CORTICAL SOURCES OF DEEP SLEEP IN YOUNG AND ELDERLY PEOPLE

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INTRODUCTION AND AIMS

It is well known that aging is accompanied by quantitative and qualitative changes of sleep. Sleep becomes shorter, lighter, is alternated by more awakenings and extended periods of wakefulness. One of the biggest changes in the old age is a decline in deep sleep that is responsible for feeling refreshed in the morning and for memory consolidation (Rasch and Born, 2013). Moreover, changes in deep sleep have recently been associated with cognitive decline and neurodegenerative processes (Mander et al., 2013). Nevertheless, quantitative sleep EEG studies that would describe age-related sleep changes at the level of cortical generators are missing.

The aim of this study was to compare spectral power characteristics of cortical EEG sources during slow-wave sleep in the first sleep cycle between young and elderly subjects and to assess their relationship with overnight memory consolidation.

METHODS

14 young (≤ 30 years) and 14 elderly (≥ 60 years) subjects underwent a two-night polysomnography assessments in the sleep laboratory (adaptation and experimental night). Sleep EEG was recorded from 19 standard scalp locations according to 10 – 20 system. All subjects also completed a computer-based paired-associates learning task consisting of presentations of 120 pairs of moderately semantically related nouns and their cued recall in the evening and in the next morning (Marshall et al., 2004; Dudysova et al., 2016). Overnight memory retention was determined by the difference in the number of recalled words between morning (after sleep) and evening cued recall.

Slow wave sleep (NREM 3) in the first sleep cycle was analyzed from the second night data. One elderly subject had to be excluded because of the absence of NREM 3 in the first sleep cycle. The data were cleaned from artifacts and the exact low resolution electromagnetic tomography (eLORETA) was used to compute EEG power in 6239 cortical voxel (Pascual-Marqui et al., 2011). We defined 8 classical frequency bands (delta: 1.5 – 4 Hz, theta: 4.5 – 8 Hz, aplha1: 8.5 – 10 Hz, alpha2: 10.5 – 12 Hz, beta1: 12.5 – 18 Hz, beta2: 18.5 – 21 Hz, beta3: 21.5 – 30 Hz and gamma: 35 – 44 Hz) as well as a narrow band of 0.7 – 0.8 Hz that corresponds to the peak of slow oscillations (SOs) related to memory consolidation (Mölle and Born, 2017). eLORETA current density in the two slowest frequency bands was related to overnight memory retention.

RESULTS

Compared to young participants, elderly subjects showed lower activity in SOs and delta frequency bands in frotal and limbic regions (p < 01, corrected). The largest difference in the band of SOs was localized in Brodmann area (BA) 6 whereas the largest difference in the delta band was localized in anterior cingulate (Table 1).

Structure	Number of voxels	mean t
Slow oscillations (0.7 – 0.8 Hz)		
Medial, Superior, Middle Frontal		
Gyrus (BA 6)	29	-5.025
Cingulate Gyrus (BA 24)	21	-5.006
Paracentral lobule (BA 31)	3	-4.972
Delta (1.5 – 4 Hz)		
Anterior Cingulate (BA 24, 32, 33)	10	-5.179
Cingulate Gyrus (BA 24, 32)	46	-5.139
Medial Frontal Gyrus (BA 9)	2	-5.013
Inferior Frontal Gyrus (BA 45, 46, 47)	45	-4.978
Middle Frontal Gyrus (BA 9, 46)	21	-4.977
Precentral Gyrus (BA 9)	2	-4.974
Insula (BA 13)	5	-3.979

Table 1: Voxels that showed significantly lower current density at low frequencies (SOs: 0.7 – 0.8 Hz and delta: 1.5 – 4 Hz) in elderly compared to young subjects during slow-wave sleep in the first sleep cycle (p < 0.01).

