Computational model for the effects of non-invasive transcranial electrical stimulation on speech-in-noise comprehension

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Transcranial electrical stimulation (tES) can non-invasively modulate neuronal activity in humans. Recent studies have shown that tES with an alternating current that follows the envelope of a speech signal can modulate the comprehension of this voice in background noise (Wilsch et al., 2018). However, how exactly tES influences cortical activity and speech comprehension remains poorly understood. Here, we present a computational model for the effects of tES on the cortical coding of speech in noise.

Based on previous work, we established a computational model of a spiking neuronal network that encodes natural speech through entraining network oscillations in the theta and gamma frequency ranges (Hyafil et al., 2015). In agreement with experimental results, the slower theta oscillations reliably predicted the onsets of syllables and provided a temporal reference frame for the faster activity in the gamma band that encoded phonemes. We attempted to use the network's spiking output to classify speech in different levels of background babble noise. The obtained results were comparable to normal human performance, with a 50% speech recognition threshold at approximately -1 dB SNR. Finally, we simulated the simultaneous application of external current with a range of different temporal patterns and stimulation intensities. We thereby observed deterioration or enhancement of the neural coding of speech in noise dependant on the parameters of the applied stimulation.

The developed model provides an insight into the neural mechanisms through which speech in noise can be processed in the human auditory cortex and how tES can enhance this processing. Moreover, our model allows to optimize the temporal pattern of the stimulation for improving speech-in-noise comprehension.

References

Hyafil et al. (2015) Elife, 4, e06213.
Wilsch et al. (2018) NeuroImage, 172, 766-774.

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