

Theta-to-Alpha Frequency Ratio as an Indicator of Mindfulness During Binaural Beat Listening

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Introduction: Mindfulness is a measure of an individual's ability to be in the present and can vary due to many factors affecting their day-to-day life. Studies suggest that meditation techniques can help individuals enhance mindfulness, yet beginners often find meditation challenging. Binaural beats (BBs) are an auditory illusion that can aid users in meditation, although they can also cause distraction for different individuals [1]. Moreover, there is no definitive explanation for how or why BBs either facilitate or hinder mindfulness during meditation. In this preliminary study, we employ the theta-to-alpha frequency ratio (TAR) as a neural indicator to determine whether novice meditators experienced benefit or hindrance while listening to BBs during meditation.

Material and Methods: 17 participants were recruited to meditate on two separate days, one day with the BB audio and another without with each meditation session lasting 10 minutes. The BB frequencies were set to 126Hz for the left ear and alternated between 134Hz to 140Hz for the right ear, ensuring the frequency difference consistently fell within the alpha range. Seven electrodes were placed in the frontal lobe as shown in Figure 1 left, as a reduction in the TAR in this area when meditators are attentive rather than mind-wandering [2]. After each meditation session, participants were asked to complete the Toronto mindfulness scale to record user experience. After all data was collected, the TAR was averaged across all electrodes. A one-tailed Pearson Correlation test calculated the correlation between the survey and the extracted TAR.

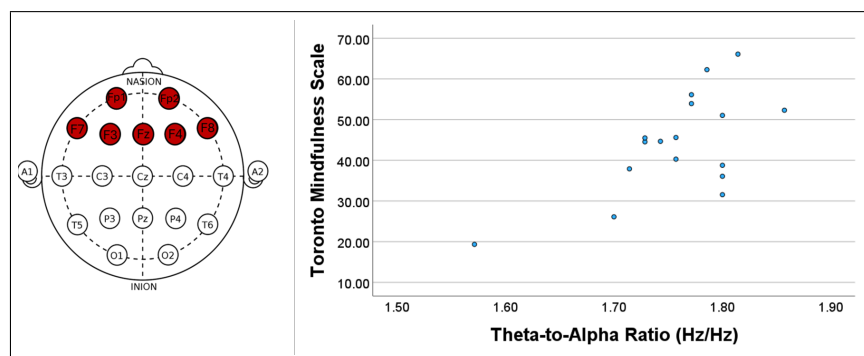


Figure 1: (Left) The EEG montage chosen for the study. (Right) A scatter plot showing the correlation between the results of the Toronto Mindfulness Scale and the theta-to-alpha frequency ratio for all 17 participants during the binaural beat session

Results: As shown in Figure 1 right for the Toronto Mindfulness Scale and the TAR during the BB condition, a correlation coefficient of 0.641 ($p=0.003$) indicating a strong correlation.

Discussion: This correlation between mindfulness and TAR wasn't present during the no audio condition, suggesting that this relationship is BB dependent. This discovery may offer additional understanding of the mechanism underlying BBs and their potential use as a tool for meditation.

Significance: This index can offer instantaneous insights into a person's level of mindfulness or distraction during BB-mediated meditation sessions, and if applied in a closed-loop neurofeedback setting, it could enable the audio to be adjusted to optimize mindfulness.

References:

- [1] Sas, C., Chopra, R. MeditAid: a wearable adaptive neurofeedback-based system for training mindfulness state. *Pers Ubiquit Comput* 19, 1169–1182 (2015).
- [2] Rodriguez-Larios J, Alaerts K. EEG alpha–theta dynamics during mind wandering in the context of breath focus meditation: An experience sampling approach with novice meditation practitioners. *Eur J Neurosci*. 2021; 53: 1855–1868, 2020.