

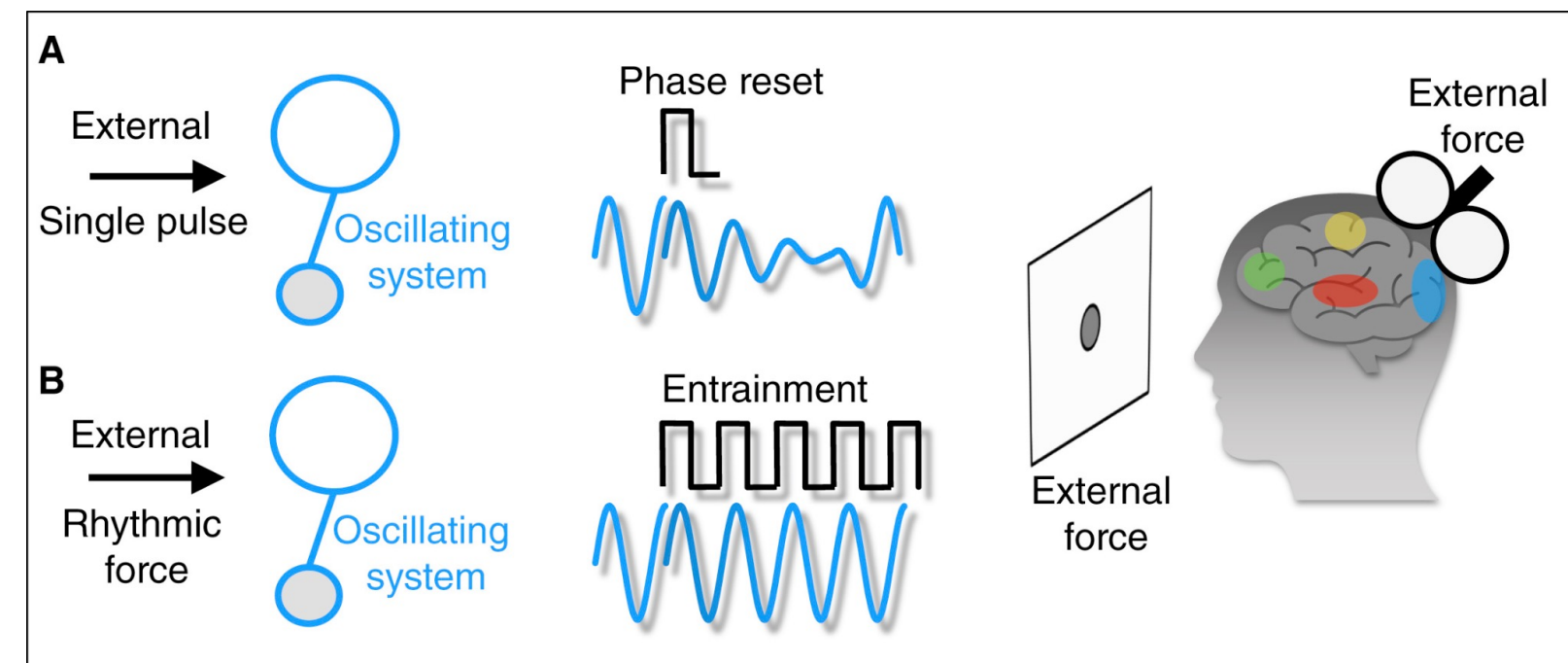
Harmonizing Brain Rhythms: control conditions for rhythmic TMS entrainment

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Introduction

This study evaluates a sham coil and arrhythmic TMS as controls for rTMS entrainment studies.

