Phase difference of bilateral brain stimulation modulates interhemispheric connectivity during binaural integration

Basil Preisig*[1,2,3], Lars Riecke[4], Matthias Sjerps[1,2], Anne Kösem[1,2,5], Benjamin Kop[1], Bob Bramson[1], Peter Hagoort[1,2] & Alexis Hervais-Adelman[3]

[1]Donders Institute for Cognitive Neuroimaging, Radboud University, Nijmegen, the Netherlands; [2]Max Planck Institute for Psycholinguistics, Nijmegen, the Netherlands; [3]Department of Psychology, Neurolinguistics, University of Zurich, Zurich, Switzerland; [4]Department of Cognitive Neuroscience, Faculty of Psychology and Neuroscience, Maastricht University, the Netherlands; [5]Lyon Neuroscience Research Center (CRNL), Brain Dynamics and Cognition Team, Université Claude Bernard Lyon 1, Lyon, France

Introduction

Functional connectivity plays a major role for information encoding, transfer, and integration. Binaural integration describes the phenomenon that different auditory cues presented to the left and the right ear (dichotic listening) can become integrated into a unified percept This phenomenon presumably relies on interhemispheric functional connectivity [1]. In a recent study [2], we found that transcranial alternating current stimulation (TACS) induced changes of gamma phase synchronization modulate interhemispheric speech cue integration. Here, we combined bilateral high-density TACS over the lateral superior temporal lobe with concurrent fMRI to test whether this effect is mediated by changes in effective brain connectivity.

