Improving visual functions in amblyopia and mild myopia with perceptual learning and concurrent transcranial random noise stimulation

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Introduction

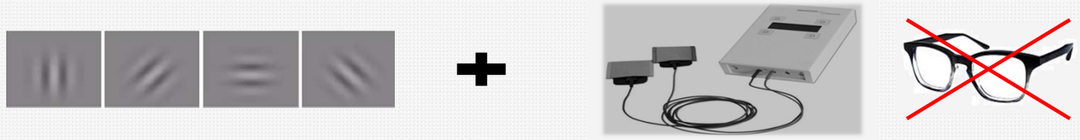
- Perceptual learning has been shown to improve visual functions in both cortical (e.g., amblyopia, Levi & Li, 2009; Polat et al., 2004; Zhou et al., 2006) and non cortical visual deficits (e.g. refractive defects such as myopia or presbyopia, Camilleri et al., 2014a; Polat, 2009). Limitations: it requires a large number of sessions, increasing the chance of drop-out or low compliance.
- Online high-frequency transcranial random noise stimulation (hf-tRNS) over the occipital cortex has recently been proven to boost the effects of PL in healthy participants (Fertonani et al., 2011; Pirulli et al., 2013).
- Aim of this research was to investigate whether a brief perceptual training (8 sessions) using a contrast detection task combined with online hf-tRNS is effective in improving visual acuity (VA) and contrast sensitivity (CS) in participants with mild myopia or amblyopia.

Method

Experiment 1 – Myopia

Participants. 30 participants (age range: 19-29 years) with mild myopia (max -2 Diopters):
3 groups: Training + hf-tRNS (N=10) vs. Training + Sham (N=10) vs. hf-tRNS only (N=10).

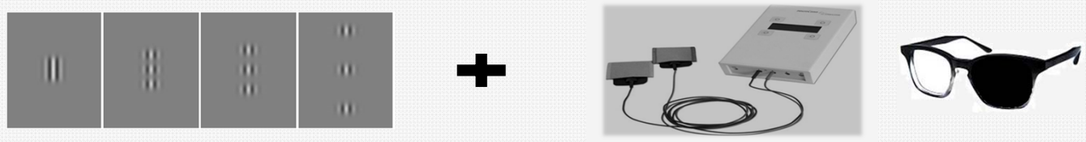
Experimental Procedure. Pre- and post tests (VA and CS) and training were administered binocularly and with no optical correction.
Perceptual training: 2IFC contrast detection task regulated by a staircase procedure (Levitt, 1971). 8 sessions. Each session was made of 8 blocks, each containing 60 trials, thus lasting ~ 45 minutes.. Orientation was changed every 2 sessions.
Brain stimulation: hf-tRNS (100-640 Hz @ 1.5mA) or sham stimulation over Oz during the first 5 blocks (~ 25 mins of stimulation).
Participants in the hf-tRNS only group were administered 8 sessions (days) of hf-tRNS (~ 25 mins of stimulation) with no concurrent perceptual training.



Experiment 2 – Amblyopia

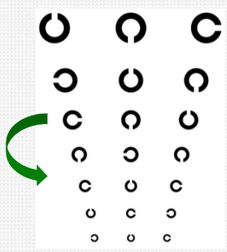
Participants. 17 participants with anisometric amblyopia (age range: 26-52 years).
2 groups: Training + hf-tRNS (N=9) vs. Training + Sham (N=8).

Experimental Procedure: Pre- and post-tests (VA and CS) were administered monocularly on either eye and with the best optical correction. Perceptual training was also administered monocularly on the amblyopic eye with the best optical correction.
Perceptual training: 2IFC contrast detection task regulated by a staircase procedure (Levitt, 1971). Since cortical lateral interactions between collinear detectors have been shown to be impaired in amblyopic patients (Polat et al., 2004), here a lateral masking contrast detection training was used (with 1.5, 3, 4 and 8 λ, varied every 2 blocks). Orientation was changed every 2 sessions (days).
Brain stimulation: hf-tRNS (100-640 Hz @ 1.5mA) or sham stimulation over Oz during the first 5 blocks (~ 25 mins of stimulation). In both groups each participant underwent 8 sessions (days) of training. Each session was made of 8 blocks, each containing 60 trials, lasting approximately 45 minutes.



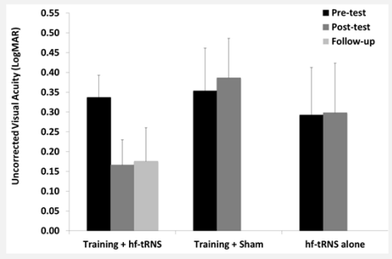
Conclusions

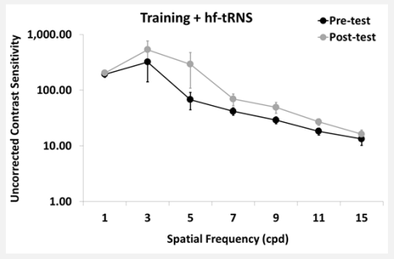
- Results indicate an effect of hf-tRNS in boosting perceptual learning of contrast detection and its transfer to VA both in individuals with mild myopia and with amblyopia.
- In both experiments there was an improvement of **nearly 2 LogMAR lines.**
- While for amblyopia the candidate neural mechanism is a modification of dysfunctional lateral interactions between detectors, in myopia an increase in contrast sensitivity could overcome the blurred signal caused by optical defocus.

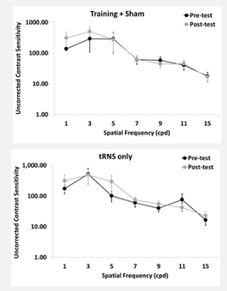


Results

Following 8 training sessions combined with hf-tRNS, uncorrected **Myopic** participants showed a significant improvement ($p<.01$) in uncorrected VA (0.17 logMAR) and CS at intermediate/high spatial frequencies (3-11cpd; $p<.05$). No significant changes were seen in either the Training + Sham group or in the hf-tRNS only group (except for a significant CS improvement at 9cpd for the hf-tRNS only group). Improvement in VA (Training + hf-tRNS group) was maintained at 2 months follow-up.







Following 8 training sessions combined with hf-tRNS, best-corrected **Amblyopic** participants showed a significant improvement ($p<.001$) in VA (especially for the amblyopic eye: 0.18 logMAR, $p<.05$), and CS ($p<.05$) at all spatial frequencies except for 0.2 cpd. Improvement in VA was maintained at 3 months follow-up. No significant changes were seen in the Training + Sham group.