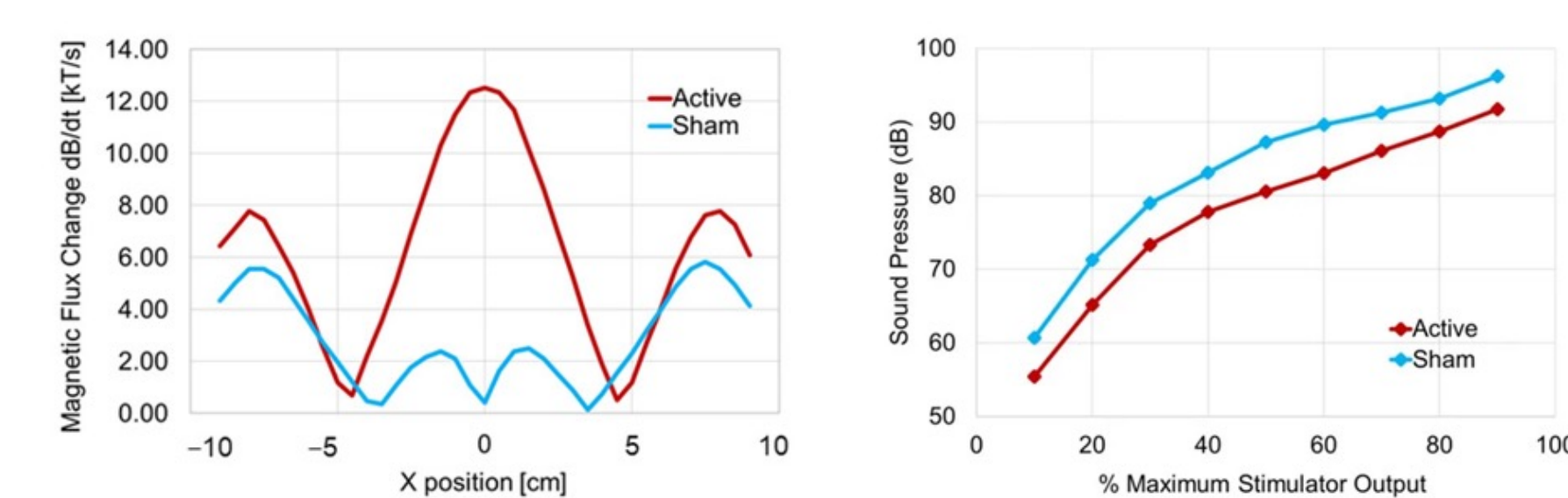


Finding a persuasive and inert control for TMS has proven difficult. Our two criteria for a good placebo were:

Do control conditions entrain alpha less than rTMS

How well do the different control conditions imitate the experience of TMS?

One control option we were evaluating is the DuoMAG 70BFP, designed to mimic peripheral nerve stimulation without the central peak of magnetic flux change.



Magnetic flux change and sound intensity produced by active (red) and sham (blue) coils

Given differences in sound, we used both stimulation matched and sound matched sham conditions.

	aTMS	shamTMS	msshamsTMS
Matched pulse pattern	✗	✓	✓
Real TMS pulses	✓	✗	✗
Matched stimulator output	✓	✓	✗
Matched sound produced	✓	✗	✓

Methods

We recorded concurrent TMS-EEG, using the Axilium cobot and the participant's MRI scan to direct TMS pulses to the target region (Intra Parietal Sulcus).



During each trial, EEG data was collected, after each trial we ran a questionnaire. These answered:

Do control conditions entrain alpha less than rTMS

- Compared power and ITPC between conditions

How well do the different control conditions imitate the experience of TMS?

