Alternating current stimulation differently modulates phoneme perception in young and older adults

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Theoretical Background

- Speech is mainly built up on temporal information and less on spectral information.
- Successful speech processing relies on short temporal information representing phoneme features.
- Perception of phonemes is determined by voice onset time (VOT).

![Spectrograms of CV syllable /da/ and /ta/](image1)

Figure 1: spectrograms of CV syllable /da/ and /ta/

- Neural oscillation patterns are essential in processing speech specific temporal features:
  - Gamma band (40 Hz): reflects processing of short temporal information (i.e. phonemes).
  - Theta band (6 Hz): corresponds with processing of supra-segmental information (i.e. prosody, intonation contour).
- Transcranial alternating current stimulation (tACS) synchronizes endogenous neural oscillations by inducing oscillations of a specific frequency.
- A pilot study shows specific alterations in VOT perception even after short stimulation period: VOT stimuli were categorized less precisely and less congruent in the 40Hz-tACS compared to 6Hz-tACS.

Study Aims

- Modulate phoneme perception by inducing speech specific oscillation patterns by means of tACS.
- Assessing age-specific susceptibilities to tACS.
- Develop and evaluate intervention to improve speech processing and perception in subjects with impaired language skills (i.e. dyslexia, older adults, aphasia, ...)

Study Design

Sample:
- Young adults (YA): 20-34 years (n = 14, M = 24.29)
- Older adults (OA): 66-76 years (n = 14, M = 70.24)
- Healthy, right-handed, normal hearing acuity
- No professional music education
- German / Swiss German native speakers, no bilinguals

Stimulus material:
- 21 consonant-vowel syllables (CV):
- VOT continuum: 1ms steps from /da/ to /ta/

TACS procedure:
- Single-blind pseudo-randomized stimulation (within-subject design)
- 5 x 7cm electrodes over T7 / T8 (Fig. 2)
- Frequencies: 6 Hz (theta band) and 40 Hz (gamma band)
- Stimulation intensity below individual lower threshold for skin sensations:
  - 6 Hz: M= 1.432 mA, SD= 0.435 mA
  - 40 Hz: M= 1.3768mA, SD= 0.429 mA

Procedure

Task:
- Auditory categorization task, random presentation of 8 x 21 CV
- Two sessions within an interval of one week (avoid carry over effects)
- Each session comprises of:
  - sham 1 (baseline)
  - three IACS runs
  - sham 2 (perceptual learning)
- TACS-frequencies are balanced between sessions

Preliminary Data

![Regression coefficients](image2)

Figure 4: Regression coefficients. A: young adults; B: older adults

![Event related potentials](image3)

Figure 5: Event related potentials. A: frequency specific effects (1: VOT 20-22, 2: VOT 38-40); B: learning effects (1: YA, 2: OA)

Discussion

- TACS age-specifically influences perceptual learning in YA and OA
- TACS selectively modulates ERPs in YA (P2) and OA (P50, N1)
- Next steps:
  - Complete data acquisition
  - Investigate individual susceptibility to IACS, learning curve and related neurophysiologic activation pattern (ERP)
  - Assess gamma / theta power before and after IACS procedure
  - Include control groups to distinguish learning effect and frequency specific modulation

References

4 Rufener, K. et al. (in prep.), 40Hz-tACS selectively modulates speech processing.

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