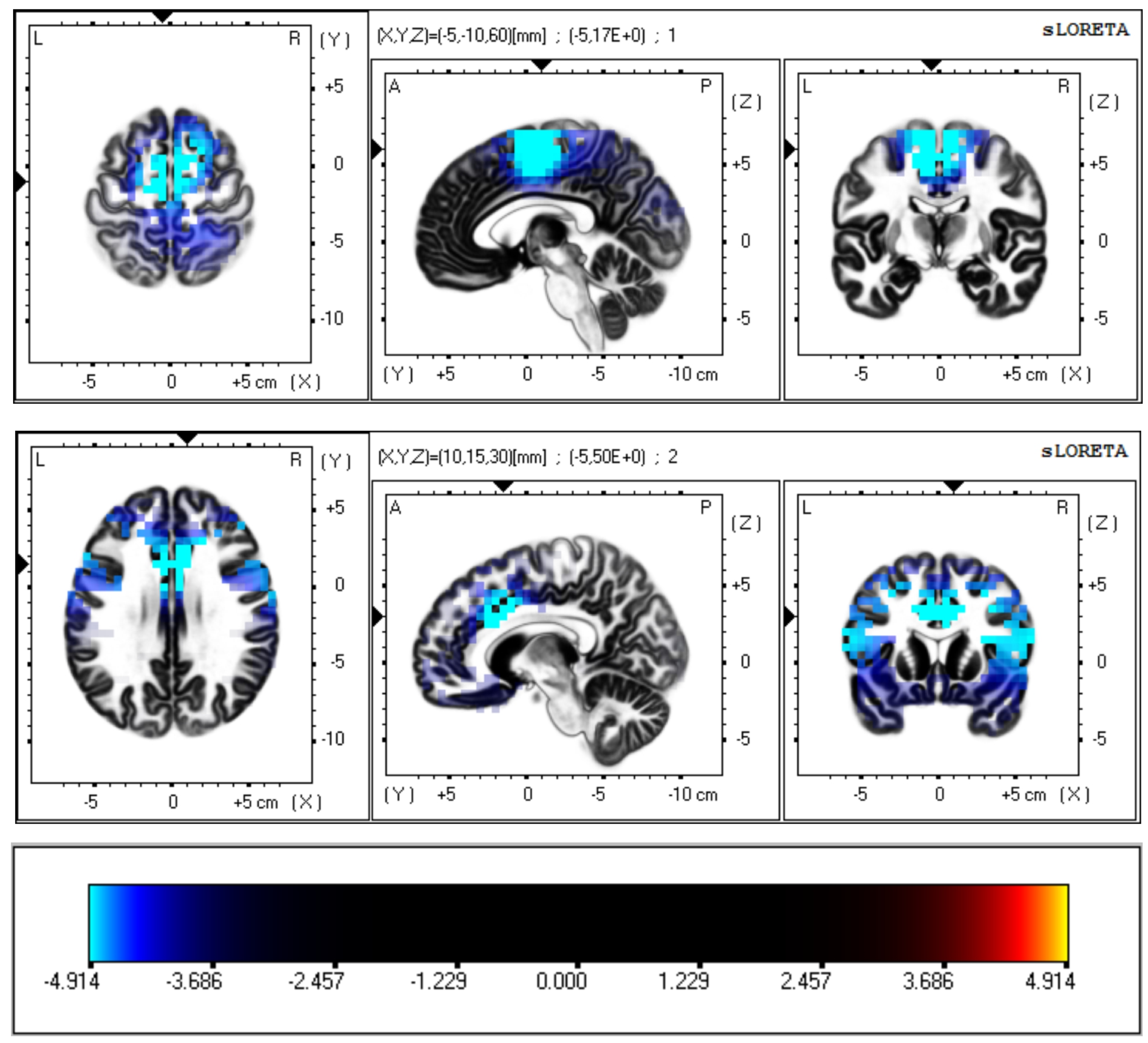

Figure 1: Axial, sagittal, and coronal images showing the MNI coordinates at the level of the most significant differences in EEG activity during slow-wave sleep in young and elderly subjects. Elderly subjects compared to young people showed lower activity in (A) slow oscillations (0.7 – 0.8 Hz) with the largest difference in Brodmann area (BA) 6 followed by BA 24 (t ≥ 4.914, p < 0.01) as well as in (B) delta (1.5 – 4 Hz) frequency band with the largest difference in anterior cingulate and cingulated gyrus followed by inferior and middle frontal gyri (t ≥ 4.914, p < 0.01). The color scale indicates t-values, significance thresholds were as follows: t ≥ 4.914, p < 0.01 and t ≥ 4.127, p < 0.05, corrected.

The first sleep cycle slow-wave sleep delta activity in anterior cingulate, i. e. in the same region that showed the largest difference between young and elderly subjects, was positively related with overnight memory consolidation (r ≥ 0.473, p < 0.05, one-sided, maximal correlation at MNI coordinates X = 5, Y = 25, Z = 25). No association was found for the slow-oscillation frequency band.

DISCUSSION AND CONCLUSION

This study shows that deep sleep in older adults contains less low frequencies. Cortical generators of low-frequency activity that were less active in the elderly are localized in frontal and limbic regions. Maximal changes occur in medial, middle and superior frontal gyri (BA 6) and cingulate gyrus. In a previous high density EEG study, the same regions have been reported to generate slow waves during sleep (Murphy et al., 2009).

As deep sleep and specifically slow oscillations play an important role in declarative memories that also decline with increasing age (Pace-Schott and Spencer, 2015), we expected that higher amount of slow-wave activity would be positively related to memory consolidation. However, we found only partial support for the hypothesis in our data. Possibly analyzing a larger sample size or redefining the SOs frequency band – either as broader or individually-adjusted band, would provide further insight.

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