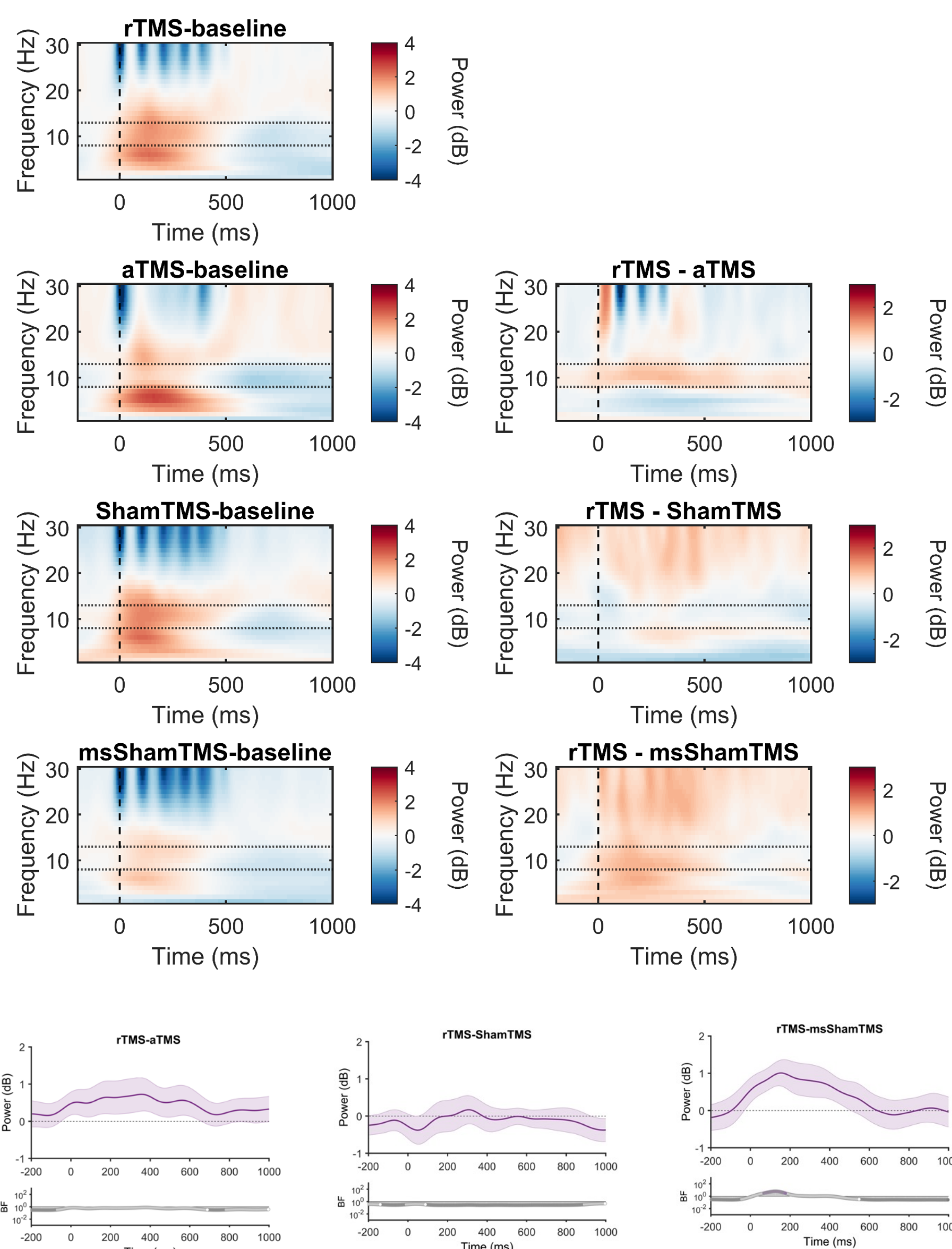
- 10-rank questions about TMS experience
- Qualitative data about TMS experience
- Guess question on which trials were placebo

