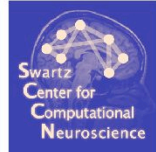


# Active EEG dynamics during learning in social settings

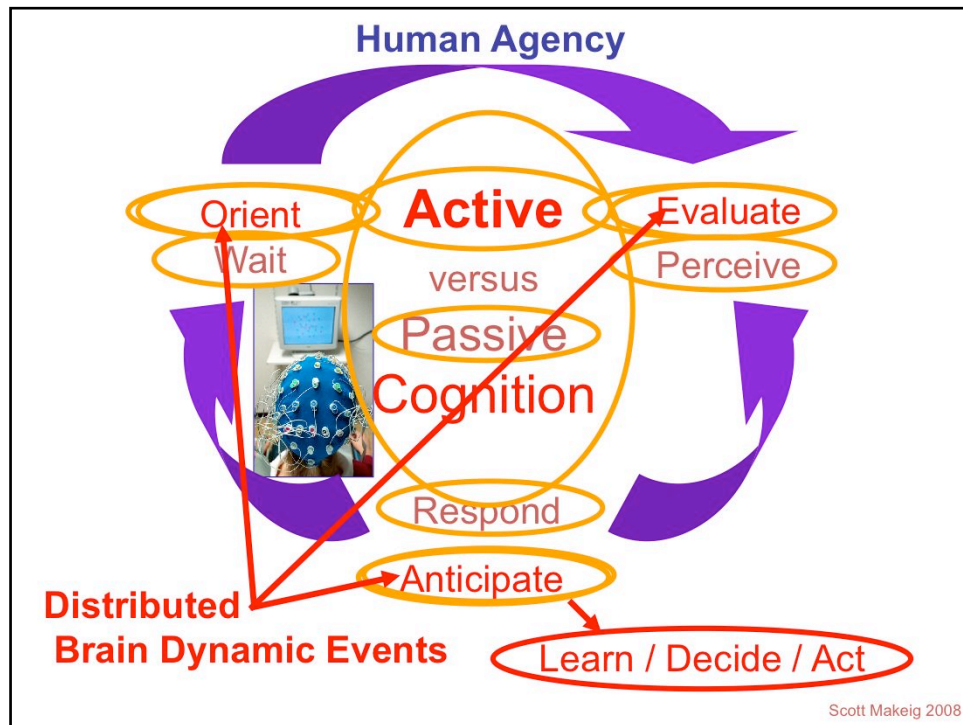


Ying Wu and Scott Makeig

TLC All-hands, UCSD

February 21, 2009

A talk for the All-Hands meeting of the TDLC (Temporal Dynamics of Learning Center) project at UCSD, Feb. 21, 2009.



The human action-perception cycle is discussed in psychology, but still little observed or modeled by cognitive neuroscience.

The cycle of active perception includes Active orienting, Evaluation, and Anticipation, leading to behavioral decision-making and learning.

This contrasts with standard electrophysiology experiments in which the subject fixates a cross on the screen, waits for isolated stimuli to appear suddenly, and then makes a minimal, highly stereotyped behavioral response.

