

Time Course of Inhibitory Control During Analogical Reasoning: An Event-Related Potential Approach

Brian M. Sweis, Krishna L. Bharani, & Robert G. Morrison
Department of Psychology, Loyola University Chicago

Introduction

- Analogical reasoning fosters human understanding and learning by enabling one to establish a link between two sources of structured information and to use this link to make comparisons and inferences.
- Previous neuropsychological and neuroimaging studies have emphasized the importance of several areas of prefrontal cortex (PFC) for inhibitory control and relational integration during analogy.
- Using EEG recording, this experiment aims to explore the time course of the neural correlates for inhibitory control during analogy and begin to understand how they are affected by individual differences in working memory (WM).

Methods

Visual Analogy Task

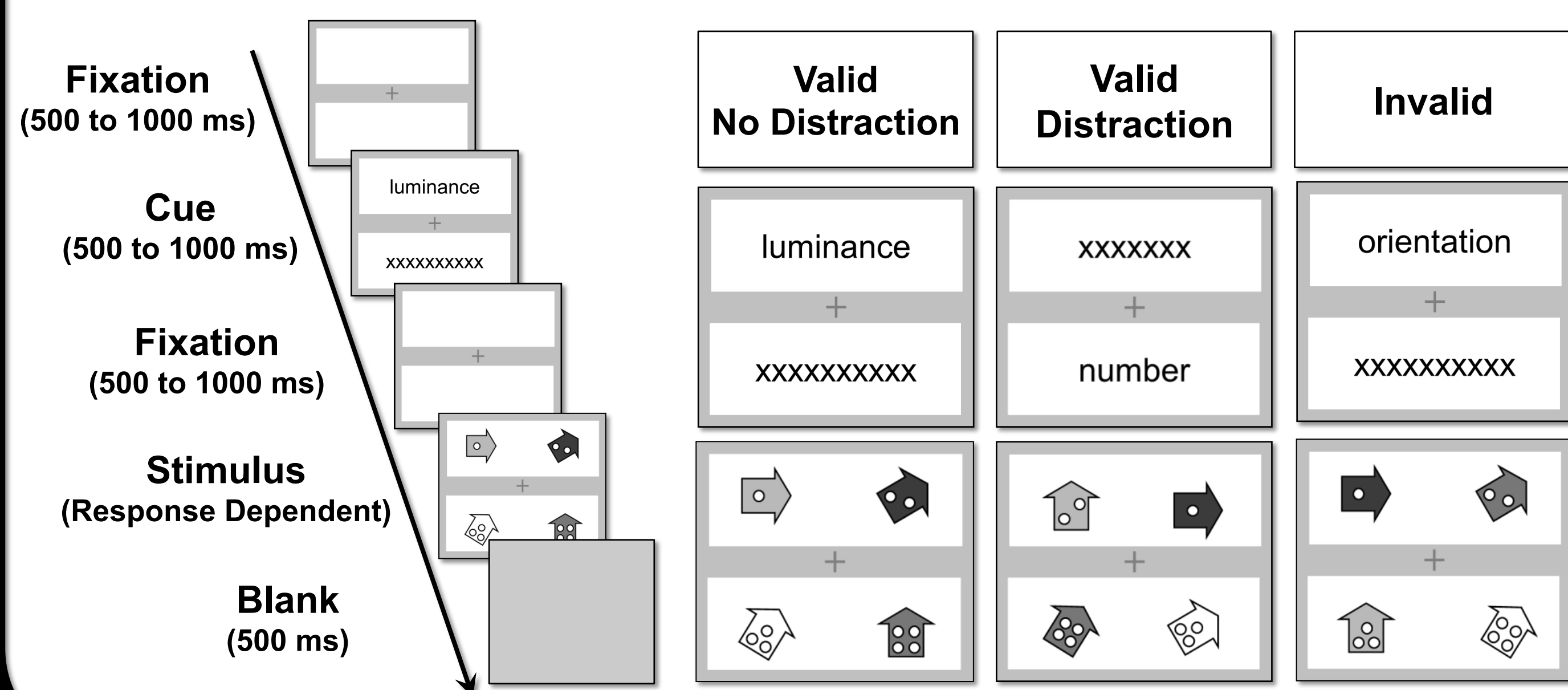
- Objects possessed three varying properties (luminance, orientation, and number).
- Participants judged if the relation between objects in the top pair matched the relation in the bottom pair, with respect to a single, cued property (Valid = match, Invalid = mismatch).
- Relations of the unattended properties disagreed with the relations of the cued properties in the “Distraction” condition.

