Oscillatory Mechanisms of Planning vs. Memory

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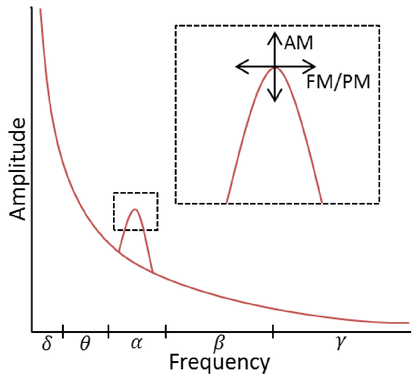
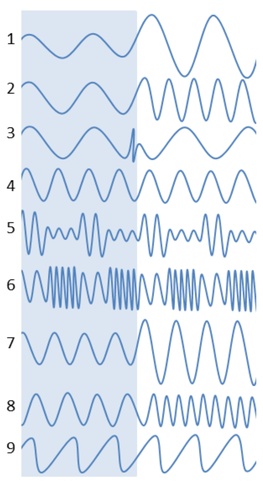
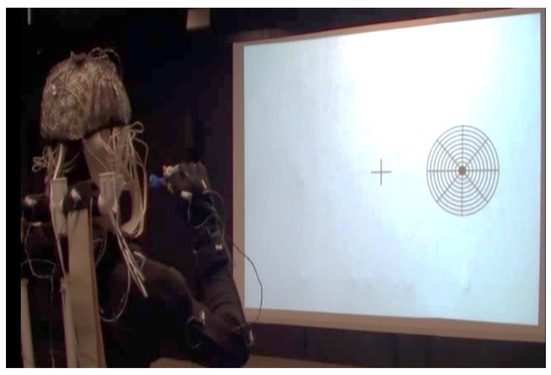


Neural oscillations measured from the brain will modulate in amplitude (AM), frequency (FM), or phase (PM)

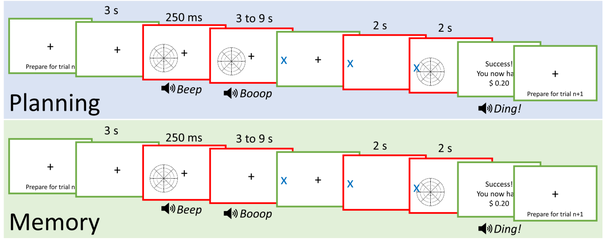


Dynamic	Rhythms
AM	1, 5, 7
FM	2, 6, 8
PM	3
PPC	1+4, 4+7
PAC	1+5
PFC	1+6
AAC	1+7
AFC	1+2, 1+8
FFC	1+8
Shape	9

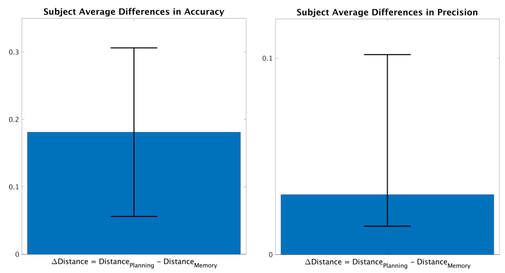
We suspect neural oscillations that modulate together, i.e. couple, support both planning and memory



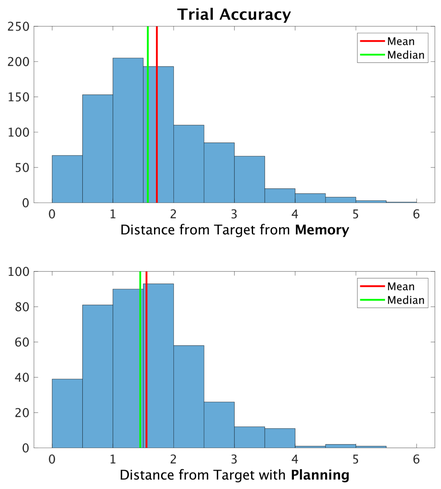
10 human subjects threw darts at visible or remembered random targets, operationalizing planning vs. memory.



Subjects waited a random 3 to 9 second time interval before hearing a throw cue.



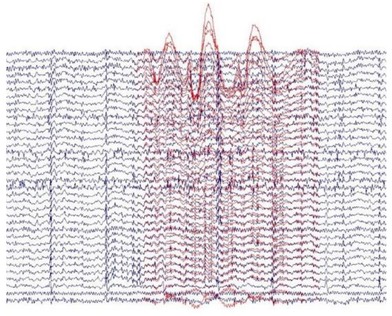
Throwing from memory reduced subject average accuracy and precision.



Throwing from memory reduced trial accuracy and precision, as well.

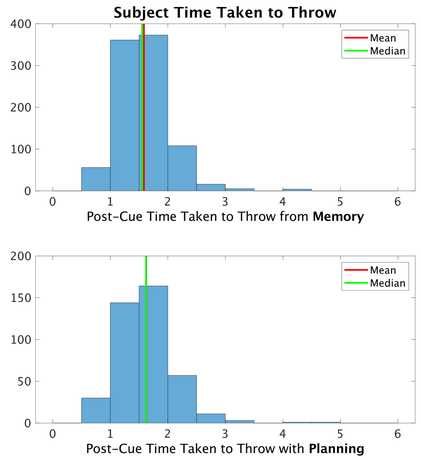
EEG Analysis Pipeline

- *Automated cleaning*
- *Source separation*
- *Remove non-brain sources*
- *Measure coupling among sources*
- *Select most coupled sources*
- *Get trial behavioral results*
- *Get trial source coupling strength*
- *Predict behavior via coupling*

