Effect Of Shared Components In Fraction Comparisons

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Introduction

Fractions
- Difficult for students to master but key for overall math achievement (Siegler, Fazio, Bailey, & Zhou, 2013)
- One of these difficulties is managing the potential conflicting numerical information from components

The N400
- An event related potential (ERP) difference wave observed during semantic incongruence
- Paradigm used in language processing also adapted to numerical tasks
- N400 will be used to examine the role that shared components play in a fraction magnitude comparison task

Methods

Participants
- 30 participants will be recruited

Task
- Participants will judged whether a probe fraction has the same magnitude (Match vs. Mismatch) as a target fraction (see *Table 1*)
- A further division will be made based on the presence of shared components making groups MatchShared (MAS), MatchNonshared (MANS), MismatchShared (MMS), and MismatchNonshared (MMNS)
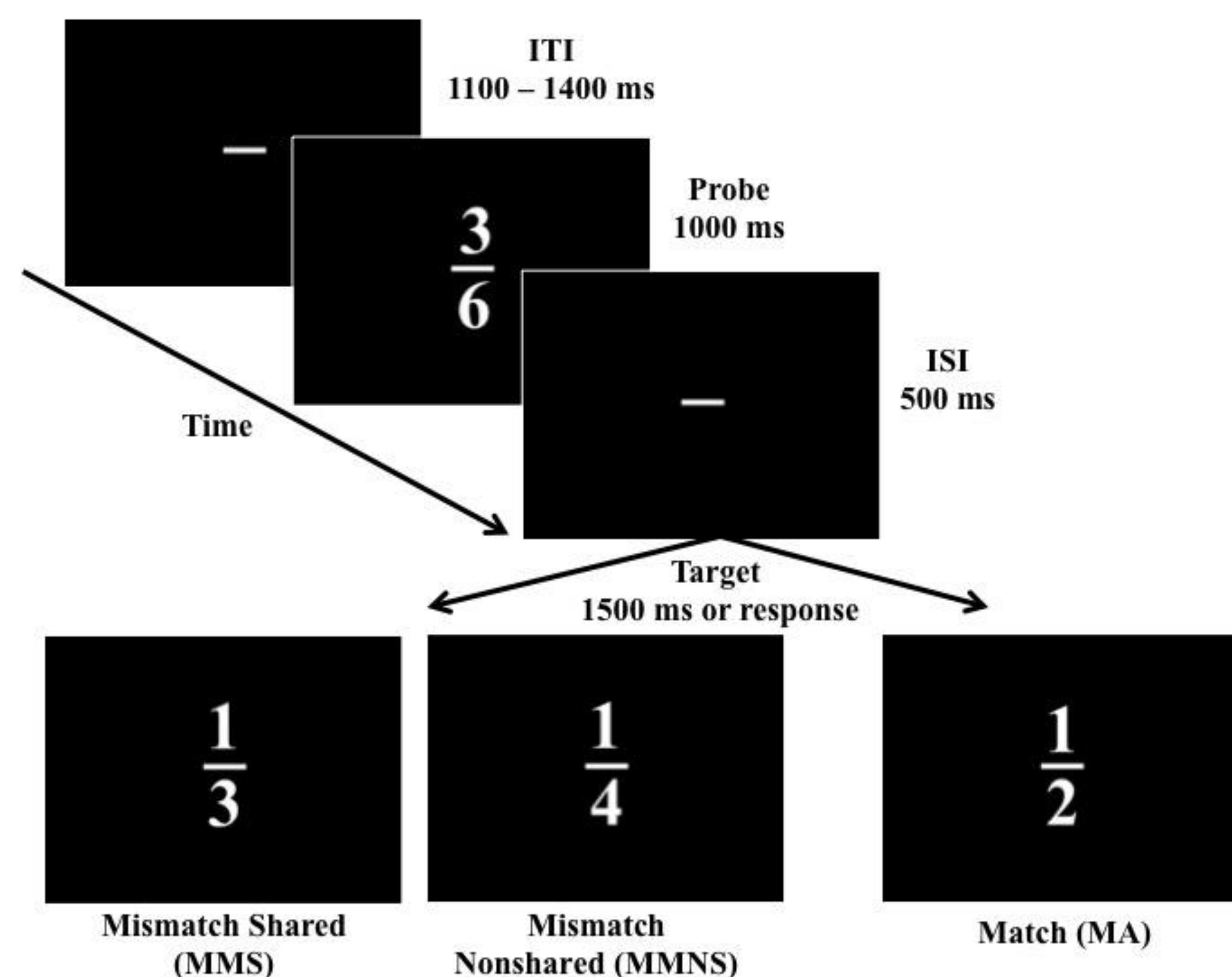- Participants will complete 600 randomized trials

