Hemispheric specialization in rhythmic processing

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Background

- Previous research suggests there may be specialization in the cerebral hemispheres for auditory processing during sensorimotor synchronization tasks, with slower rhythms preferentially processed in the left hemisphere and faster rhythms processed in the right hemisphere [1,2], and more recently in beta band activity in the auditory cortex[3]. It is unclear, however, how this hemispheric specialization in beta band activity is effected by meter, although a recent meta analysis has found increased activity in the right primary motor cortex compared to the left motor cortex during music listening tasks[4].
- To further study hemispheric specialization with regards to tempo and meter we tasked subjects with tapping to several rhythms with their left and right hands, as well as to listen to rhythms without tapping as a separate condition while EEG was recorded.
- The investigation is ongoing, but we present results to the non-tapping condition aligning with the notion of hemispheric differences in rhythm processing

Methods

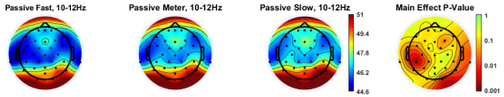
- Subjects were presented with three different rhythms and tasked to either tap with their left, tap with their right, or attend the rhythm without tapping, in a counter balanced design.
- During the no tapping condition, there were occasional deviant tones (0 to 3) in the rhythms that the subjects were tasked to count, to ensure they were attending the rhythms.
- 200 tones for both slow and fast rhythms divided into four blocks
- 200 meters for the metered rhythm (400 tones) divided into four blocks
- Slow rhythm = 800 ms interonset interval
- Fast rhythm = 500 ms interonset interval
- Metered rhythm = Duple rhythm, with 500 ms interonset interval (1, 2, 1, 2, 1, 2, etc.)
- Each tone had a duration of 50ms, and was at 262 Hz
- N = 13, all right handed
- 32 channel ANT-Neuro EEG system
- **ERSP** – Event related spectral perturbation shows change in spectral power at given frequencies in time compared to baseline
- **ITC** – Inter-trial Coherence shows phase coherence across trials

References

1 Repp, B. H. (2005). Sensorimotor synchronization: a review of the tapping literature. Psychonomic bulletin & review, 12(6), 969-992. **2** Pflug A, Gompf F, Kell CA. 2017. Bimanual tapping of a syncopated rhythm reveals hemispheric preferences for relative movement frequencies. Human Movement Science 54:287–296. **3** Pflug, A., Gompf, F., Muthuraman, M., Groppa, S., & Kell, C. A. (2019). Differential contributions of the two human cerebral hemispheres to action timing. eLife, 8. **4** Gordon, C. L., Cobb, P. R., & Balasubramaniam, R. (2018). Recruitment of the motor system during music listening: An ALE meta-analysis of fMRI data. PloS one, 13(11).

Spectral Power Differences

Significant effects in the Mu range between the fast, slow, and meter condition over the left hemisphere

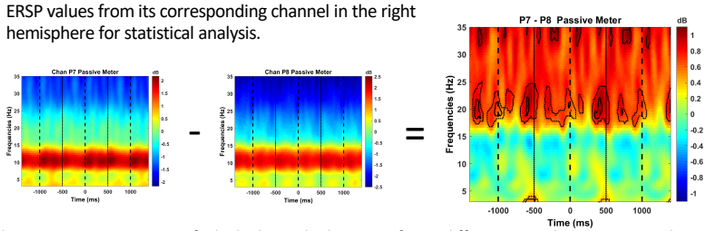


No significant effects in the spectral power for other frequency ranges were found.

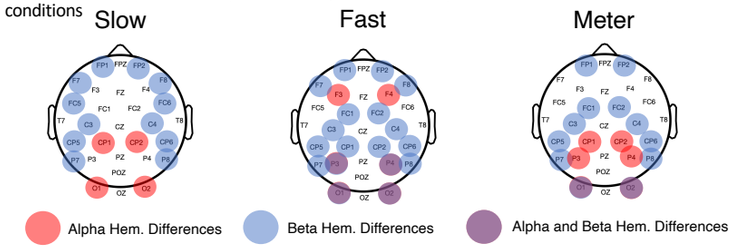
ERSP Hemispheric Differences

To measure hemispheric differences in the t/f data not seen in the averaged spectral power, ERSP values from channels in the left hemisphere were subtracted from ERSP values from its corresponding channel in the right hemisphere for statistical analysis.

