No effect of transcranial direct current stimulation over the auditory cortex on auditory-evoked potentials

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Background

Transcranial direct current stimulation (tDCS) is a non-invasive brain stimulation technique to modulate cortical excitability. Various investigations have shown tDCS to modify behavior as well as symptom severity in psychiatric disorders[1,2]. However, the underlying neural mechanisms causing behavioral effects are still hardly understood and results in recent investigations of tDCS effects on auditory processing, i.e. on auditory-evoked potentials (AEP), were inconsistent[3,4]. In these recent investigations, sample sizes were small and reported results restricted to effects after stimulation. Thus, we aimed to investigate the effects of tDCS on auditory processing in more detail by including a larger population compared to earlier publications and by comparing effects of stimulation before, during, and after tDCS application.

Hypotheses

Based on results in earlier studies, we expected an increase of P50 amplitude after anodal compared to sham tDCS as well as a shortening of N100 latency.

Methods

We included 24 healthy subjects in a crossover design to receive anodal or sham tDCS in two sessions with one week apart (Figure 1).

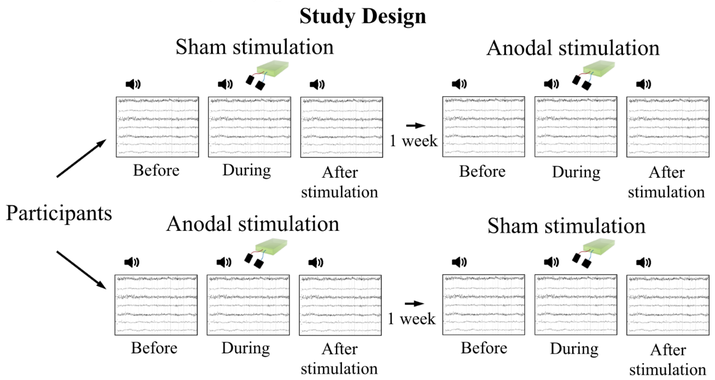

Figure 1: Study design. Participants attended two measurement sessions with one week in between to avoid carry-over effects of stimulation. Order of stimulation was assigned randomly. EEG was recorded during tone presentation at three time points per session: before, during, and after tDCS, respectively.

Stimulation was applied in a double-blind design. During an AEP paradigm (listening to tones), we applied 20 min of tDCS over the left posterior superior temporal cortex, targeting the primary auditory cortex (A1), with the reference electrode placed right supraorbitally (Figure 2).

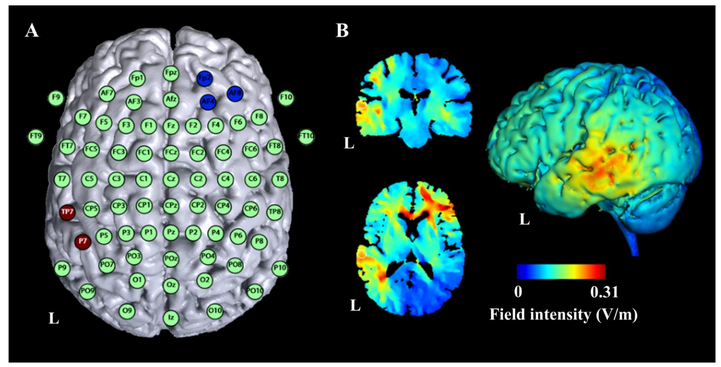

Figure 2: Simulation of tDCS current flow. (A) Montage of tDCS electrodes with anode over TP7 and P7 of the international 10-20 EEG system and reference electrode over Fp2, AF4, and AF8. (B) Simulation of 1 mA current flow with the montage of the current study. L indicates left hemisphere.

Amplitudes and latencies of P50, N100, and P200 AEP were compared between three time points (pre, during, after stimulation) and for two types of stimulation (anodal, sham). An additional topographical analysis of variance (TANOVA) was applied with the same factors to analyze potential global effects of tDCS.

Results

Our results showed no difference in AEP for anodal compared to sham stimulation and no difference in AEP after stimulation compared to baseline. Grand Averages of AEP separately for every condition are shown in Figure 3, mean amplitudes and latencies with standard derivations in Table 1.

