Changes in Alpha Oscillatory Power in Response to Working Memory Training

Kara J. Blacker, Joshua B. Ewen, & Susan M. Courtney

Johns Hopkins University, Baltimore, MD, USA

Background

- Working memory (WM) is the ability to hold task-relevant information in mind over brief delays
- Recent work has suggested that this critical skill can be improved with training (review: Morrison & Chein, 2011; meta-analysis: Au et al. 2015)
  - However, training outcome differs across studies, perhaps due to use of different training tasks
  - And the neural mechanisms underlying WM training are unclear (review: Buschkuehl et al. 2012)
- Recent evidence suggests that oscillations in the alpha range (8-13Hz) are involved in WM maintenance (review: Roux & Uhlhaas 2013)
  - Specifically, increased frontal alpha power is involved in top-down modulation of attention and WM performance (Zanto et al. 2011; Sauseng et al. 2005; Palva et al. 2011)

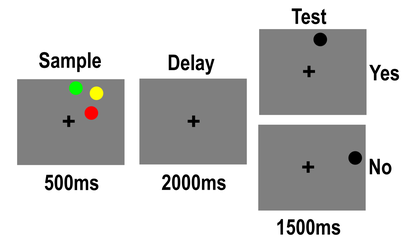
Hypothesis

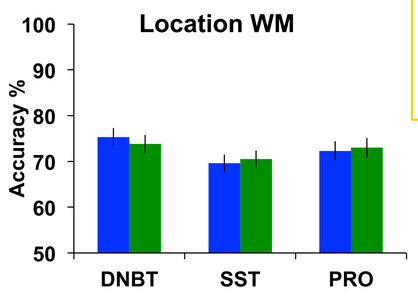
The underlying neural mechanism supporting training-related improvement in WM is changes in alpha oscillatory activity

Method

- Dual N-back Training (DNBT) group
  - N=20
- Symmetry Span Training (SST) group
  - N=22
- Permuted Rule Operations (PRO) group
  - N=19
  - Active (non-WM) control group
- Participants completed 4 weeks (10 hours) of adaptive training between pre- and post-training EEG sessions
- EEG data were analyzed using time frequency analysis and cluster-based permutation tests implemented in Fieldtrip

WM Task during EEG

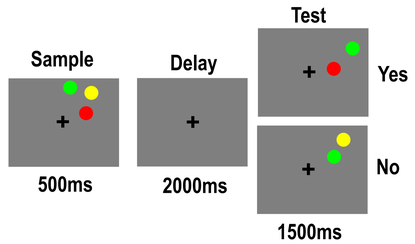


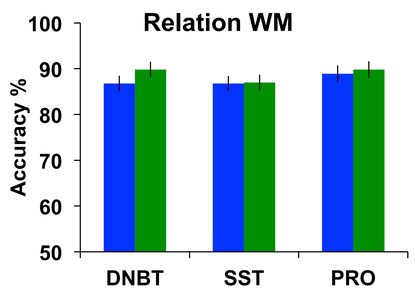


LOCATION TRIALS (left): Participants maintained the 3 locations of the colored circles in WM. RELATION TRIALS (right): Participants maintained the 3 spatial relations (relative vertical relationship between the 3 circles) in WM.