Working Memory Task

- Participants were asked to verify simple math problems while remembering strings of letters.

Scalp electroencephalography (EEG)

- Brain activity was recorded using a 32-channel Biosemi Active2 EEG system.

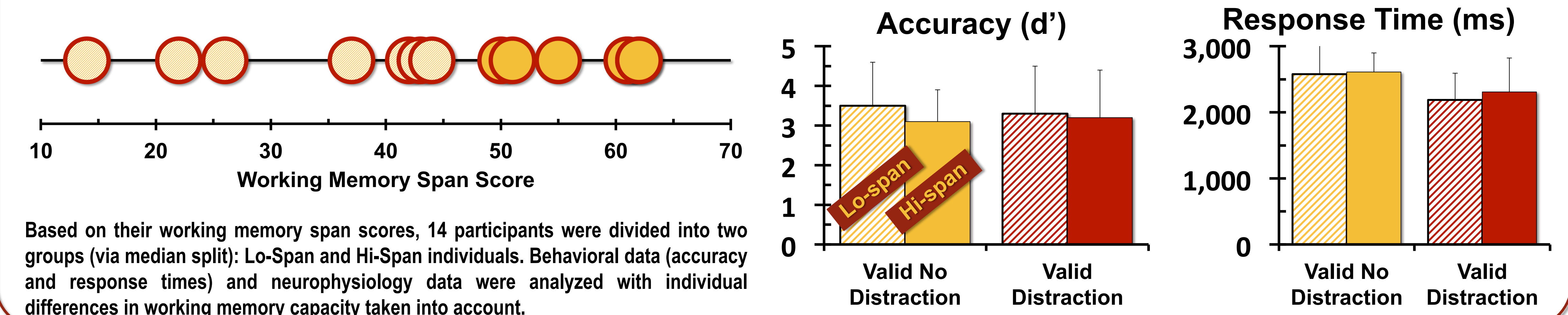


Discussion

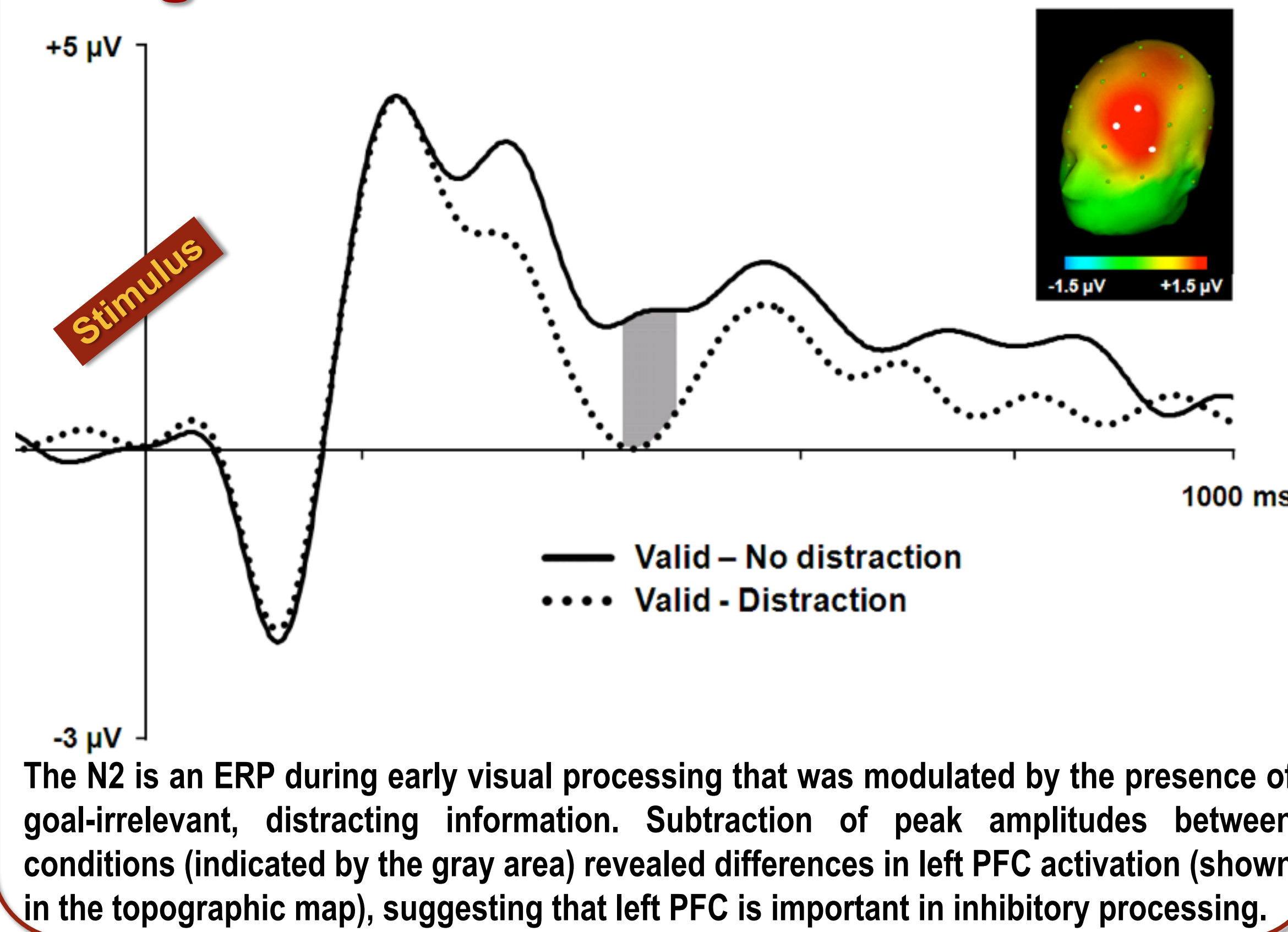
- While no behavioral differences were observed across distraction conditions or WM groups, measurements of neural correlates differed.
- Goal-irrelevant information evoked a greater N2 ERP, an index of inhibitory processing, in left PFC early during analogy processing.
- Frontopolar late positive complex ERP, a metric of analogical mapping / relational integration as demonstrated in previous experiments, was shown again in this study.
- Individual differences in WM span interacted with distraction N2 and LPC ERPs.
- Differences in WM capabilities may govern how cognitive processes such as inhibitory control engage during analogical reasoning.

