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Asymmetries in the theta/beta ratio distinguish cognitively normal elderly from those with mild cognitive impairment

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Abstract

Background: The search for psychophysiological markers that distinguish normal from abnormal aging has produced many candidate EEG dynamics, but relatively little research has been done (or at least reported) on the theta/beta ratio or brain wave asymmetries.

Methods: We previously reported frontal asymmetries (frontal alpha and frontal beta asymmetry) originally investigated in the context of anxiety and approach-avoidance motivation that distinguish MCI from healthy, cognitively normal persons (HC). Another potentially more cognitively-involved marker, the ratio of theta to beta frequencies (TBR), originally investigated as a marker of attention deficits, might also usefully distinguish cognitive HC from MCI. We took advantage of a previously collected data set to conduct an exploratory analysis of the pattern of TBR in HC and MCI participants. Resting state EEG (rsEEG) was measured before and after a simple motion direction discrimination task. We investigated the standard frontal TBR as measured at frontal electrode FZ. We estimated power spectral density in the resting state (eyes closed) for both pre- and post-task, extracting estimates of TBR at electrode Fz.

Results: We found that MCI had significantly higher TBR than cognitively normal elderly, $F(1,95)=4.98$, $p=0.028$, with no effect of timepoint and no interaction. We then explored the possibility that TBR itself has meaningful asymmetries, calculating the TBR asymmetry at the following electrode pairs: F3-F4, C3-C4, CP3-CP4, P3-P4, PO3-PO4. This analysis revealed an interesting pattern, with group (HC vs. MCI) interacting with location, $F(4,380)=5.25$, $p<0.001$. Relative to HC, MCI participants had higher TBR on the right (positive TBR asymmetry) in frontal electrodes (F3-F4), but higher TBR on the left (negative TBR asymmetry) over parietal-occipital sites (P3-P4 and PO3-PO4). The parietal asymmetry may reflect the early spread of lesions from inferior temporal regions to areas subserving language and visuospatial processing, but the frontal asymmetry is less obviously tied to known progression of brain lesions, and may reflect heterogeneity in the underlying pathogenesis of this sample of people with MCI.

Conclusion: TBR asymmetries obtained in rsEEG can contribute significantly to successful discrimination of older persons with MCI from those with normal cognitive functioning.

Figure 1. Theta/beta asymmetry as a function of location and group.