Scalp and intracerebral (LORETA) theta and gamma EEG coherence in meditation

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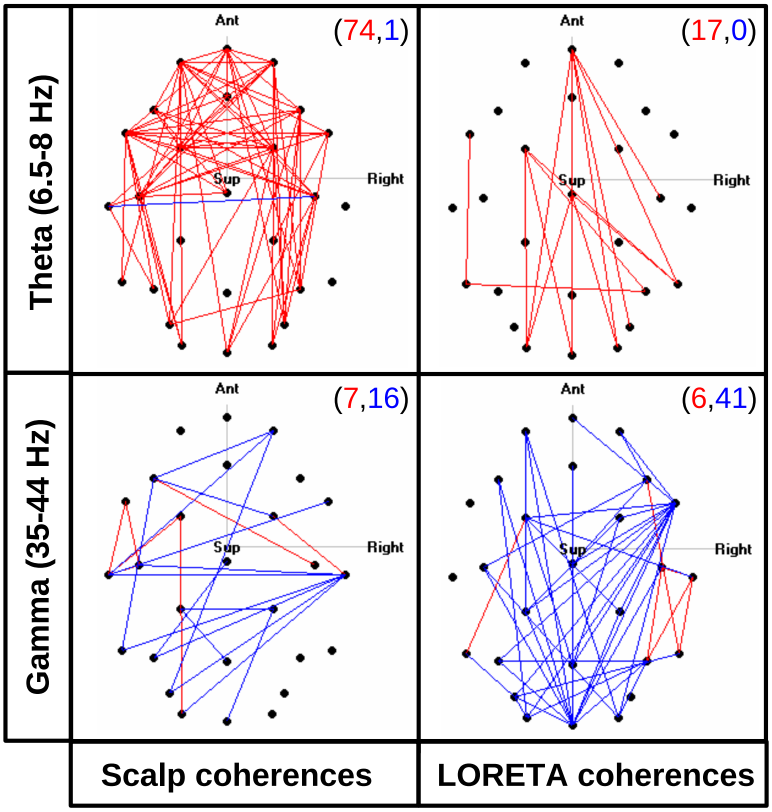
Background: Changes in EEG coherence, and in the theta and gamma EEG frequency bands have been reported during meditation. Since, however, scalp locations do not necessarily indicate directly underlying sources, only coherences computed between intracerebral model sources can reveal interpretable, functional connectivities between brain areas.

Methods: 27-channel EEG was recorded (10-20 System) from a long-term meditator while performing several times three different meditations (Ch'an Buddhism), and during a control condition. These meditations and the control condition were repeated in 4 identical, independent sessions. The subject was sitting in the lotus position with half-closed eyes either meditating or resting (=control condition). From the first 3 minutes of the meditation and control conditions, all artifact-free 2-second EEG epochs (N=2323) were analyzed. Intracerebral model sources were computed using LORETA for 2394 voxels; each voxel was assigned to the closest scalp electrode position, forming 27 cone-shaped brain regions of interest (ROIs). For the center of mass of each ROI, the LORETA time series was computed (LORETA ROI time series). Theta (6.5-8 Hz) and gamma (35-44 Hz) frequency band coherences were computed between all pairs of scalp EEG electrodes (average reference) and between all possible pairs (351) of intracerebral LORETA ROI time series. T-statistics compared the coherences between the control and the meditation condition.

Coherence differences: Meditation vs. Control



significant higher coherence in meditation ($p<.05$)
significant lower coherence in meditation ($p<.05$)
In brackets: number of cases; red higher, blue lower in meditation

Results: During the meditations as compared to the control condition, all significant changes in theta band coherences were increases, while most significant changes in gamma band coherences were decreases, both for scalp EEG (average reference) and for LORETA. But, the spatial distribution of the scalp and the LORETA coherence differences differed strongly, both for theta and for gamma. E.g., for theta, the ratio of significant coherence changes involving anterior compared to posterior locations was about 3:1 for scalp EEG, but about 2:3 for intracerebral LORETA (chi square = 13.3, p=0.003). Theta LORETA coherences increased in all three meditations. Gamma LORETA coherences predominantly showed decreases, but, consistent in the three meditations, had isolated increases in both temporal brain regions (anterior-posterior).

Conclusions: As expected, the results of the scalp computed EEG coherences differed from the results of the intracerebrally (LORETA) computed coherences. During meditation, the relevant LORETA results showed general coherence increases for the theta band, and decreases for the gamma band, but the gamma band also revealed isolated increases in both temporal regions.

References:

Pascual-Marqui, R.D., Michel, C.M. & Lehmann, D. (1994). Low resolution electromagnetic tomography: a new method for localizing electrical activity in the brain. International Journal of Psychophysiology, 18: 49-65.

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