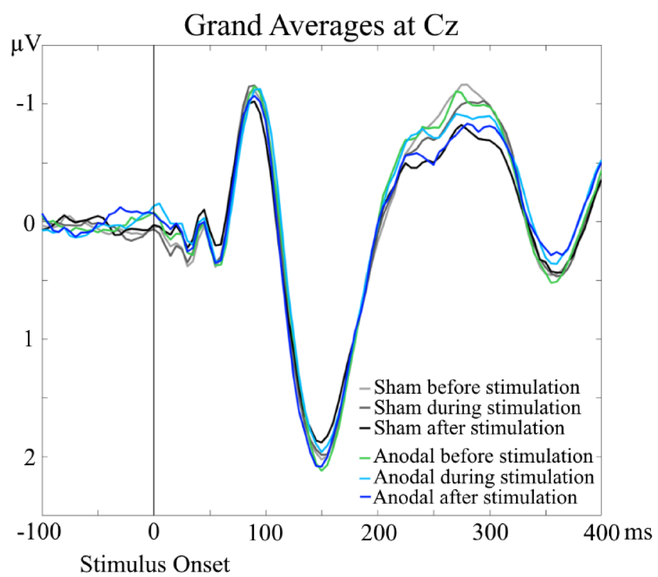

Figure 3: Grand Averages of AEP at Cz electrodes, separately for every condition. No significant differences were evident for P50, N100, and P200 amplitudes and latencies in the AEP analyses.

Additionally, the TANOVA only showed some topographical differences for the different time points at 240-305ms after stimulus onset (topographies for AEP peak intervals are shown in Figure 4).

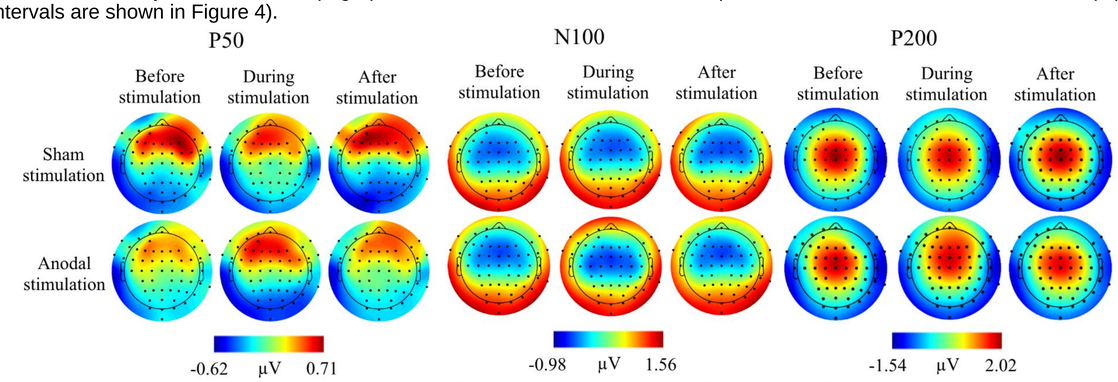

Figure 4: Topographies for grand average AEP of an interval of 55-75 ms for P50 auditory component, an interval of 85-115 ms for N100 auditory component, and an interval of 125-190 ms for P200 auditory component, separately for the different conditions. The peak intervals were identified by grand average AEP.

	P50		N100		P200	
Condition	Amplitudes (µV)	Latencies (ms)	Amplitudes (µV)	Latencies (ms)	Amplitudes (µV)	Latencies (ms)
Sham before	.65 (.52)	57.67 (7.74)	-1.46 (.95)	89.59 (9.69)	2.34 (.69)	150.83 (11.89)
Sham during	.58 (.56)	56.08 (9.17)	-1.41 (.92)	89.92 (8.86)	2.24 (.57)	150.00 (9.66)
Sham after	.47 (.63)	56.71 (10.84)	-1.34 (.81)	89.63 (11.80)	2.19 (.74)	150.29 (13.54)
Anodal before	.62 (.69)	60.79 (7.24)	-1.45 (.93)	90.46 (10.55)	2.34 (.73)	153.54 (9.72)
Anodal during	.56 (.67)	58.63 (9.75)	-1.43 (1.03)	91.63 (11.49)	2.20 (.58)	151.46 (9.35)
Anodal after	.58 (.62)	58.25 (9.68)	-1.48 (.75)	89.83 (12.67)	2.39 (.93)	148.50 (8.76)

Table 1: Mean amplitudes and latencies (standard derivation in brackets) of P50, N100, and P200 for the different conditions.

Discussion

In contrast to our hypotheses, anodal tDCS did not change AEP when applied over the left posterior superior temporal cortex to target A1. Potential reasons for the negative findings could be the tDCS electrode montage or other parameters related to stimulation. Furthermore, we cannot exclude potential effects of cathodal stimulation that we might have missed due to our study design. The late effect we found for topographies for the different measurement time points reflects a habituation effect.

Conclusion

We were not able to replicate earlier results even when investigating the expected effects of tDCS in a larger cohort and with a longer duration of stimulation. Our results suggest that tDCS fails to substantially modify basic processing in the auditory cortex.

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