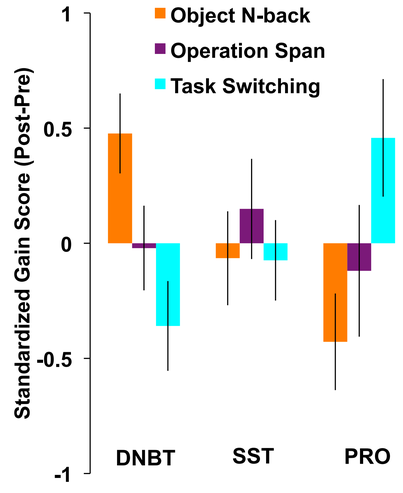
Pre-Training

Post-Training



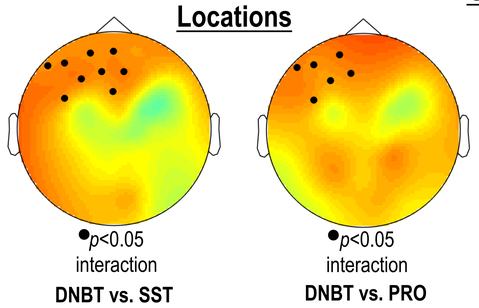


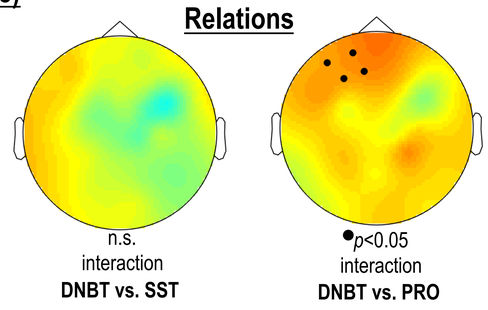
Near Transfer



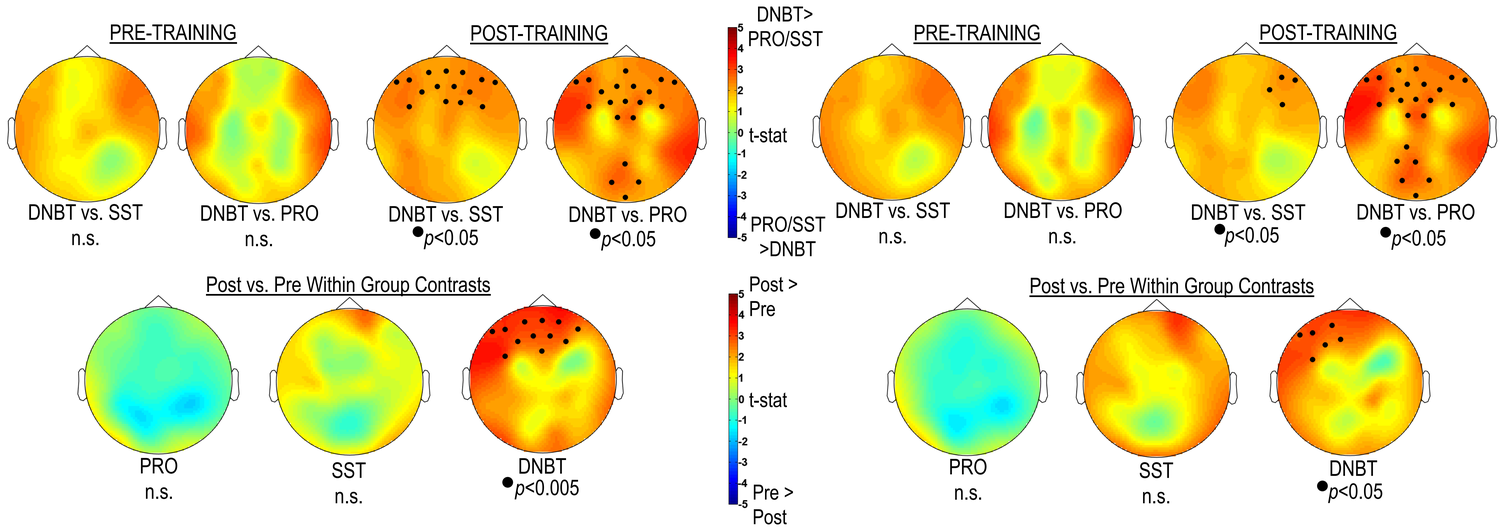
Delay Period Alpha Power (8-13Hz)

Group x Session (Post vs. Pre)





Post-hoc Contrasts



Results Summary

- The 3 training groups showed significant improvement on their respective near transfer tasks, illustrating the effectiveness of training
- While the 3 groups were similar before training, after training the DNBT group showed increased frontal alpha power compared to both other groups after training
- The DNBT group showed a significant increase in frontal alpha power from before to after training, whereas the PRO and SST groups did not

Conclusions

- Dual N-back training caused an increase in frontal alpha power compared to our other groups
- These results suggest that the neural mechanism underlying WM improvement following DNBT is enhanced top-down modulation of attention via frontal alpha oscillations

References

Au, J., Sheehan, E., Tsai, N., Duncan, G. J., Buschkuehl, M., & Jaeggi, S. M. (2015). Improving fluid intelligence with training on working memory: a meta-analysis. *Psychonomic Bulletin and Review, 22*(2), 366-377.

Buschkuehl, M., Jaeggi, S.M., & Jonides, J. (2012). Neuronal effects following working memory training. *Developmental Cognitive Neuroscience, 2S*, S167-179.

Morrison, A.B., & Chein, J.M. (2011). Does working memory training work? The promise and challenges of enhancing cognition by training working memory. *Psychonomic Bulletin and Review, 18*, 46-60.

Palva, S., Kulashekhar, S., Hamalainen, M., & Palva, J. M. (2011). Localization of cortical phase and amplitude dynamics during visual working memory encoding and retention. *Journal of Neuroscience, 31*(13), 5013-5025.

Roux, F., & Uhlhaas, P. J. (2013). Working memory and neural oscillations: alpha-gamma versus theta-gamma codes for distinct WM information? *Trends in Cognitive Science*.

Sauseng, P., Klimesch, W., Doppelmayr, M., Pecherstorfer, T., Freunberger, R., & Hanslmayr, S. (2005). EEG alpha synchronization and functional coupling during top-down processing in a working memory task. *Human Brain Mapping, 26*(2), 148-155.

Zanto, T. P., Rubens, M. T., Thangavel, A., & Gazzaley, A. (2011). Causal role of the prefrontal cortex in top-down modulation of visual processing and working memory. *Nature Neuroscience, 14*(5), 656-661.

Acknowledgements & Reprints

Funding: JHU Science of Learning Institute Fellowship to KJB

For an e-copy of this poster please scan this code or email: kara.blacker@jhu.edu