Spring 3-31-2017

Dynamics of Motor System Excitability during Auditory Anticipation

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Motor System Excitability Dynamics During Auditory Anticipation

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Background

Neural motor system plays a role in anticipation and perception of regular events and is active when hearing rhythms.[1]

Neural (e.g., beta) oscillations anticipate regular sounds[2], but this has not been seen specifically in motor system excitability.

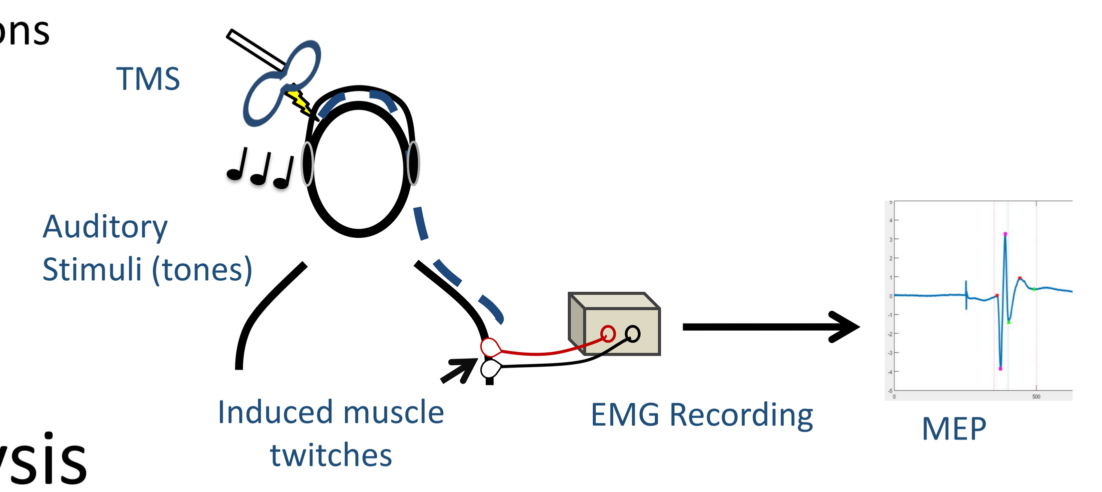
The time course of motor excitability has not been characterized during auditory anticipation and beat perception.

Does motor system excitability synchronize to temporal frequencies of regular sounds?

We used Transcranial Magnetic Stimulation (TMS) to test for motor system fluctuations while listening to isochronous tone sequences.

Methods

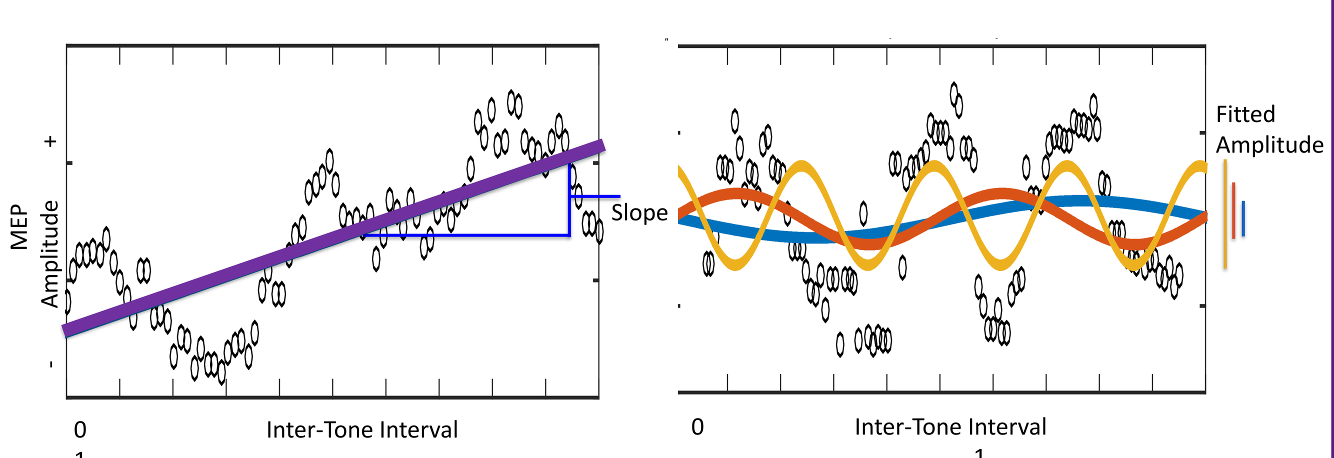
- Single-pulse TMS (110% Motor Threshold) over left M1 to elicit motor-evoked potentials (MEPs)
- MEP amplitude measured by electromyography (EMG) from right first dorsal interosseous (FDI) muscle
- Larger MEP amplitude -> Greater motor system excitability
- TMS applied at 100 possible time points between tone or beat positions