EEG Data

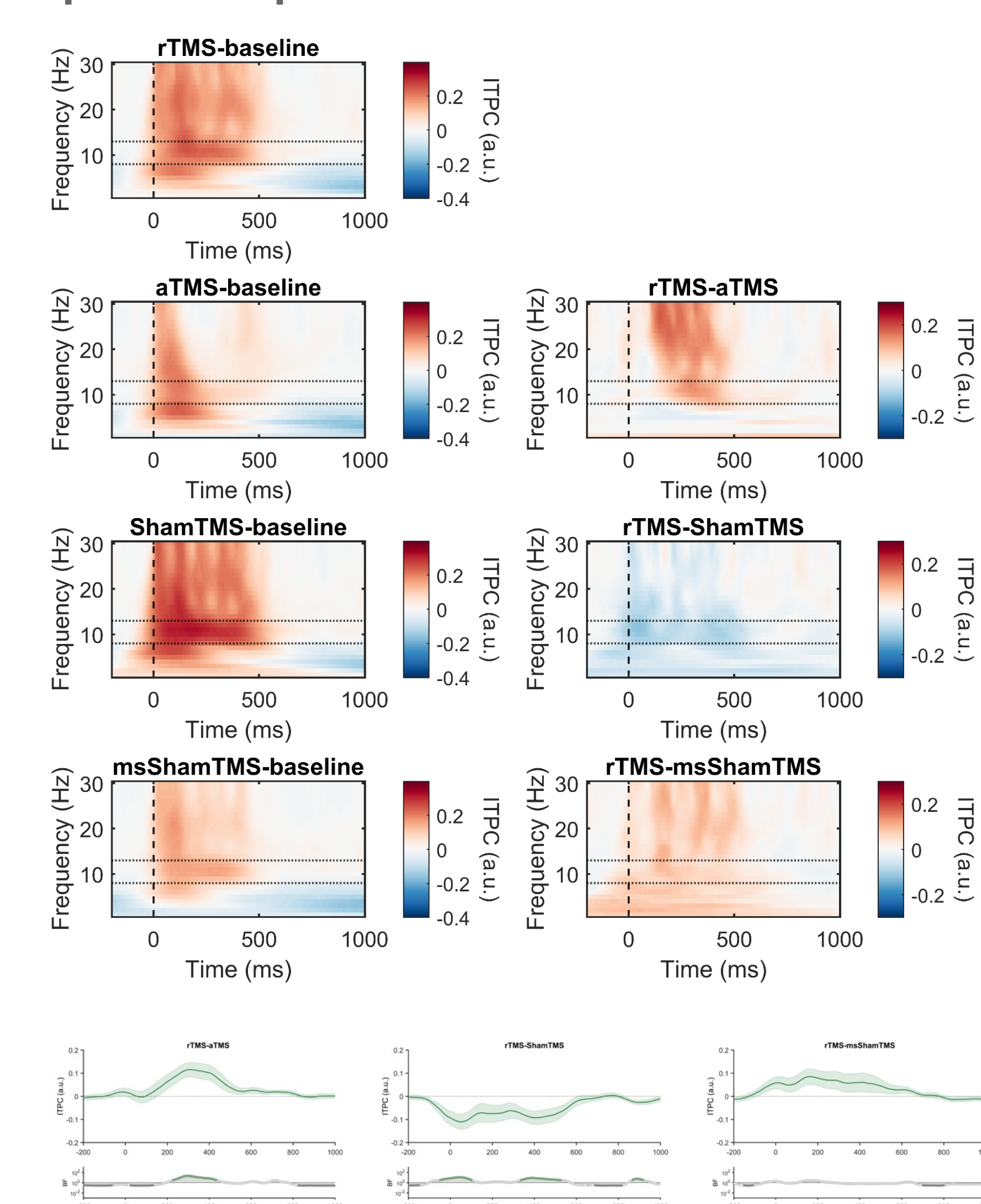
To show that control conditions are entraining alpha less than rTMS we want to see:

- Left time-frequency plots:** less of a red band in the alpha band frequencies (dotted lines).
- Right time-frequency difference plots:** a red band inbetween the dotted lines, to show more alpha in rTMS than the control.
- Topographical comparison plots:** more red on the right (stimulated) hemisphere.

Alpha power plots:



Alpha ITPC plots:

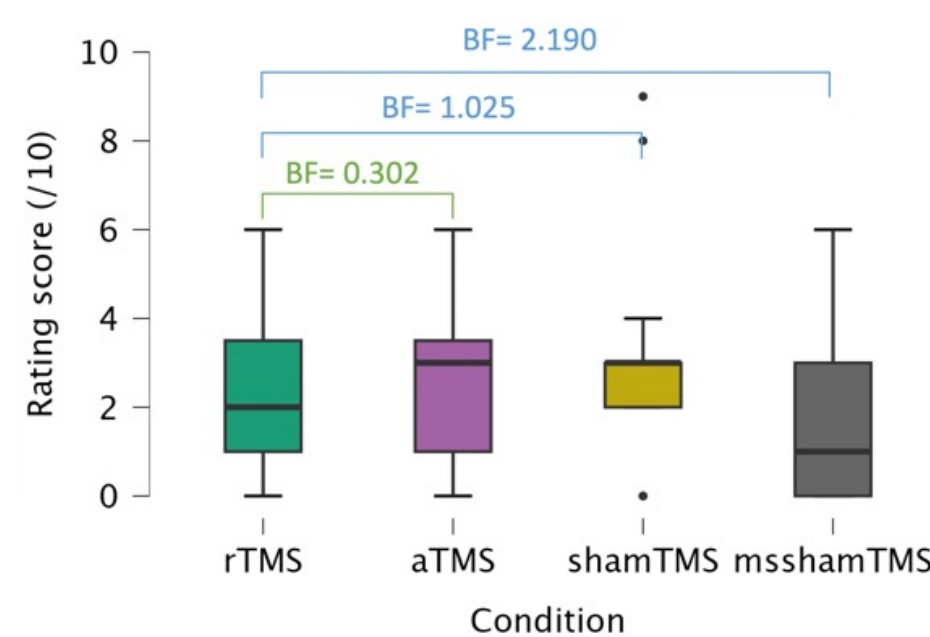


The EEG data supports that aTMS and msshamsTMS entrains lower alpha power and ITPC than rTMS, while shamTMS entrains alpha to a similar level.

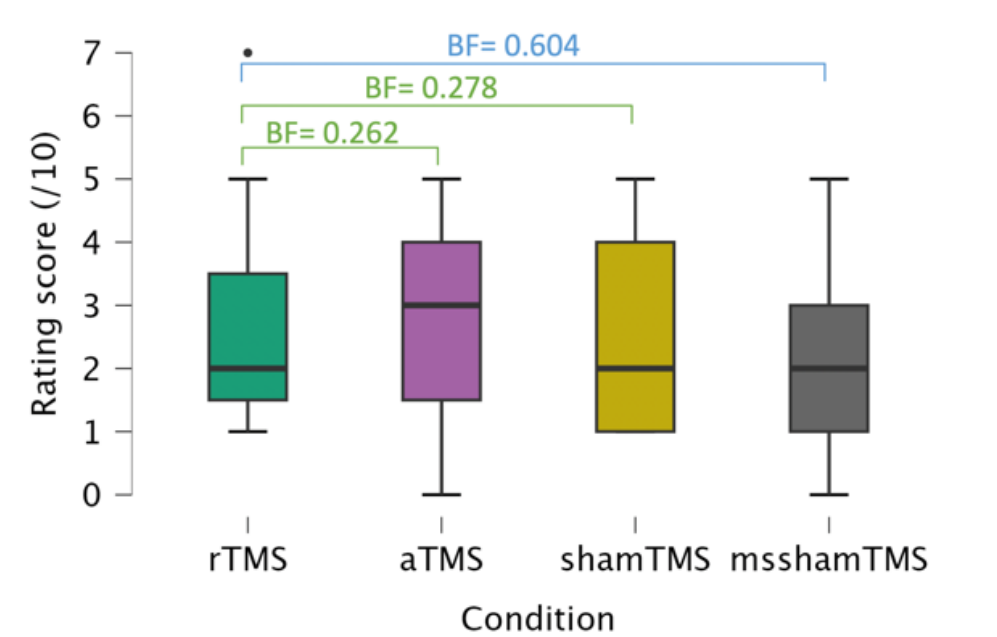
Behavioural Data

Questionnaire Data:

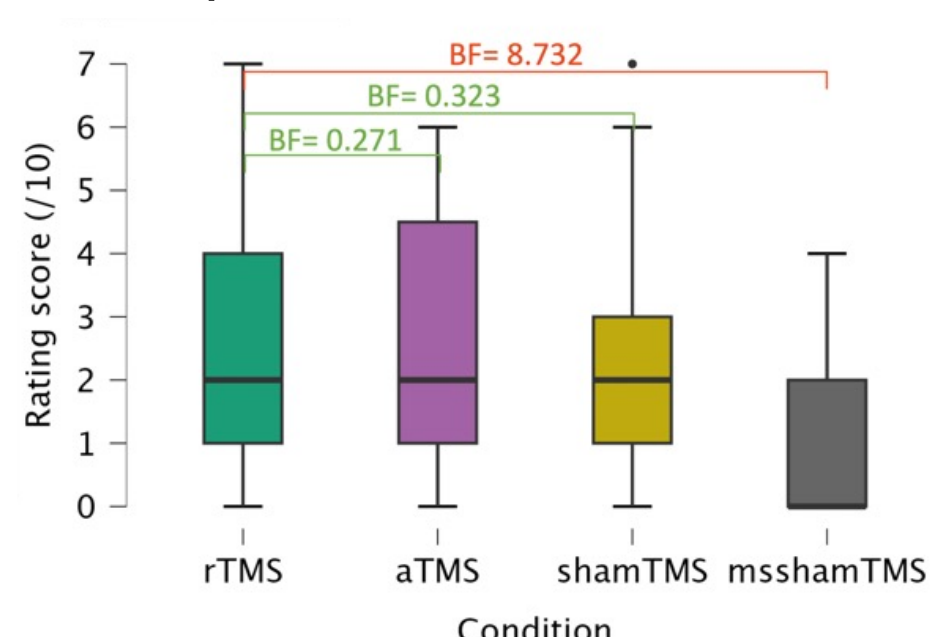
How annoying were the TMS pulses?



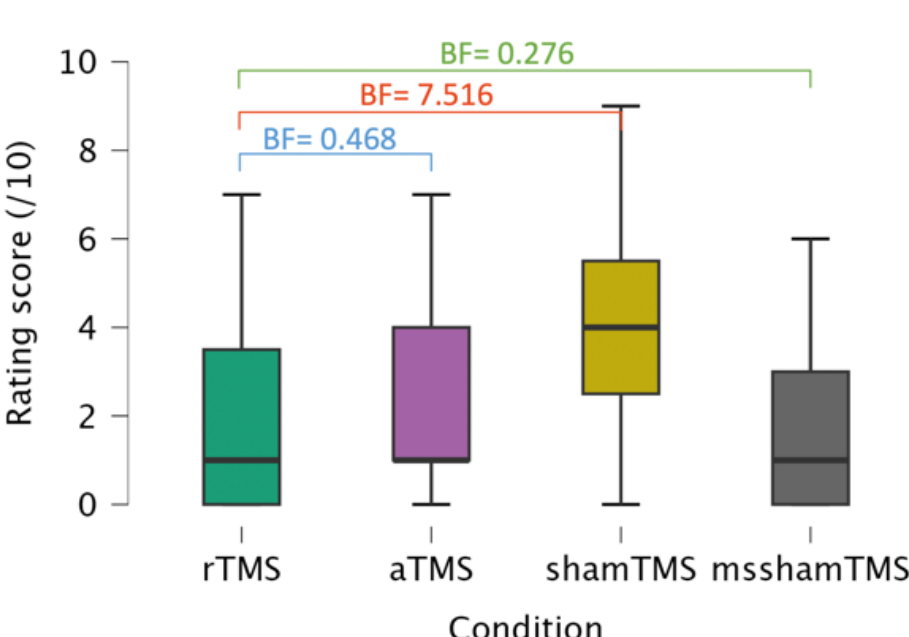
How loud were the TMS pulses?



If painful, how painful were the TMS pulses?



If any twitches, how strong were these twitches?