Methods

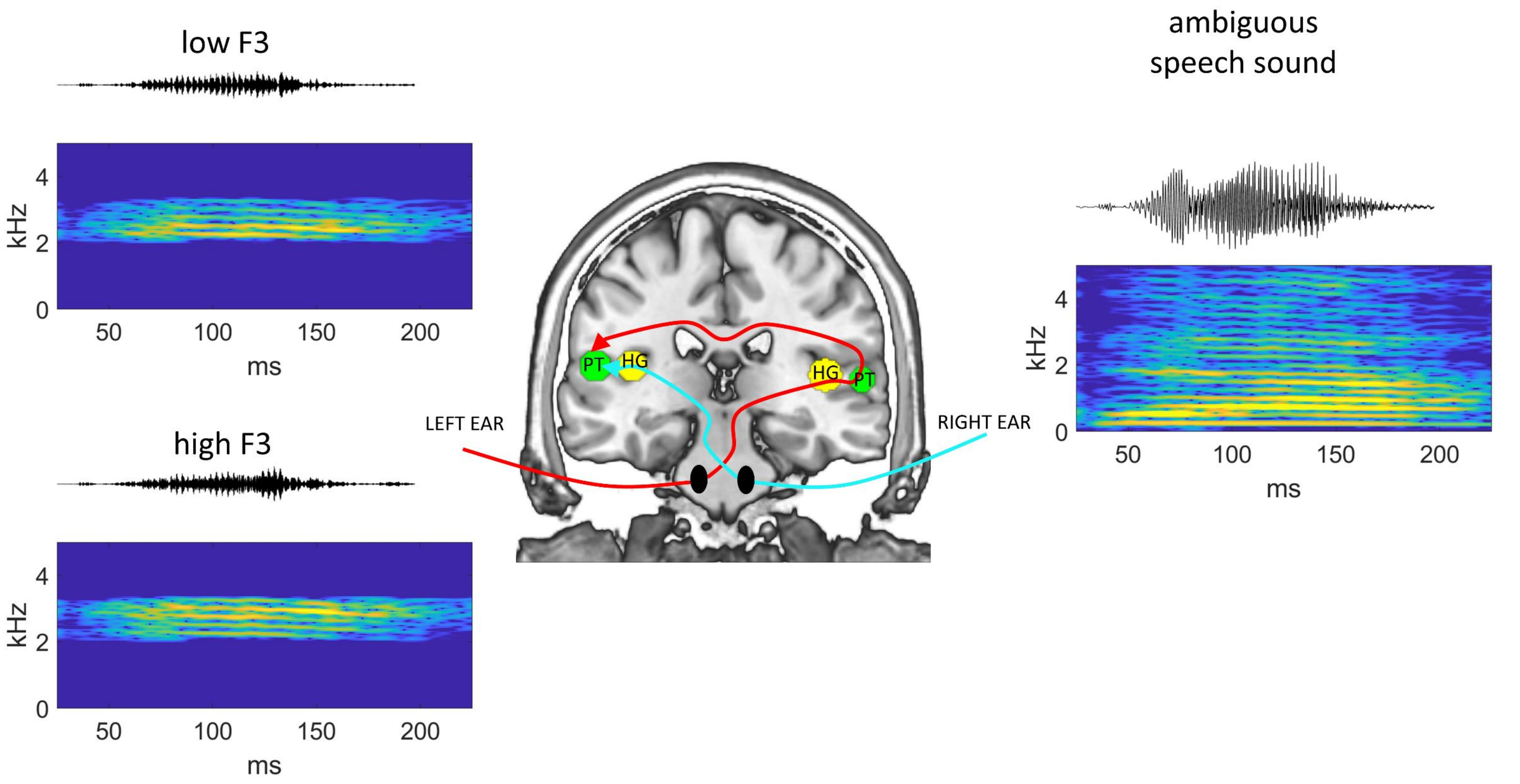

Fig. 1. Center: Dominant processing pathway underlying binaural integration [3]. The red line represents the processing pathway of left-ear speech cue (either high or low frequency third formant (F3)). Left side: Sound pressure waveform and corresponding sound spectrogram of the speech cue presented to the left ear. Left side up: low F3 supporting a /ga/ interpretation. Left side below: high F3 supporting a /da/ interpretation. Right side: Sound pressure waveform and corresponding spectrogram of the ambiguous speech sound presented to the right ear. *Note*. PT: Planum temporal; HG: Heschl's gyrus