Figure 1. Experimental progression of a Match (MA) or Mismatch (MM) trial showing a MismatchShared(MMS), MismatchNonshaed(MMNS), and MatchNonshared for 1/3, 1/4, and 1/2 respectively.

Methods (continued)

MatchShared (MAS)		MatchNonshared (MANS)		MismatchShared (MMS)		MismatchNonshared (MMNS)	
Probe	Target	Probe	Target	Probe	Target	Probe	Target
2/4	1/2	3/6	1/2	2/3	1/2	3/4	1/2
3/9	1/3	2/6	1/3	3/4	1/3	4/5	1/3
4/16	1/4	3/12	1/4	4/5	1/4	5/6	1/4
5/25	1/5	2/10	1/5	5/6	1/5	2/3	1/5

Table 1. Full set of fraction pairs used as stimulus for fractions 1/2, 1/3, 1/4, and 1/5 in all four groups. MatchShared (MAS) fraction pairs match in numerical magnitude and share a common component, MatchNonshared (MANS) pairs match in numerical magnitude without common component, MismatchShared (MMS) pairs don't match in numerical value but share a common component, and MismatchNonshared (MMNS) don't match in numerical value and don't share a common component.

Electrophysiology
- EEGs will be recorded using a 32-channel system
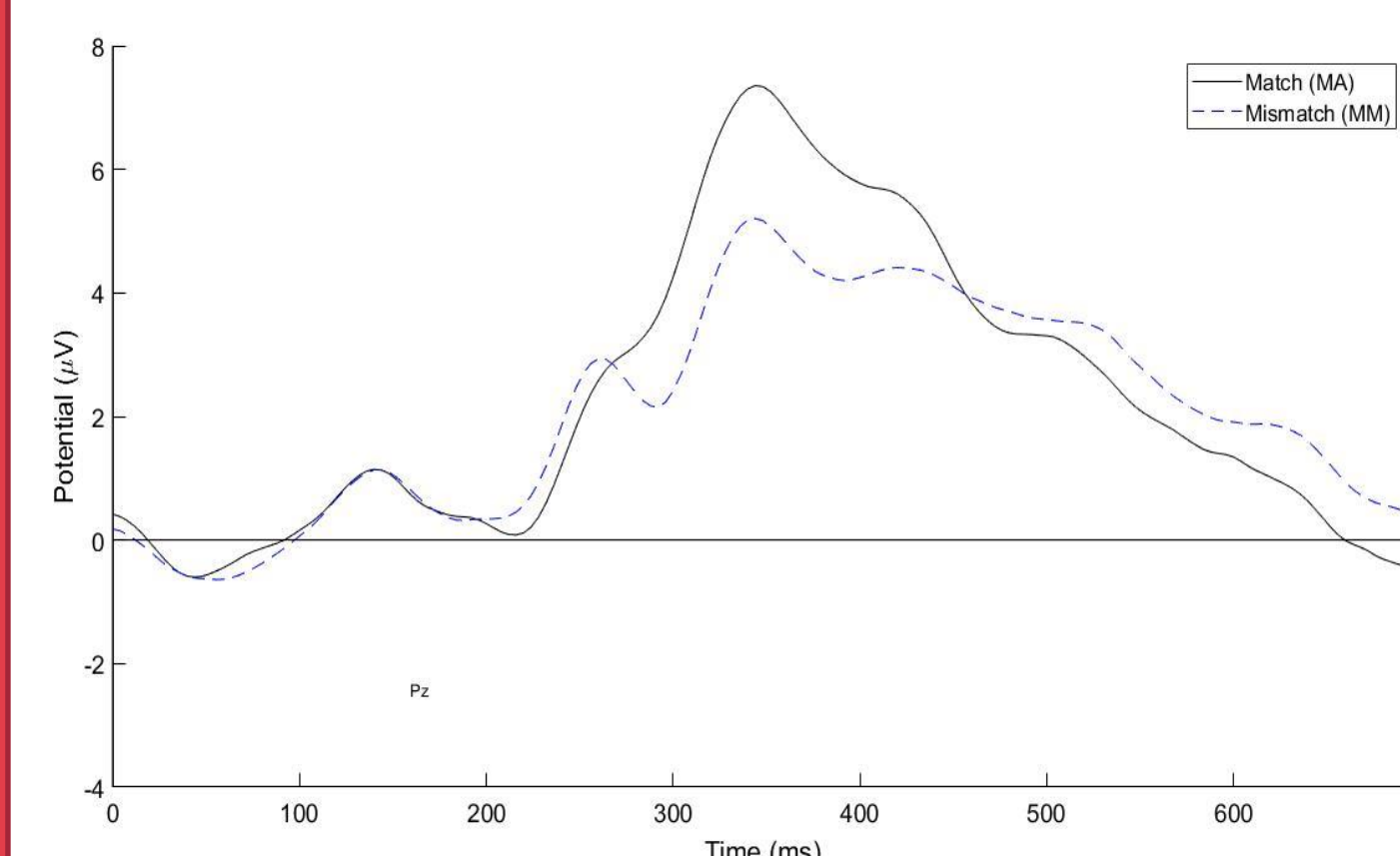- ERPs will be calculated for Match and Mismatch conditions across Shared and Nonshared groups

Figure 2. Typical ERP average waveforms for electrode Pz showing the N400 effect.

Figure 3. 32 electrode EEG cap used in ELDEN lab.

Data Analysis & Expected Results

Behavioral Analysis & Expected Results
- A condition (Match/Mismatch) x component (Shared/Nonshared) interaction is hypothesized where the Shared component group in the Mismatch condition will show slower reaction times and lower accuracy when compared to the Match condition
- The presence of Shared components draws on additional attentional resources which might aid the Match comparison but which have to be inhibited in the Mismatch group resulting in faster reaction times for the former and slower for the latter (interference effects)