Results

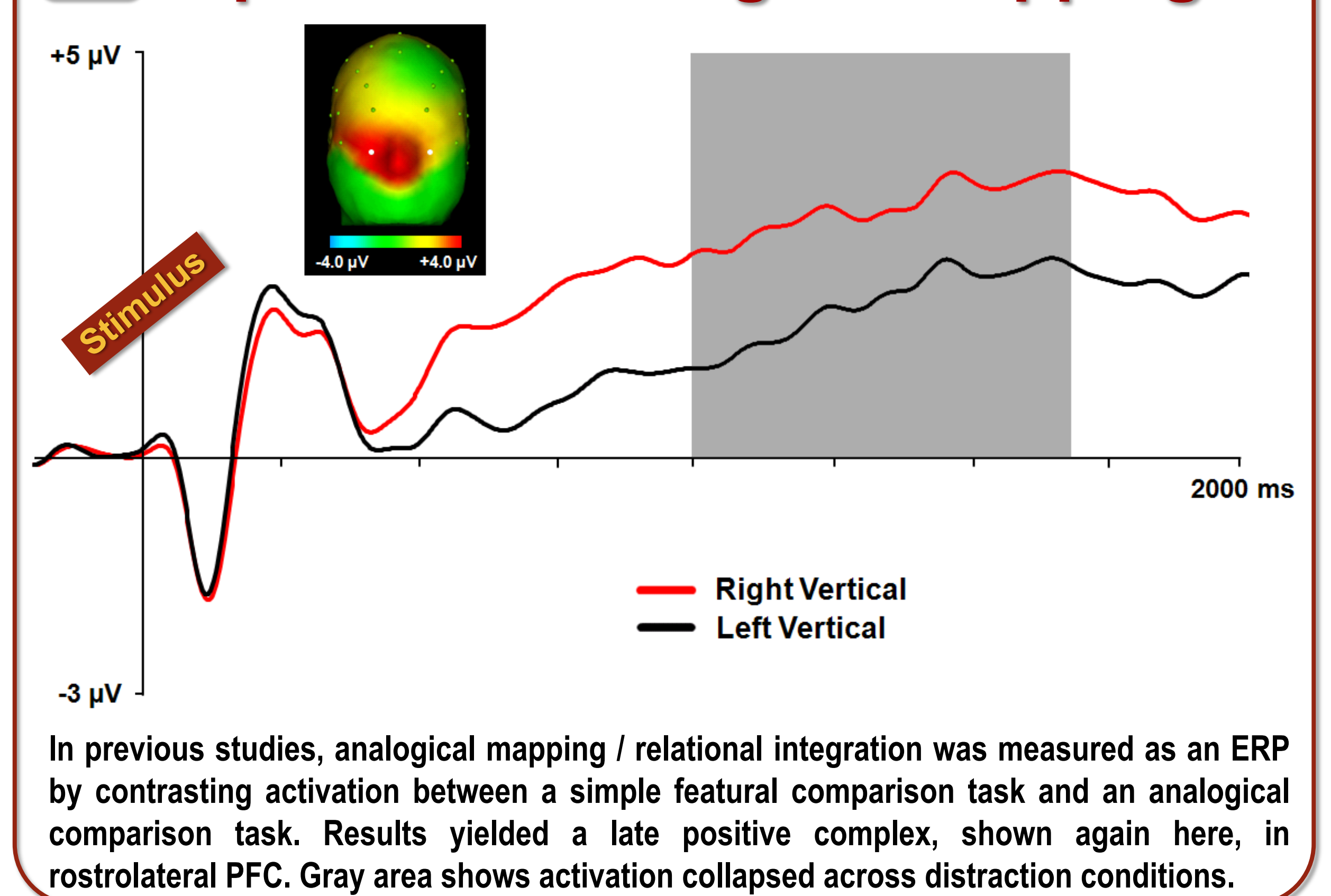
1 No differences were observed in accuracy or response times across distraction conditions or