subsequent sleep. Interestingly, sleep also seems to consolidate in a similar way TBR information correctly encoded and TBF information not correctly suppressed.

Support: FNRS, FMRE, ULg.

References:

[1] Rauchs, G., Desgranges, B., Foret, J., & Eustache, F. (2005), 'The relationships between memory systems and sleep stages', *Journal of Sleep Research*, vol. 14, no. 2, pp. 123-140.

[2] Crick, F., & Mitchinson, G. (1983), 'The function of dream sleep', *Nature*, vol. 304, no. 5922, pp. 111-114.

[3] Albouy, G., Sterpenich, V., Balteau, E., Vandewalle, G., Desseilles, M., Dang-Vu, T., Darsaud, A., Ruby, P., Luppi, P.H., Degueldre, C., Peigneux, P., Luxen, A., & Maquet, P. (2008), 'Both the hippocampus and striatum are involved in consolidation of motor sequence memory', *Neuron*, vol. 58, no. 2, pp. 261-272.

Figure 1

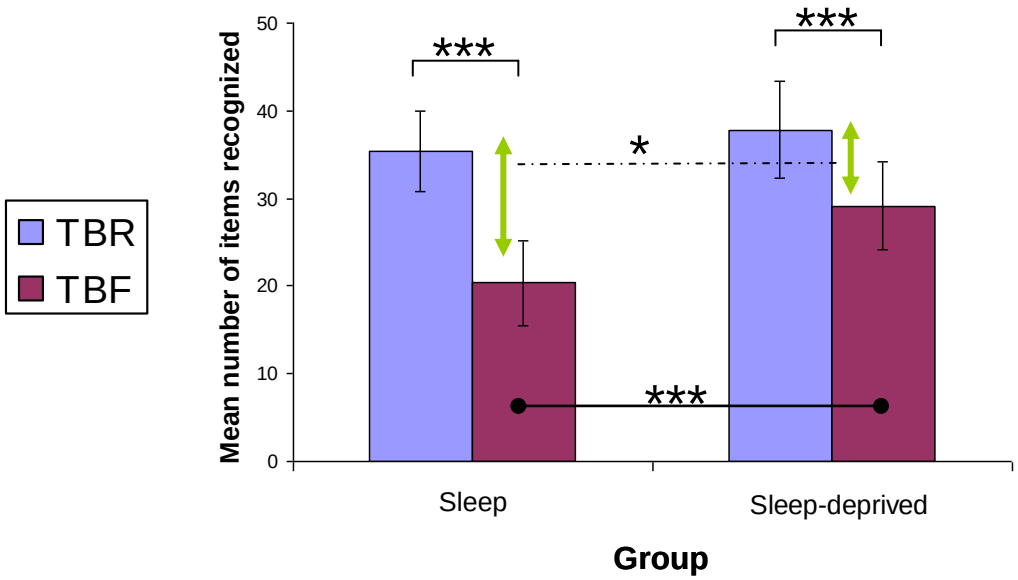
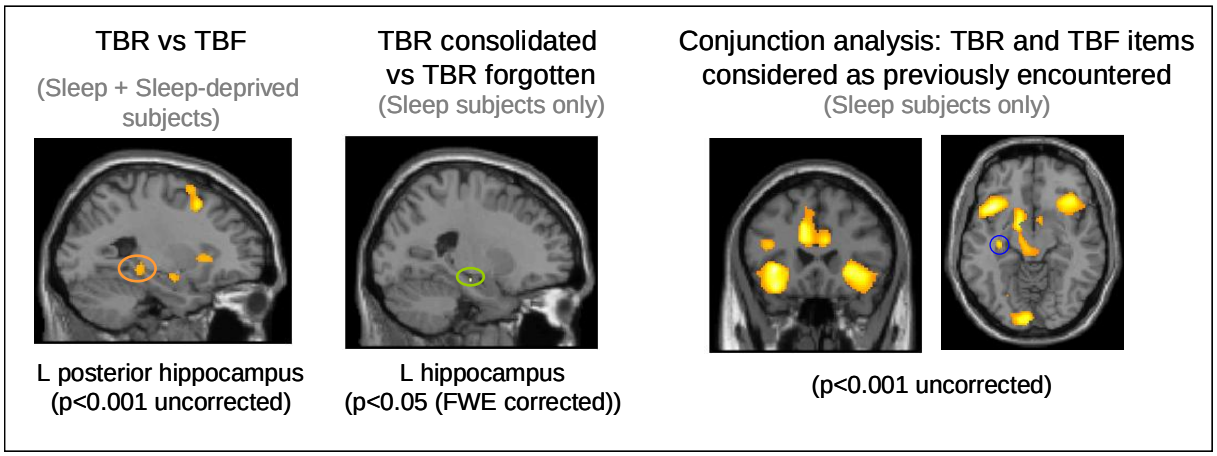

TBR
TBF
Mean number of items recognized
50
40
30
20
10
0
***
***
*
***
Sleep
Sleep-deprived
Group

Figure 2


TBR vs TBF
(Sleep + Sleep-deprived subjects)
L posterior hippocampus
(p<0.001 uncorrected)
TBR consolidated vs TBR forgotten
(Sleep subjects only)
L hippocampus
(p<0.05 (FWE corrected))
Conjunction analysis: TBR and TBF items considered as previously encountered
(Sleep subjects only)
(p<0.001 uncorrected)