EEG Analysis & Expected Results
- Permutation-based cluster differences for electrodes Cz, P3, P4, Pz, CP1, and CP2 will be calculated using on the 300-500ms time range (Groppe, Urbach, & Kutas, 2011)
- Shared components is hypothesize to modulate the amplitude of the N400 across match/mismatch comparisons showing componential interference
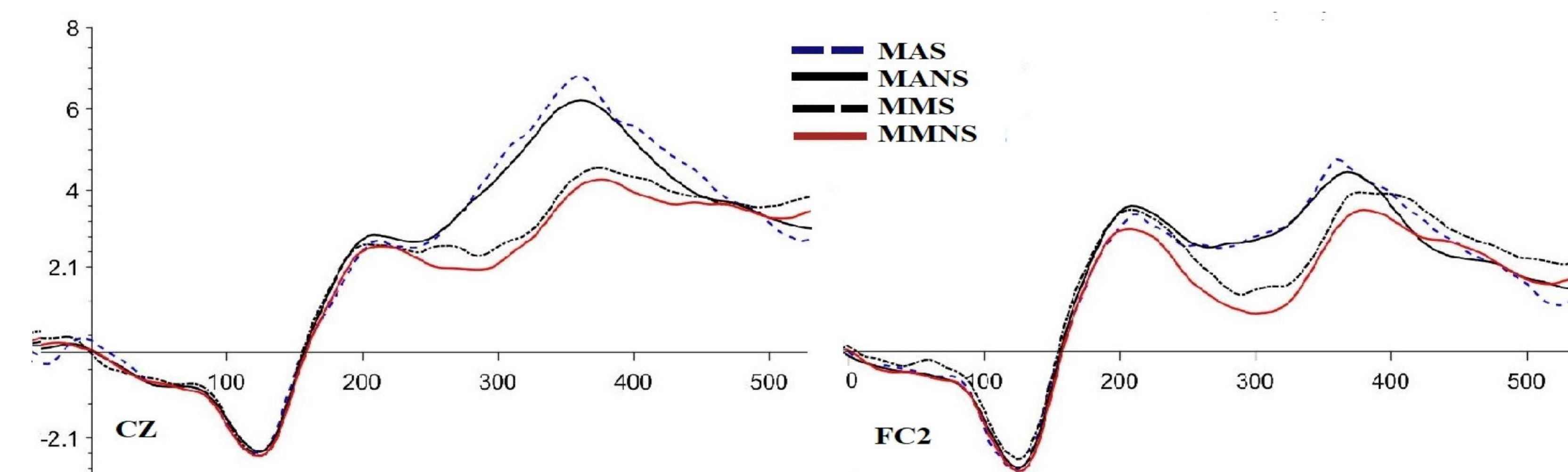

Figure 4: Hypothesized cluster differences between MatchShared (MAS) and MismatchShared (MMS) and between MatchNonshared (MANS) and MismatchNonshared (MMNS).

Significance

- The susceptibility to interference from shared components could highlight the presence of a Stroop-like conflict between a fraction's magnitude and its numerical components (Meert, Grégoire, & Noël, 2010)
- This finding would point to the need of inhibition in fraction processing

Future Directions
- Expand set of stimuli to other fractions (including double digit fractions)
- Study how the N400 is affected by numerical distance of both magnitude and components

Potential Implications

- Inhibition might have a key role in processing fractions
- Inhibition of interference can draw on attentional resources resulting in higher overall reaction times and higher N400 amplitudes
- Higher levels of inhibition have been shown to predict fraction comparison proficiency (Gómez, Jiménez, Bobadilla, Reyes, & Dartnell, 2015)
- Inhibition might not simply be a feature arising during fraction judgment but a cognitive function necessary for successful fraction processing

References

Fazio, L. K., DeWolf, M., & Siegler, R. S. (2016). Strategy use and strategy choice in fraction magnitude comparison. *Journal of Experimental Psychology: Learning Memory and Cognition, 42*(1), 1–16. http://doi.org/10.1037/xlm0000153

Gómez, D. M., Jiménez, A., Bobadilla, R., Reyes, C., & Dartnell, P. (2015). The effect of inhibitory control on general mathematics achievement and fraction comparison in middle school children. ZDM -Mathematics Education, 47(5), 801–811. http://doi.org/10.1007/s11858-015-0685-4

Groppe, D. M., Urbach, T. P., & Kutas, M. (2011). Mass univariate analysis of event-related brain potentials/fields I: A critical tutorial review. *Psychophysiology, 48*(12), 1711-1725

Meert, G., Grégoire, J., & Noël, M.-P. P. (2010a). Comparing the magnitude of two fractions with common components: Which representations are used by 10- and 12-year-olds? Journal of Experimental Child Psychology, 107(3), 244–259. http://doi.org/http://dx.doi.org/10.1016/j.jecp.2010.04.008

Siegler, R. S., Fazio, L. K., Bailey, D. H., & Zhou, X. (2013). Fractions: The new frontier for theories of numerical development. Trends in Cognitive Sciences, 17(1), 13–19. http://doi.org/10.1016/j.tics.2012.11.004

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