working memory capacity groups.



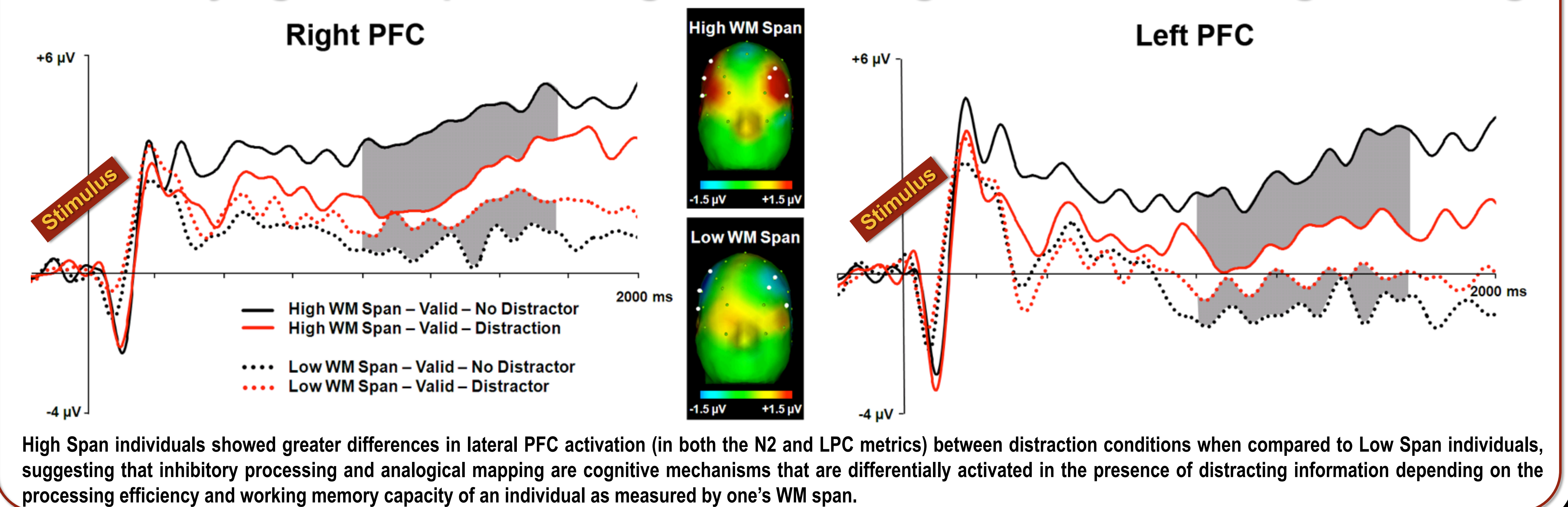
2 Distraction condition evoked a greater N2 ERP in the Left PFC.



