



ERP Markers for Number Gesture Processing

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Abstract

ERP markers for recognition of montring, counting, and unconventional number gestures were compared. Behavioral results showed montring gestures were recognized faster and more accurately. The ERP results showed that recognition of montring configurations drew larger attentional resources, marked by higher positivity in the P1/N1 range, and montring and counting showed similar patterns of semantic processing, marked by higher positivity in the P3 range. Overall the results support the hypothesis that canonical finger numeral configurations acquire symbolic meanings and are associated with numerical magnitudes.

Introduction

- Finger-based representations used to indicate numerosities, count, and do arithmetic across cultures
- Research distinguished two forms of finger configurations: **finger montring and finger counting** (Wasner, Moeller, Fischer, & Nuerk, 2015)
- Montring (MC)** used to represent cardinal numerosities and serves a communicative function
- Counting (CC)** is ordinal in both for counting and arithmetic

Montring

Counting

Unconventional



Figure 1. Stimuli showing the montring (MC), counting (CC), and unconventional (UC) number gesture configurations.

- Canonical finger configurations (**MC & CC**) are identified faster and more accurately but no neuroimaging data yet
- It is not clear if these effects are due to faster recognition or differences in representation of numbers
- Event related potential (ERP) technique is ideal for comparing the processing of finger gestures given its high temporal resolution (Luck, 2014)
- This study compares the ERP markers for recognition of montring (MC), counting (CC), and unconventional (UC) number gestures**

Methods

Participants

- 22 right-handed, native English speaking (13 female, M=20.47 years)

Stimuli & Task

- Finger counting and finger montring habits data collected
- 24 pictures (4 x Condition x Right or Left)
- Gestures presented for 500 ms followed by an Arabic numeral (see figure 2)
- Participants pressed one of two controller buttons to indicate match or mismatch
- 10 blocks of 96 trials (counterbalanced responses)

EEG

- Recorded using BrainVision 32 Channel ActiChamp system
- 10/20 International Standard of Electrode Placement
- Electrode impedance was kept under 10 k Ω
- Sampling rate 0.5-70 Hz, 500 samples/sec

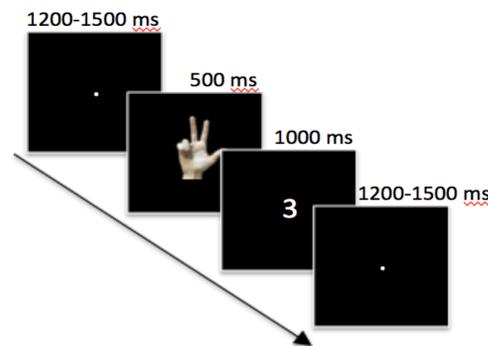
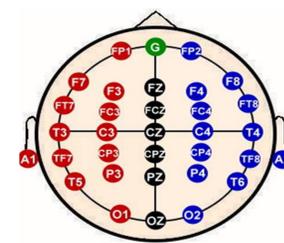


Figure 2. Stimulus presentation order for each trial.



Results

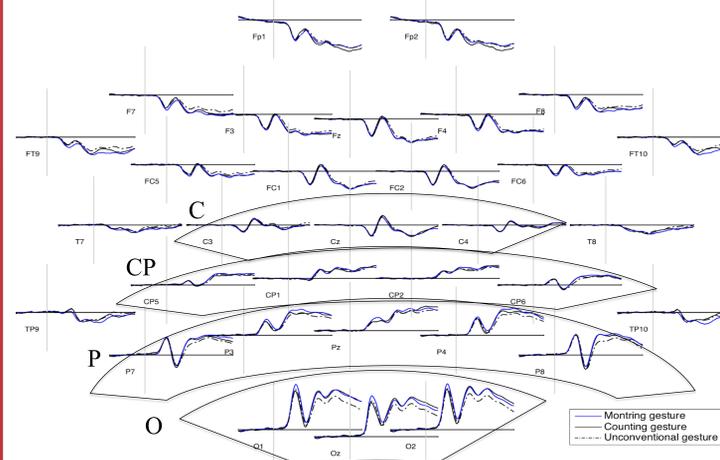


Figure 3. ERPs across 32 electrodes. Four caudal areas are grouped O (O1/z/2), P (P7/3/z/4/8), CP (CP5/1/2/6), C (C3/z/4).

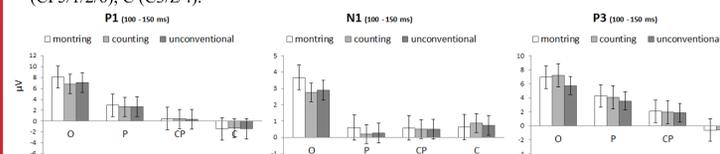


Figure 4. Average amplitudes (μ V) for the three conditions (montring, counting, unconventional), across the three intervals (P1, N1, P3) and four electrode sites (O, P, CP, C)

Behavioral Data

- A one-way ANOVA showed a significant effect on accuracy and reaction time between MC and CC as well as MC and UC (pairwise comparisons $p < .005$)

EEG Data

- Electrodes were grouped into four caudal areas as O (O1/z/2), P (P7/3/z/4/8), CP (CP5/1/2/6), C (C3/z/4)
- Time intervals
P1 (100 – 150ms) & N1 (150 – 210ms)– visually evoked potentials
P3 (250 – 500ms) – modulated by levels of attention
- A 4 x 3 ANOVA (area: O, P, CP, C x condition: MC, CC, UC) showed an effect of both area and condition as well as an interaction between condition and area for all intervals
- Pairwise comparisons showed that the ERPs for processing of MC gestures showed larger P1 and N1 effects compared to CC and UC
- P3 showed a different pattern where MC and CC overlapped, showing higher average amplitudes

Conclusions

- Montring configurations identified faster and more accurately than counting and unconventional configurations as seen in previous research (Di Luca et al., 2010)
- Differences in ERP markers across the three finger configurations were found
- Montring showed higher P1/N1 positivity compared to counting and unconventional, which points to early perceptual processing and attention related differences
- Montring and counting showed similar P3 signatures, distinguished from unconventional with significantly higher positivity, which points to similar semantic processing of canonical configurations

Significance

- The findings provide support for the proposal that canonical number gestures acquire symbolic numerical meanings, like Arabic numerals, during development (Di Luca et al., 2010)
- The effects can be observed both in modulation of attentional resources during early perceptual processing as well as in later semantic processing
- These results suggest canonical number gestures can be used as tools in the development of number sense in children**

References

- Di Luca, S., Lefèvre, N., & Pesenti, M. (2010). Place and summation coding for canonical and non-canonical finger numeral representations. *Cognition*, 117(1), 95–100.
- Luck, S. J. (2011). Electrophysiological Correlates of the Focusing of Attention within Complex Visual Scenes: N2pc and Related ERP Components. In *The Oxford Handbook of Event-Related Potential Components*. Oxford University Press.
- Wasner, M., Moeller, K., Fischer, M. H., & Nuerk, H.-C. (2015). Related but not the same: Ordinality, cardinality and 1-to-1 correspondence in finger-based numerical representations. *Journal of Cognitive Psychology*, 27(4), 426–441.

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