Experimental Procedure

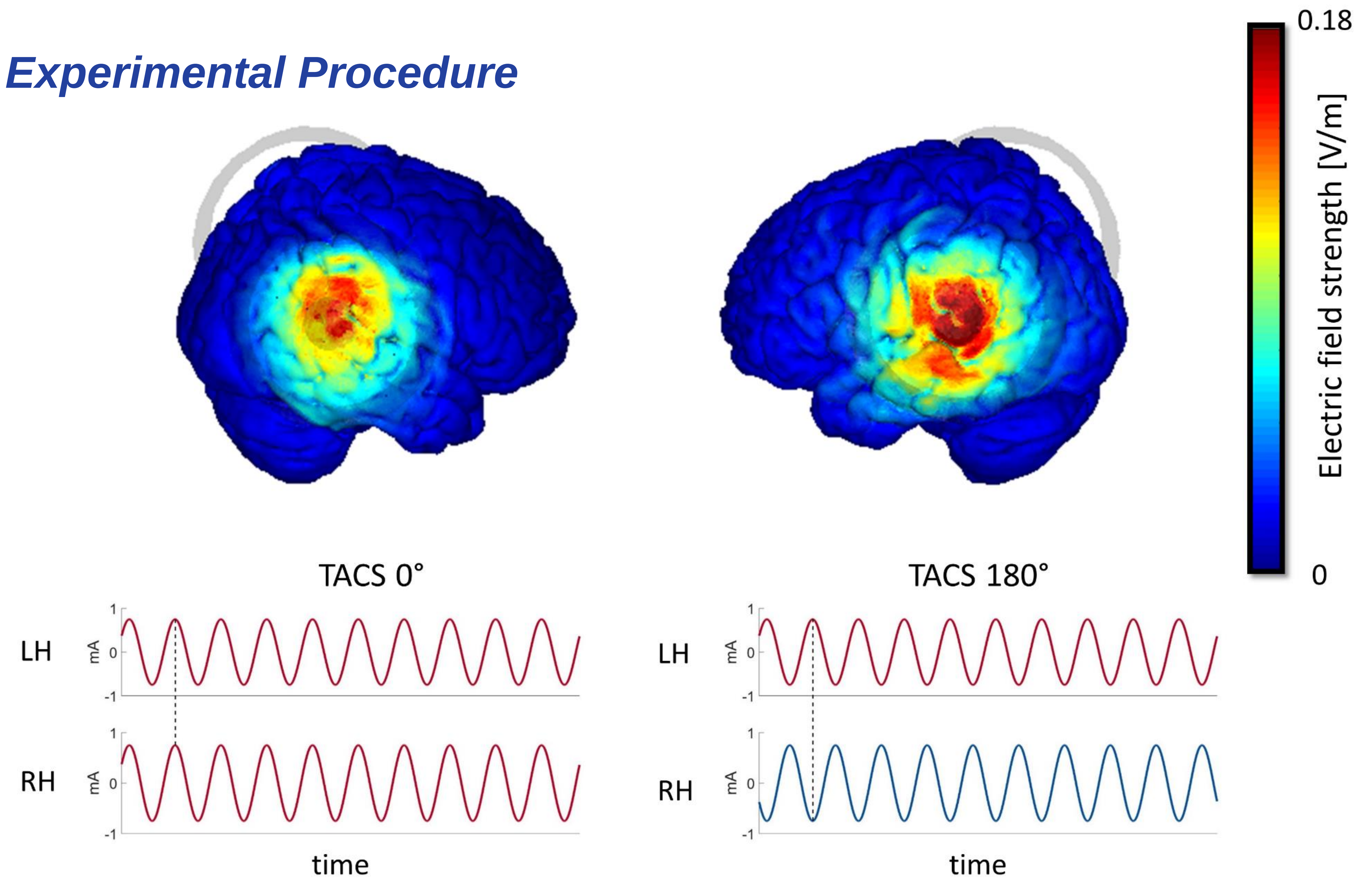

Fig. 2. We applied dual-site high-density (HD) TACS above the left and right supratemporal plane at 40Hz. The interhemispheric phase synchrony was manipulated using TACS with a interhemispheric phase lag of 0° (TACS 0°) and TACS with interhemispheric lag of 180° (dotted line, TACS 180°). The colors represent the polarity (positive = red; negative = blue) of the current for the time stamp highlighted by the dotted line. RH: Right hemisphere; LH: Left hemisphere

- 28 right-handed native-Dutch volunteers (mean age 21.9, 9 male)
- Within-subject design
- 8 task fMRI runs (4 TACS and 4 sham runs)
- 88 task trials per run (60 ambiguous stimuli, 28 unambiguous stimuli)
- Whole brain fMRI data (resolution 2x2x2 mm, 66 slices)
- Multiband sparse sequence (TR=3000 ms, TA=930ms, TE=34ms).
- 128 Volumes per scan run
- 1 additional passive baseline run (336 Volumes, TR=2000ms), at the beginning of the experiment.

Binaural integration

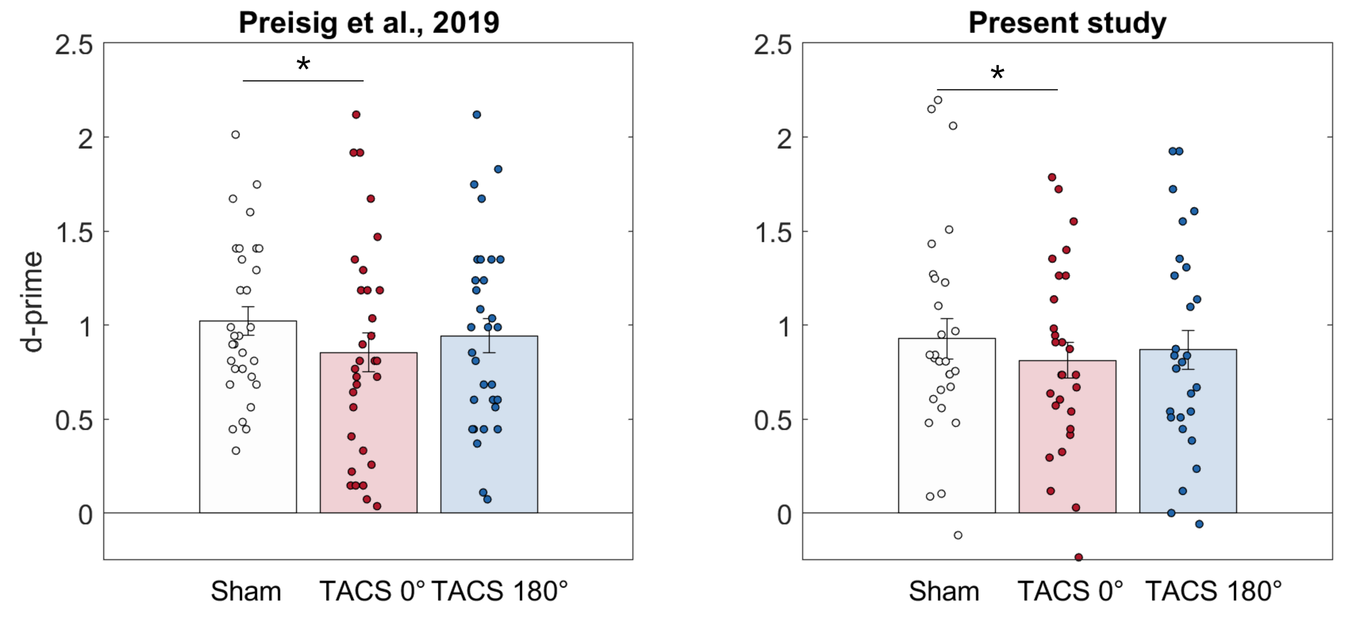

Fig. 3. Binaural integration (d-prime, mean ± SEM) as a function of TACS condition (sham, TACS 0°, TACS 180. In line, with [2, left chart] binaural integration was lower for the TACS 0° condition as compared to sham (paired t-test, p = .036, one-tailed, effect size: d=0.21). Dots represent the data points of single participants.