3 Frontopolar late positive complex represents analogical mapping.

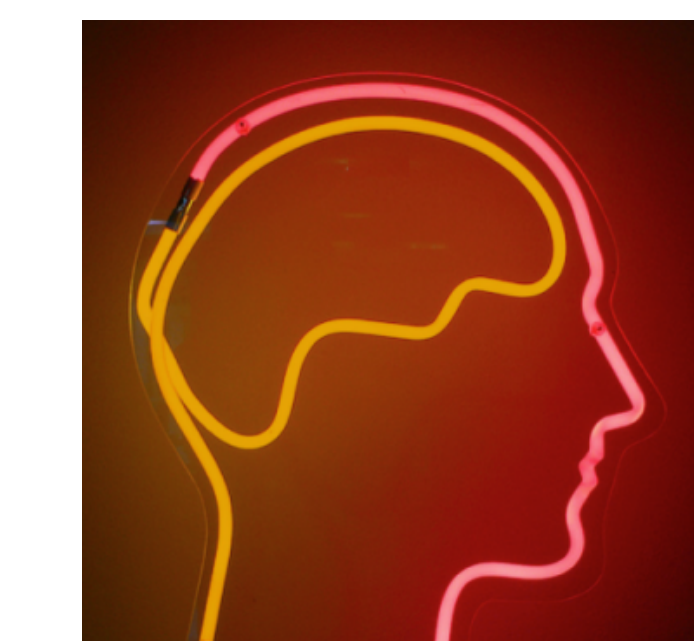


4 Individual differences in working memory capacity revealed asymmetries underlying neural processing of distracting information during reasoning.



References

- Bunge, S. A., Wendelken, C., Badre, D., & Wagner, A. D. (2005). Analogical reasoning and prefrontal cortex: Evidence for separable retrieval and integration mechanisms. *Cerebral Cortex*, 15(3), 239-249.
- Conway, A. R. A., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. *Psychonomic Bulletin & Review*, 12, 769-786.
- Folstein, J. R., & van Petten, C. V. (2008). Influence of cognitive control and mismatch on the N2 component of the ERP: A review. *Psychophysiology*, 45, 152-170.
- Morrison, R. G., Krawczyk, D. C., Holyoak, K. J., Hummel, J. E., Chow, T. W., Miller, B. L., & Knowlton, B. J. (2004). A neurocomputational model of analogical reasoning and its breakdown in frontotemporal lobar degeneration. *Journal of Cognitive Neuroscience*, 16(2), 260-271.
- Nikitin, S., & Morrison, R. G. (2011, April). Analogical Reasoning in Human Prefrontal Cortex: An Event-Related Potential Approach. *Cognitive Neuroscience Society Annual Meeting*, San Francisco, CA.
- Viskontas, I. V., Morrison, R. G., Holyoak, K. J., Hummel, J. E., & Knowlton, B. J. (2004). Relational integration, inhibition, and analogical reasoning in older adults. *Psychology and Aging*, 19(4), 581-591.
- Vogel, E. K., McCollough, A. W., & Machizawa, M. G. (2005). Neural measures reveal individual differences in controlling access to working memory. *Nature*, 438, 500-503.



CAN Lab
Cognitive & Affective Neuroscience
canlab.org

The authors would like to thank Matthew Kmiecik and Miraj Chokshi for technical support and the American Federation of Aging Research, the Illinois Department of Public Health, and the Loyola Undergraduate Research Opportunities Program (LUROP) for their generous support.