

Differential effects of fast and slow sleep spindles in early and late sleep on the consolidation of an explicit memory

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INTRODUCTION

A beneficial effect of sleep spindles on the consolidation of explicit memory has been supported by recent studies. The present study explores whether overnight improvements in a word-pair association task is differentially correlated to characteristics of fast (>13 Hz) or slow (<13 Hz) sleep spindles.

METHODS

24 young healthy subjects participated either in a control condition without intentional learning or in an experimental condition (declarative memory task: paired-associate word list) 2.5 hours before sleep (Fig.1). Subjects performed a cued recall task after the encoding session and after sleep in the morning. Sleep spindles were detected automatically by means of Somnolyzer 24x7 in C3-A2 (Fig 2). Spindle features were determined for fast, slow, and all spindles in five 1.5-hours parts and in the entire night (Fig.3).

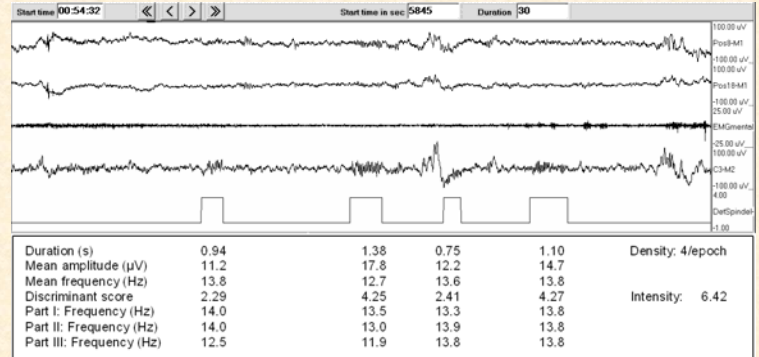


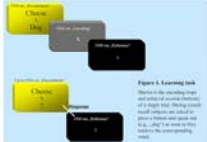
Fig. 2: Example of the Siesta spindle detector. In the upper part, a 30-s epoch shows two EOG (Pos8-A1 and Pos18-A1), one EMG (mental) and one EEG (C3-A2) channels, together with a channel marking the detected sleep spindle episodes (healthy control, female, 26 years, stage-2 sleep).

Learning Task:

Word Pair Association:
160 word pairs, presented twice

Total duration of encoding: 60 minutes

Encoding:



Retrieval:

„cued recall“

Control Task:

Pseudo word pairs (no intentional learning):
160 pseudo word pairs, presented twice

Total duration of encoding: 60 minutes

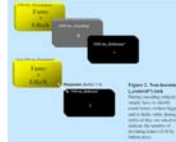


Fig.1

Density and intensity for fast and slow spindles

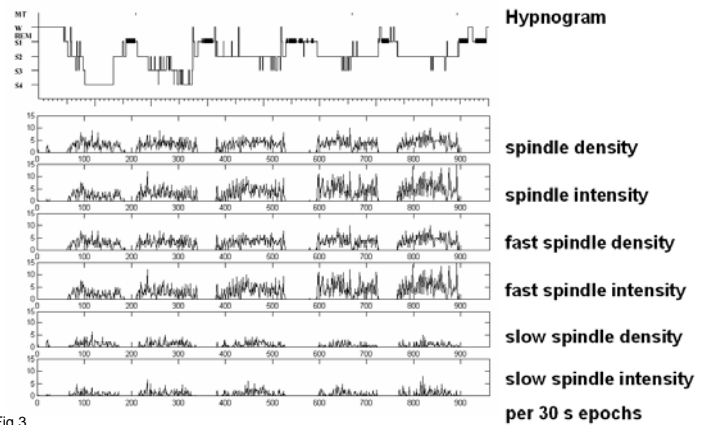
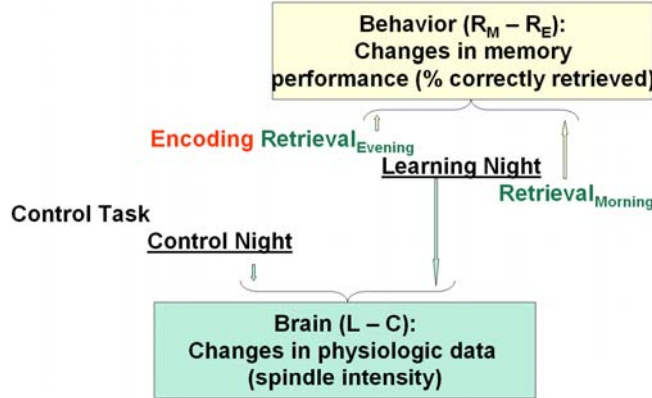


Fig.3



RESULTS

There were no significant differences regarding sleep efficiency and architecture as well as spindle activity between both nights. However, there was a significant correlation between changes in spindle density and intensity (experimental minus control night) and overnight changes in memory performance ($r = -.44$, $p < .05$ and $r = .52$, $p < .01$ for density and intensity, respectively). These correlations were most prominent in the early parts of the night (Fig 4). Changes in memory performance correlated significantly only with fast but not with slow spindle measures (Fig.5).

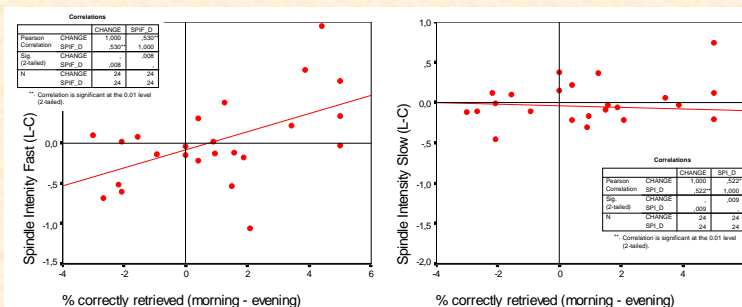


Fig. 5: Changes in spindle intensity (learning – control night) vs. overnight changes in memory performance

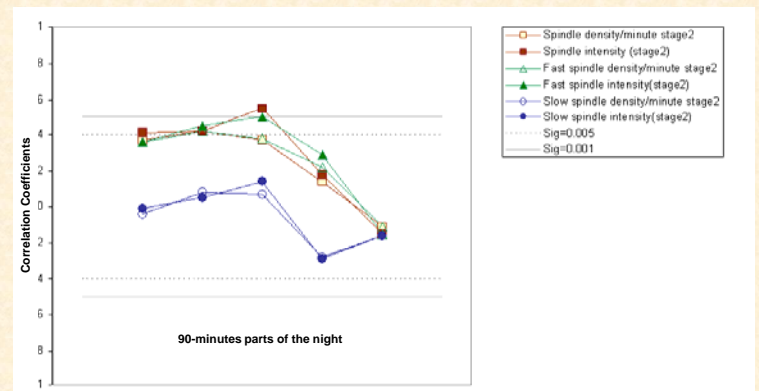


Fig. 4: Correlation of spindle measures and overnight changes in memory performance during the course of the night

DISCUSSION

Significant correlations were observed predominantly in the first parts of the night, which is in line with the hypothesis that early sleep is critical for consolidation of declarative memory. The differential effect of fast and slow spindles provide further evidence for differential functional significances of both spindle types.