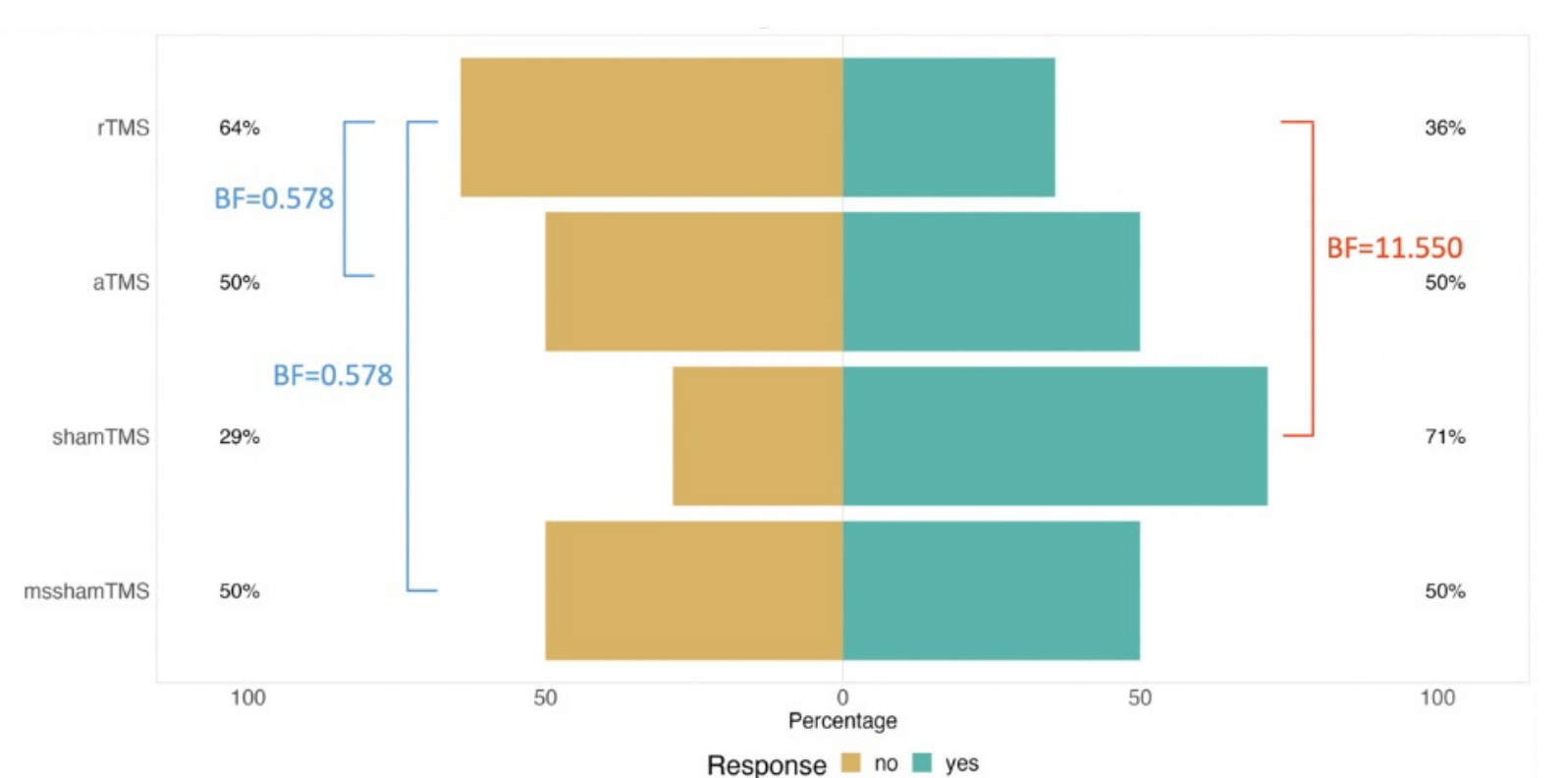
Summary table for questionnaire data:

	aTMS	shamTMS	msshamsTMS
Matched subjective sound	✓ (BF=0.262)	✓ (BF=0.278)	? (BF=0.604)
Matched "painfulness"	✓ (BF=0.271)	✓ (BF=0.323)	✗ (BF=8.732)
Matched "twitchiness"	? (BF=0.468)	✗ (BF=7.516)	✓ (BF=0.276)
Matched persuasiveness	? (BF=0.578)	✗ (BF=11.550)	? (BF=0.578)

Qualitative data summary:

- 11/15 participants ranked the 'strongest' feeling condition as real
- 3/15 participants mentioned some conditions as being 'twitchier' and some conditions as being 'more painful', 3/3 assumed that the twitchier conditions were real.
- 2/15 participants mentioned a change in rhythm between conditions, 1/15 correctly identified the aTMS rhythm as the difference.

Sham guess summary



Conclusion

- This study supports the use of aTMS, and possibly the DuoMAG 70BFP coil when sound matched, as a control condition for rTMS entrainment studies.
- Using the DuoMAG 70BFP coil when not sound matched is not supported by this paper, given the louder sound, higher entrainment, and possible brain activation induced by the periphery of the coil.