Analysis

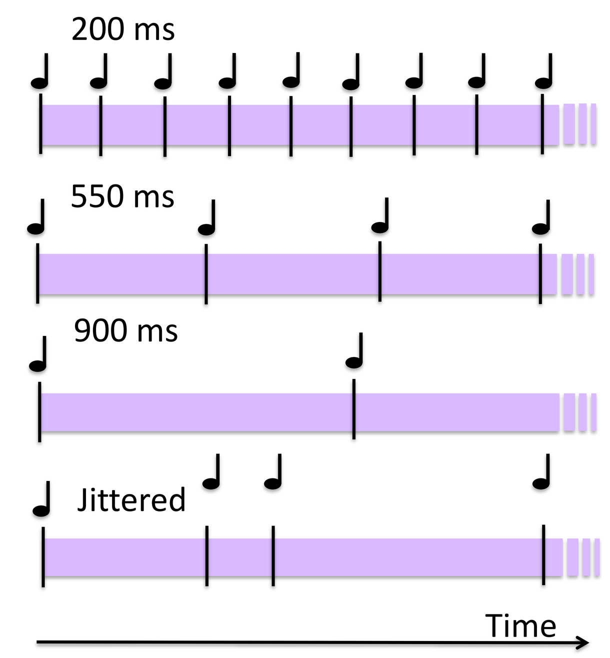
Characterized fluctuations of standardized and smoothed MEP values between tones for each participant.

a. Linear fit – Does excitability increase/decrease before the tone?
b. Cosine fits – Does excitability fluctuate at frequency related to the tone rate?



a. Linear fit to smoothed data   b. Cosine fits to detrended data

Results of Isochronous Sequences



N = 20

Isochronous tones (30s)

Sequence rate (200ms, 550ms, 900ms, jittered) x Fitted rate (200ms, 550ms, 900ms)

MEP Data

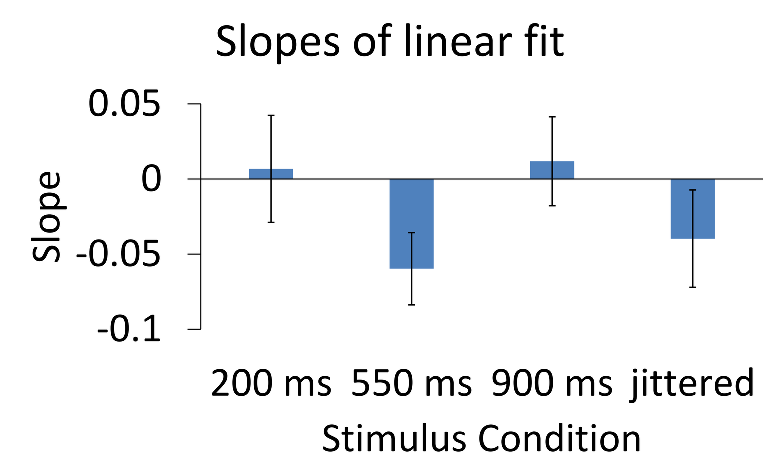


Figure 3. Slopes from linear fits to smoothed MEPs as a function of time within inter-tone interval. No slopes are significantly greater than zero.

Tone Tapping Data

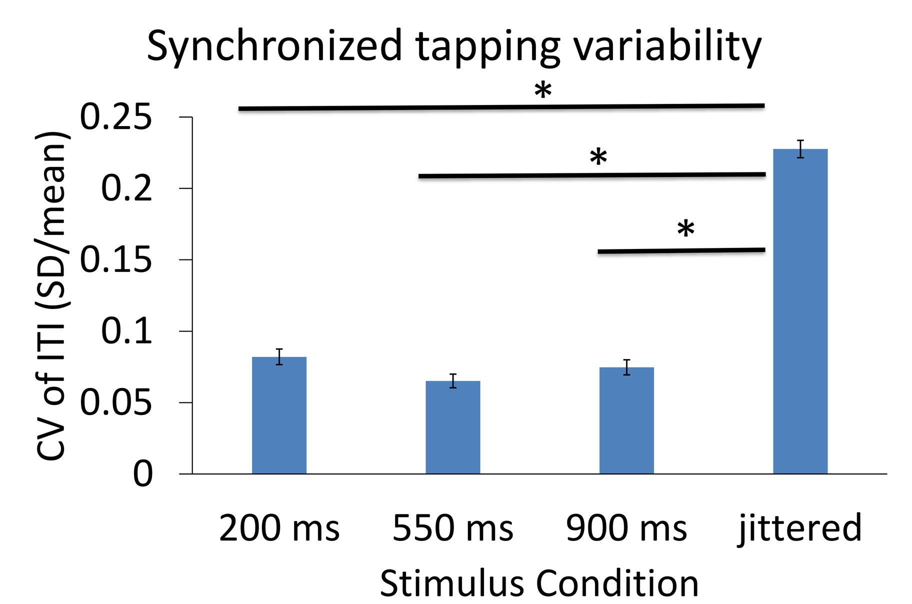


Figure 1. Coefficient of variation of inter-tap intervals. Tapping was more variable for the jittered condition than the isochronous conditions, $F(2,41) = 341.56$, $p < .001$.