TACS modulates local brain activity

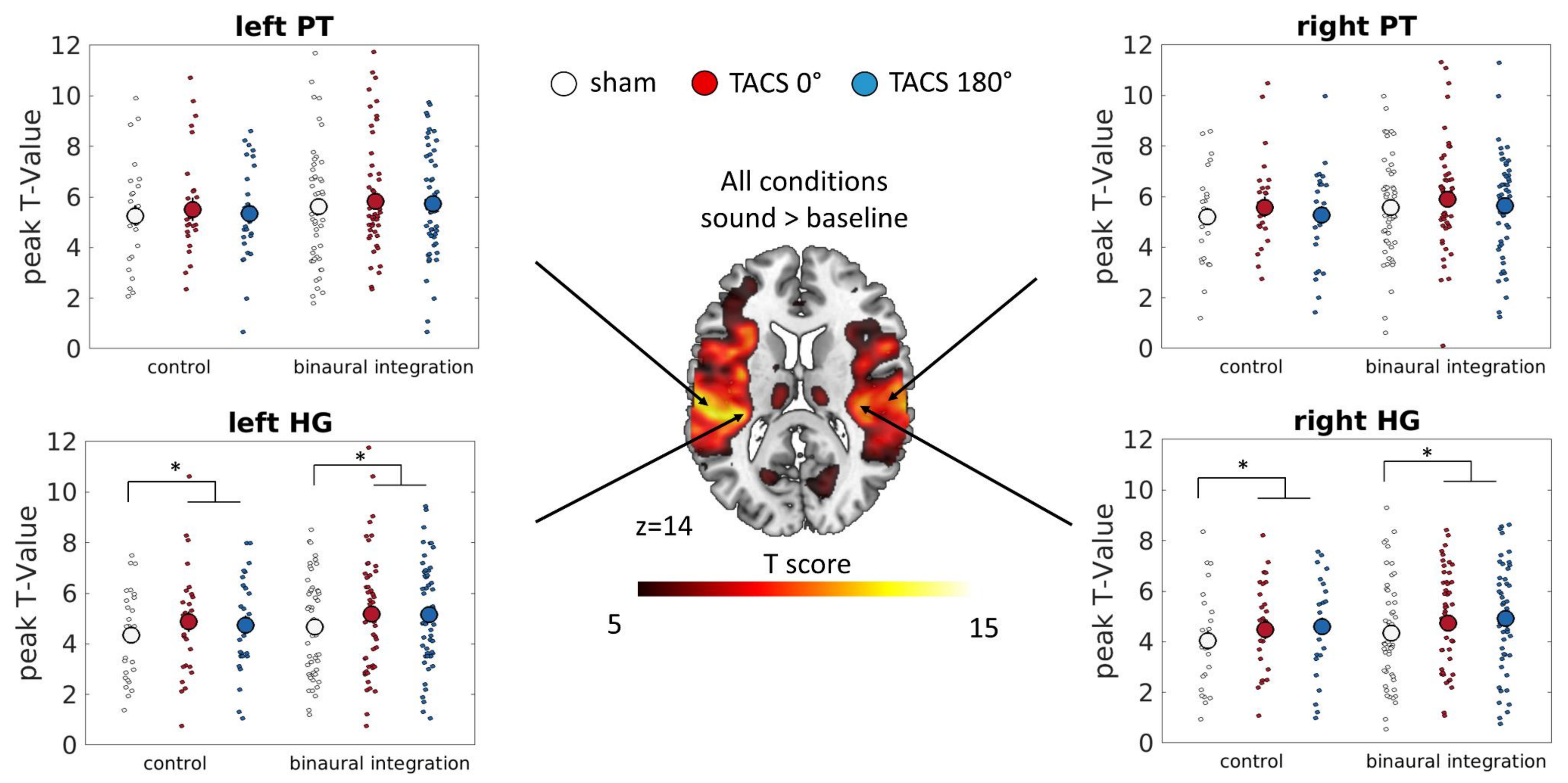

Fig. 4. Stimuli for binaural integration lead to stronger auditory activation than unambiguous control stimuli. Participants' peak voxel activation within the ROI is shown for each stimulation condition (sham, TACS 0°, TACS 180°). Dots represent the data points of single participants. Circle and vertical line represent mean ± SEM across participants.