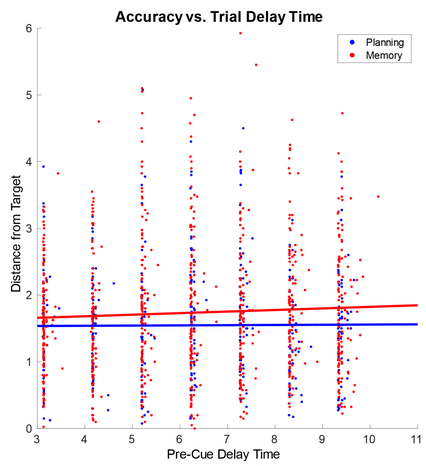


EEG data (128 channels, 512 Hz) were preprocessed using Artifact Subspace Reconstruction

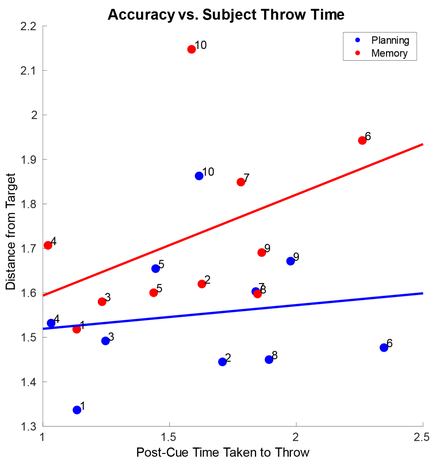
Mullen, T., Kothe, C., Chi, Y. M., Ojeda, A., Kerth, T., Makeig, S., ... & Jung, T. P. (2013, July). Real-time modeling and 3D visualization of source dynamics and connectivity using wearable EEG. In *Engineering in Medicine and Biology Society (EMBC), 2013 35th Annual International Conference of the IEEE* (pp. 2184-2187). IEEE.



Subjects take longer and more variable time to throw when planning.



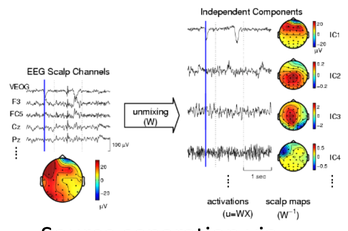
Longer delays during memory decreased accuracy, as expected; no effect when planning.



Time taken to throw and accuracy might be related, but results inconclusive.

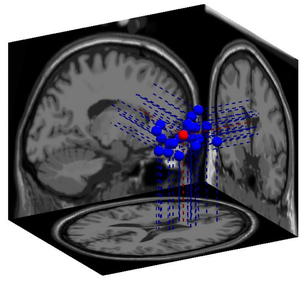
$$Accuracy = \beta_0 + \beta_1 IsPlanning + \beta_2 DelayTime + \beta_3 ThrowTime$$

Multiple regression models had small but significant explanatory power ($R^2_{adj} = 0.01$) -- throwing from memory decreased accuracy, longer delay and throw times trendingly decreased accuracy.

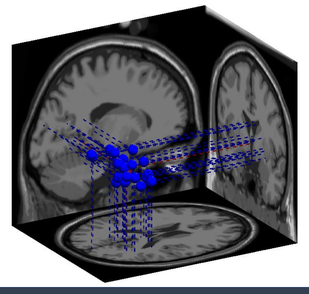


Source separation via independent component analysis

Delorme, A., & Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. Journal of neuroscience methods, 134(1), 9-21.

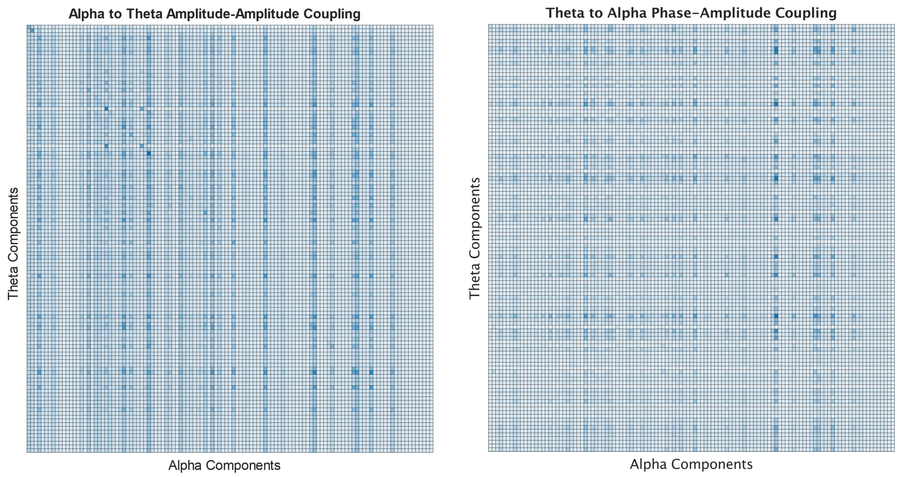


Source localization via geometric head model allows removal of non-brain sources. Frontal theta and posterior alpha sources were found.



Interpretation

Despite the distinction in behavior between memory and planning, we suspect that the underlying neural mechanisms are similar.



Strongly coupled components were selected for each subject.
Two subjects with clear coupling structures shown above.

$$Accuracy = \beta_0 + \beta_1 IsPlanning + \beta_2 DelayTime + \beta_3 ThrowTime + + \beta_4 Coupling$$

Including coupling during each trial into multiple regression models increased explanatory power. Theta to Alpha Phase-Amplitude Coupling and Amplitude-Amplitude Coupling may differentiate memory vs. planning.

Interpretation

EEG source selection and coupling measures need refinement. Attempts to create General Linear Model approach across frequency and coupling modes made. No convincing results yet. Plans to use Source Information Flow Toolbox for autoregressive models and causality and further differentiate memory and planning.