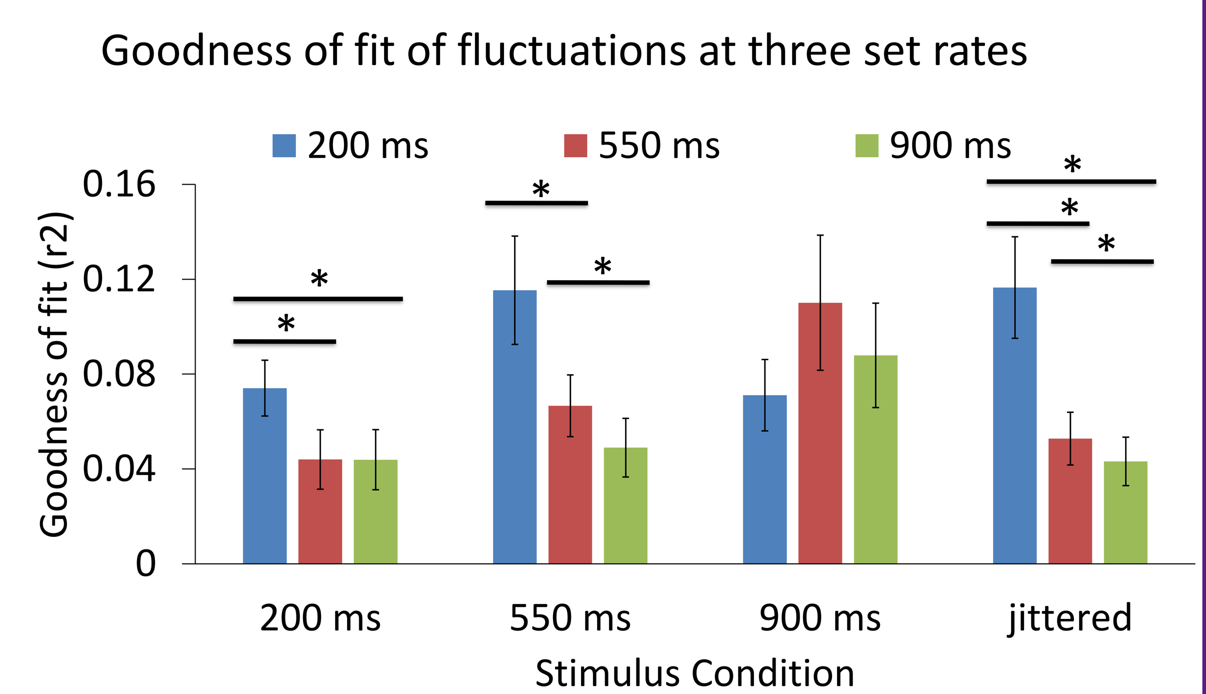


Figure 4. Goodness of fit (R^2) for cosine fits to smoothed MEPs as a function of time within inter-tone interval. The 3 (Fitted rate) x 4 (Sequence rate) interaction, $F(3,62) = 3.52$, $p = .017$, indicated that the 200 ms fitted rate matched the corresponding sequence rate best, however, the predicted correspondence between stimulus and fitted rates was not seen for the rest of the MEP data.