Dashed lines = p<0.05
Solid lines = p<0.01

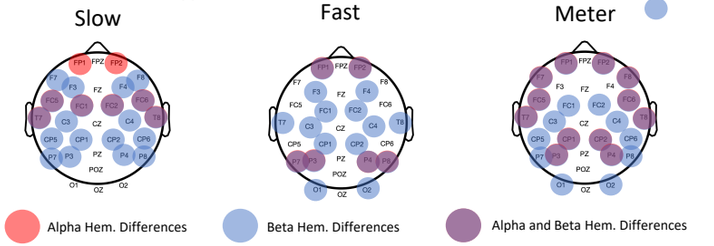


Below are representations of which channels show significant differences with its corresponding channel in the opposite hemisphere in the t/f domain for alpha and beta bands for the 3 passive conditions



ITC Hemispheric Differences

The same treatment was applied to ITC values



Beta Modulation

While ERSP and ITC Hemispheric differences plots provide evidence of differential hemispheric activity, they do not indicate a specialized role for a given hemisphere. To further investigate, frequency band plots for ERSP and ITC values where calculated for individual channels and compared with the corresponding channel on the opposite hemisphere. Evidence of specialization primarily appears in the low beta band and is most apparent in ITC values.

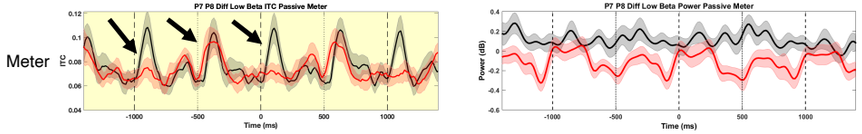
Low Beta = 14 – 20 Hz

ITC

Channels P7 and P8

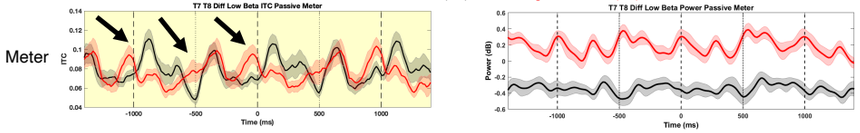
Black = Left Channel (P7) Red = Right channel (P8)

ERSP



Channels T7 and T8

Black = Left Channel (T7) Red = Right channel (T8)



These data indicate beta band activity in the right hemisphere may be specialized for meter processing based on differences in coherence and power modulation.

Alpha Modulation

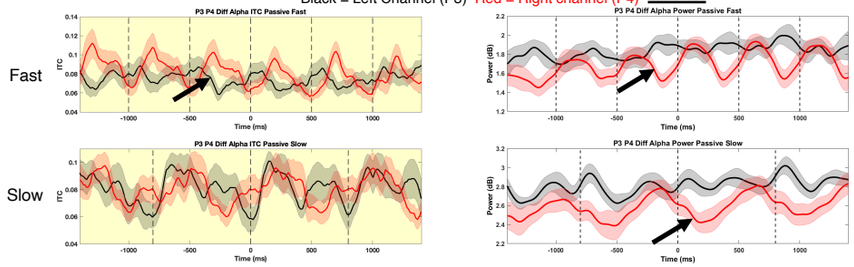
Alpha = 9 – 13 Hz

ITC

Channels P3 and P4

Black = Left Channel (P3) Red = Right channel (P4)

ERSP



Alpha activity in the right hemisphere appears to be generally modulated by rhythms more than the left hemisphere

Conclusions

- Mu activity suggest hemispheric differences in processing rhythms of different tempos in line with previous work[3], and that the right hemisphere may be involved regardless of the tempo or meter.
- Beta activity appears to suggest right hemispheric specialization for the processing of meter, as was suggested by Gordon et al, 2018, yet it is unclear if the activity seen here is related to activity in the primary motor cortex as found in their paper, or from the auditory cortex as suggested by Plug et al., 2019.
- Alpha activity suggests the right hemisphere may be more generally involved in processing auditory rhythms.