Testing the Motor Simulation Theory in Processing Canonical and Non-Canonical Finger Numeral Configurations

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ABSTRACT

We tested the hypotheses that

- the previously found behavioral and ERP differences in processing canonical and non-canonical finger numeral configurations are due to differential recruitment of pre-existing motor schemas for canonical configurations
- motor simulations are involved in processing canonical finger-numeral configurations

The evidence did not support these hypotheses.

INTRODUCTION

Canonical (CC)

Non-Canonical (NC)

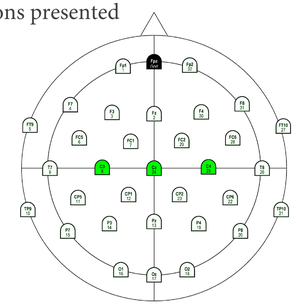
We studied two types of finger numeral configurations :

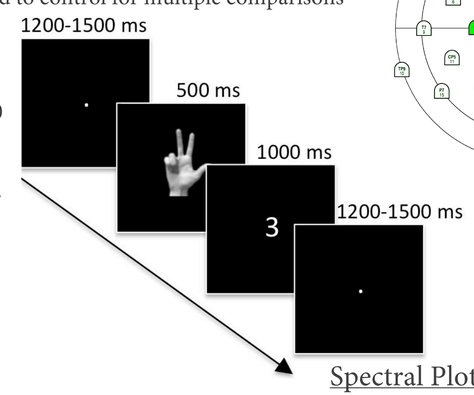
- **Canonical** (CC; finger counting) is used both for counting and arithmetic, and has a self-directed, facilitative function.
- **Non-canonical** (NC) are configurations that are usually used not used for counting.

- Previous studies have reported behavioral differences in processing canonical and non-canonical finger numeral configurations[1][2].
- A **motor simulation hypothesis** was proposed to explain these behavioral performance differences [3]: When processing CC a motor simulation mechanism is more readily engaged, whereas this may not be the case for NC, since the generation of the finger numeral configurations presented is not part of the participants' motor repertoire.
- **Mu suppression**, modulation of 8-13 Hz spectral response over central sites, has been used as a measure for involvement of motor simulations across a wide range of tasks [4].
- We tested the **motor simulation hypothesis** by conducting an **ERSP** (Event-Related Spectral Perturbation) and **spectral analyses**, specifically focusing on mu suppression.
- We predicted higher mu suppression when processing CC compared to NC, since CC is hypothesized to trigger motor simulations.

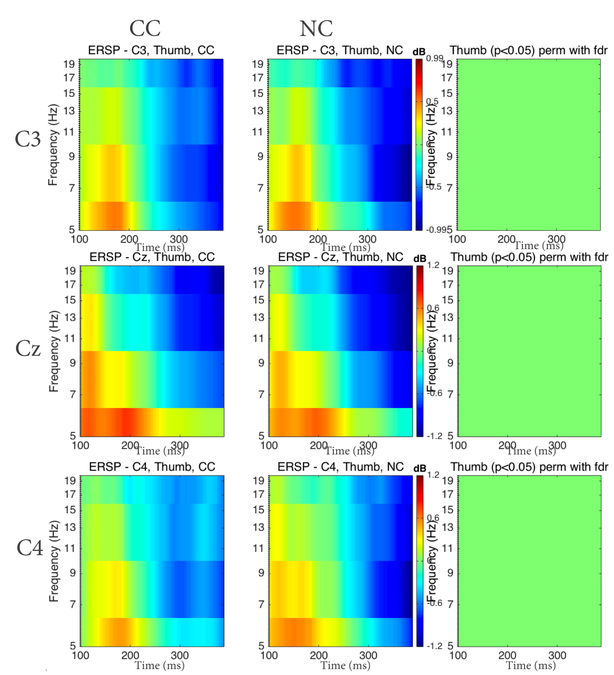
METHODS

- 20 right-handed, native English speaking undergraduate students (13 female, M=19.68 years, SD=1.84)
- All participants had finger counting habits compatible with the canonical configurations presented
- 32-Channel Brainvision ActiChamp EEG system
- EEGLAB was used for analysis.
- Data from the three central sites (C3, Cz, & C4) were analyzed
- FDR correction (p-threshold = 0.05) was used to control for multiple comparisons
- Stimuli: 8 pictures for each condition, showing numerosities from 1 to 4, with the left and the right hand.
- 320 trials for each condition, mixed across 10 blocks.
- Task: Observe the finger numeral configuration for 500 ms and decide whether the Arabic numeral shown in the validation step matches the finger configuration by clicking on of the two buttons.
- Data is publicly available [5]

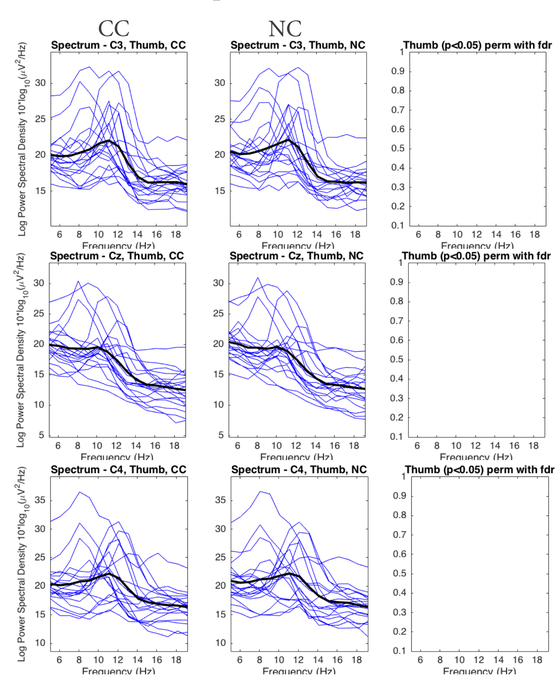




ERSP Plots



Spectral Plots



CONCLUSIONS/SIGNIFICANCE

We found no evidence for mu suppression differences between processing canonical and non-canonical finger numeral configurations. Therefore, the evidence so far does not seem to support differential involvement of motor simulations in processing canonical finger numeral configurations.

FUTURE DIRECTIONS

- The data set used [5] involves 500 ms epochs, which are suitable for ERP analysis but not ideal for conducting ERSP/spectral analysis due to the short epoch durations. In a future study, we would like to re-test the simulation hypothesis by using a paradigm specifically tailored for ERSP/spectral analysis, with longer epoch durations.
- An alternative paradigm can involve video clips of finger counting actions, since mu suppression is known to be more sensitive to observed actions compared to still images.
- An fMRI paradigm should also be considered, since it would allow comparison of BOLD response over motor areas during processing of canonical and non-canonical configurations.

REFERENCES

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