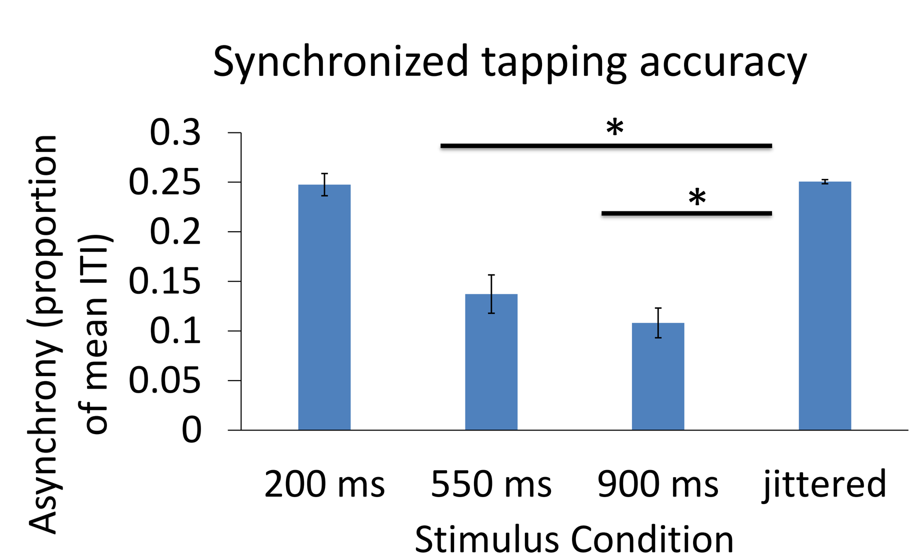


Figure 2. Proportion of asynchrony of the inter-tap interval. The tapping accuracy is worse for the jittered condition than for the 550 ms and 900 ms isochronous conditions, $F(2,35) = 40.52$, $p < .001$.

*$p < 0.05$

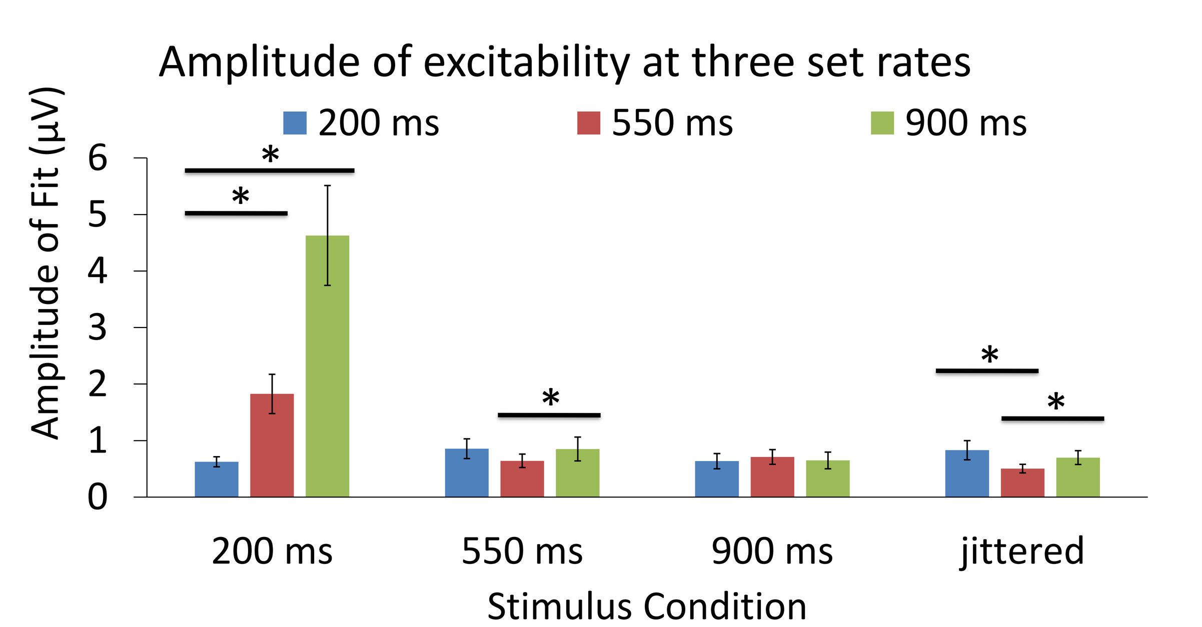


Figure 5. Mean amplitude parameter values (±SEM) from cosine fits to smoothed MEPs as a function of time within inter-tone interval. The 3 (Fitted rate) x 4 (Sequence rate) interaction, $F(1,23) = 19.09$, $p < .001$, indicated that MEPs fluctuated to different extents depending on the frequency of the stimulus rate (or whether the rhythm was jittered) and the rate of the fitted cosine, however the differences between fits did not match the predicted correspondence between stimulus and fitted rates.

Discussion

While listening to isochronous sequences, motor system excitability did not selectively fluctuate at the rate of regular tones.

Over the tone interval, motor system excitability did not increase, suggesting that excitability does not anticipate regular tones.

In the tapping data, the jittered condition showed more variability and lower accuracy than the isochronous conditions, indicating an effect of anticipation.

These results suggest some synchronization of motor system excitability to auditory predictability, in the form of strictly regular sounds. This informs our understanding of auditory-motor integration, of the role of the motor system in auditory timing.

Further work can be done to explore the dynamics of motor system excitability using rhythmic stimuli or using a measure of excitability other than MEPs such as reaction time in a “Go-no go” task.

Conclusion

During listening to regular sounds, we did not observe that excitability in the neural motor system fluctuates with regularity in correspondence to the perceived regularity.

Acknowledgements

We are grateful to our funding sources: NSERC, McDonnell Foundation, and the Canadian Foundation for Innovation.

NSERC CRSNG
James S. McDonnell Foundation
Canada Foundation for Innovation
Fondation canadienne pour l'innovation

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