

Cross-frequency dynamics of neural and cardiac rhythms in the context of effortful cognition and breath focus meditation

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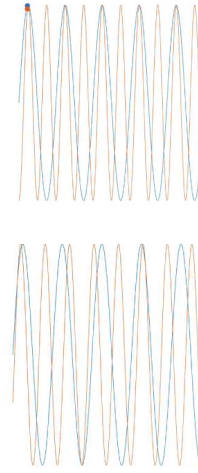
BACKGROUND

- Cross-frequency coupling/decoupling between pairs of oscillators is proposed as the mechanism through which communication occurs at different spatio-temporal scales in the brain^{1,2} and body³.
- Phase-synchronization depends on the numerical ratio between peak frequencies:
- The functional role of different cross-frequency ratios has been previously investigated between neural rhythms alpha-theta during rest, meditation and an arithmetic task^{4,5}, as well as between alpha-heartrate and alpha-respiration during a memory task, rest and sleep⁶.

Harmonic cross-frequency ratios (e.g., two oscillator frequencies where $f_2 = f_1/2$; integer number) **allow** cross-frequency coupling → information integration.

Vs.

Non-harmonic cross-frequency ratios (e.g., $f_2 = f_1/g$, where g is an irrational number; i.e., golden mean = 1.618) **preclude** cross-frequency coupling → no information integration.



HYPOTHESIS Alpha-heart rate cross-frequency ratios will approximate a harmonic relationship of 8 during effortful cognition, while approximating a non-harmonic relationship during breath focus (8*1.618=12.94).

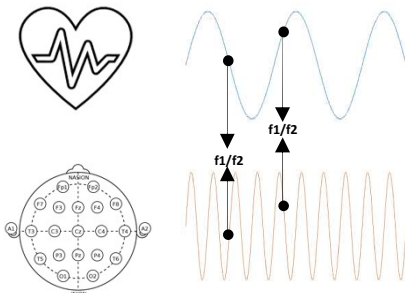
METHODS

18 participants (11 female, age 23.55 ± 2.89 with no prior meditation experience).

~5 minute recording per condition of rest, breath focus meditation and arithmetic task.

Measurements of neural (EEG, 19 electrodes 10/20 placement) and cardiac (ECG three lead) activity.

All analyses were performed in MATLAB⁷ with use of fieldtrip and custom code.

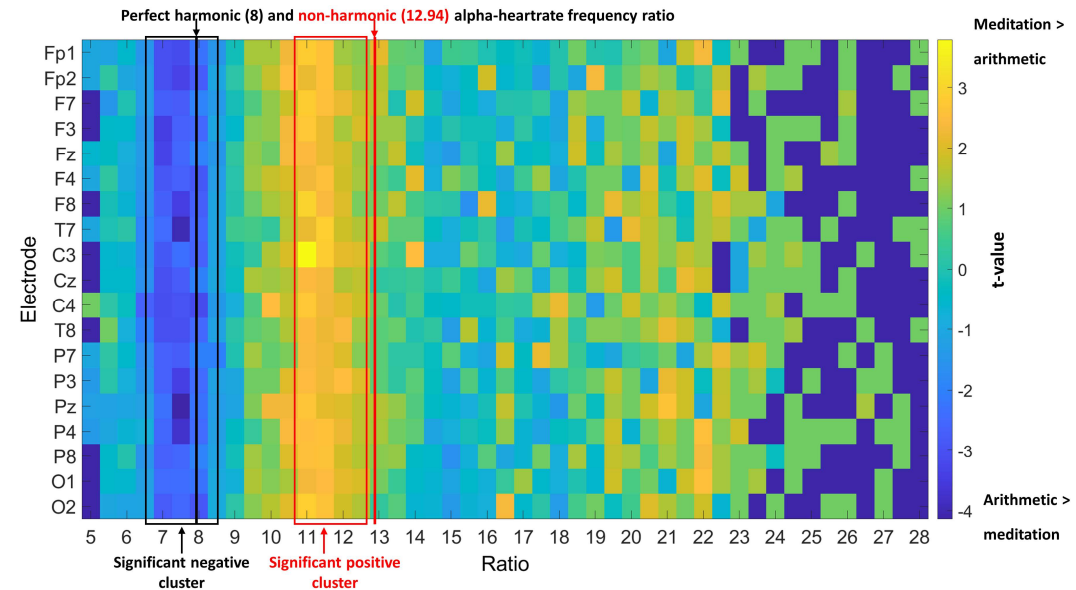


Analysis steps

1. Instantaneous ratios between neural alpha (8-14Hz) and heartrate (1-1.67 Hz) frequencies.

2. Percentage of each possible ratio incidence and condition t- test.

3. Cluster-based permutation test (see Figure)



RESULTS

Figure above shows that, compared to breath focus meditation, during arithmetic condition, ratios at or approximating the harmonic value 8 between alpha and heartrate frequencies are significantly more frequent across all electrodes (significant positive cluster).

During breath focus meditation, ratios at or approximating the non-harmonic value 12.94 are more frequent across electrodes compared to arithmetic task.

CONCLUSION

The cross-frequency relationships predominant in each condition suggest that during effortful cognition (arithmetic task) there is a greater degree of coupling between neural and cardiac/respiratory oscillators.

Conversely, breath focus meditation seems to be characterized by decoupling between these oscillators

These findings are in line with recent research showing interdependence between brain and body physiology during cognition⁸.

References

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