TACS modulates interhemispheric coupling

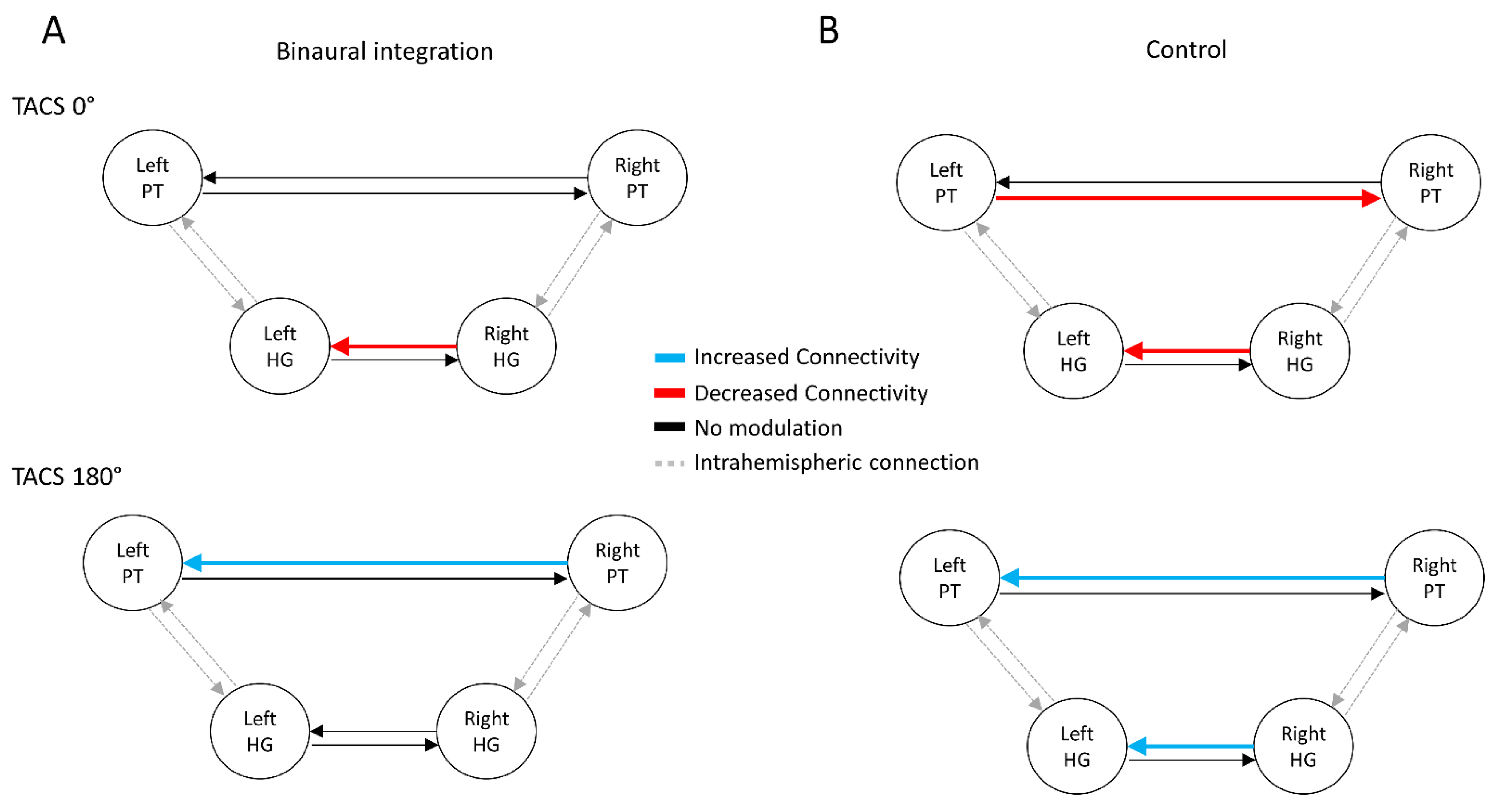

Fig. 5. Dynamic causal modelling (DCM). Connectivity changes induced by TACS 0° and TACS 180° in the (A) binaural integration condition and (B) control condition.

Discussion

The phase of bilateral TACS modulates effective connectivity of interhemispheric connections

TACS 0° decreased interhemispheric coupling and TACS 180° increased interhemispheric coupling

The modulation of TACS 0° on the connection right->left HG in the binaural integration condition correlates with task performance (r=0.41, p=.032). The stronger the perturbation TACS 0°, the lower the proportion of integrated speech cues

Our findings support the notion that interhemispheric transfer of auditory information relies on the oscillatory coupling in the gamma frequency band

References

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@BasilPreisig

basilpreisig@gmx.ch

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