## Concentration – A Spatial Learning Card Game



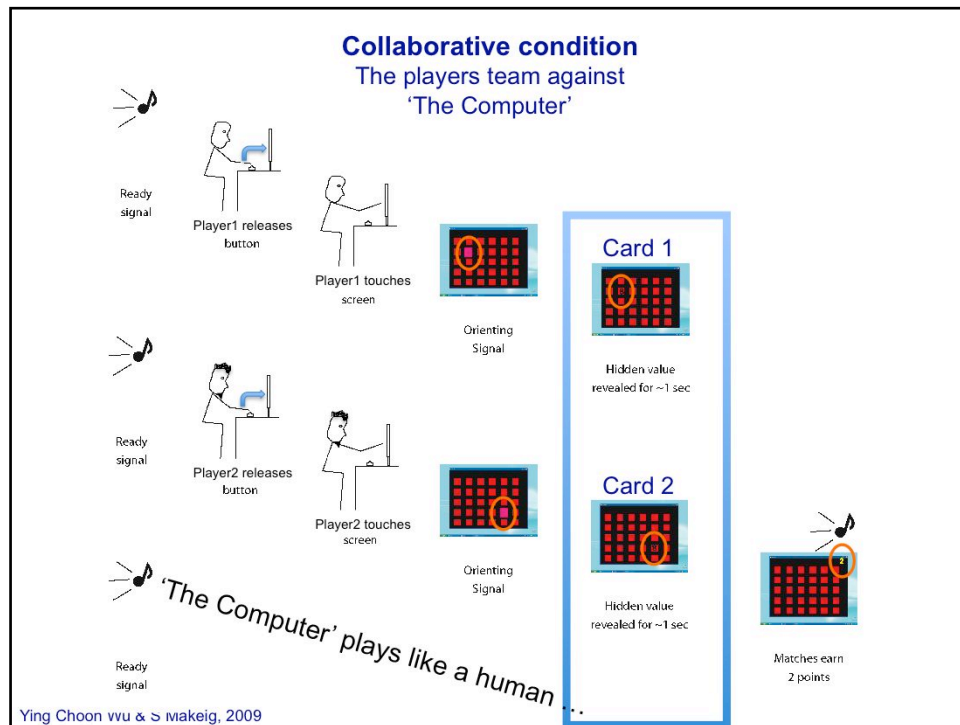
### Three game conditions

- Competitive (Play | Watch)
- Collaborative (Play | Watch)
- Solo (Play | Watch)

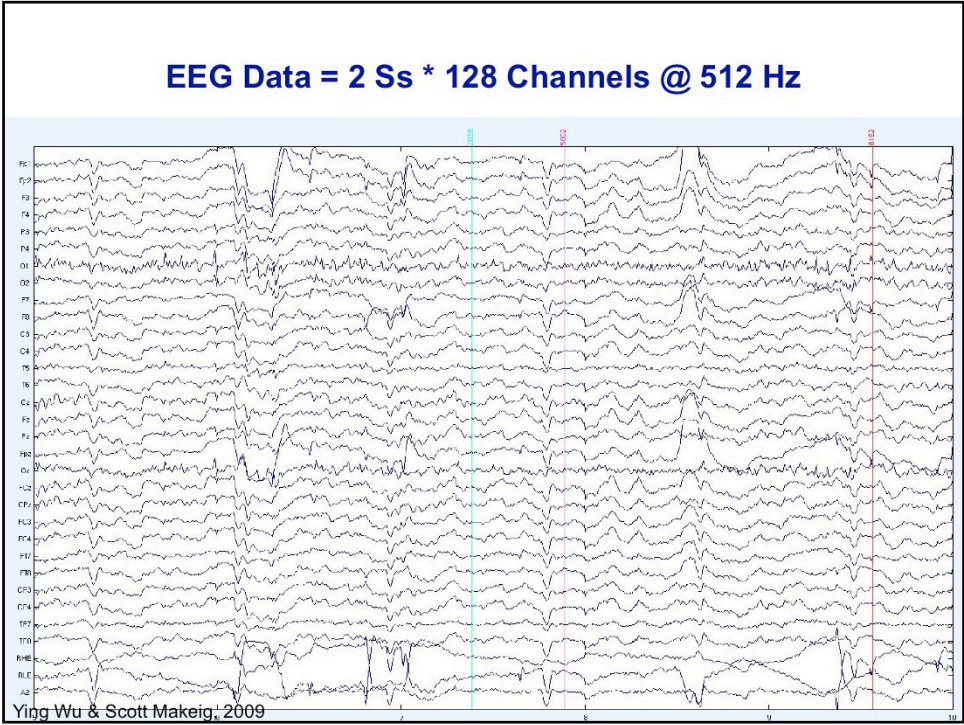
Ying Choon Wu & S Makeig, 2009

This talk gives first fragmentary results of advanced EEG analysis of data from a two-person spatial memory game ('Concentration') in which participants attempt to 'turn over' (here touch) cards with matching numbers to win points (and here, increase their financial bonus).

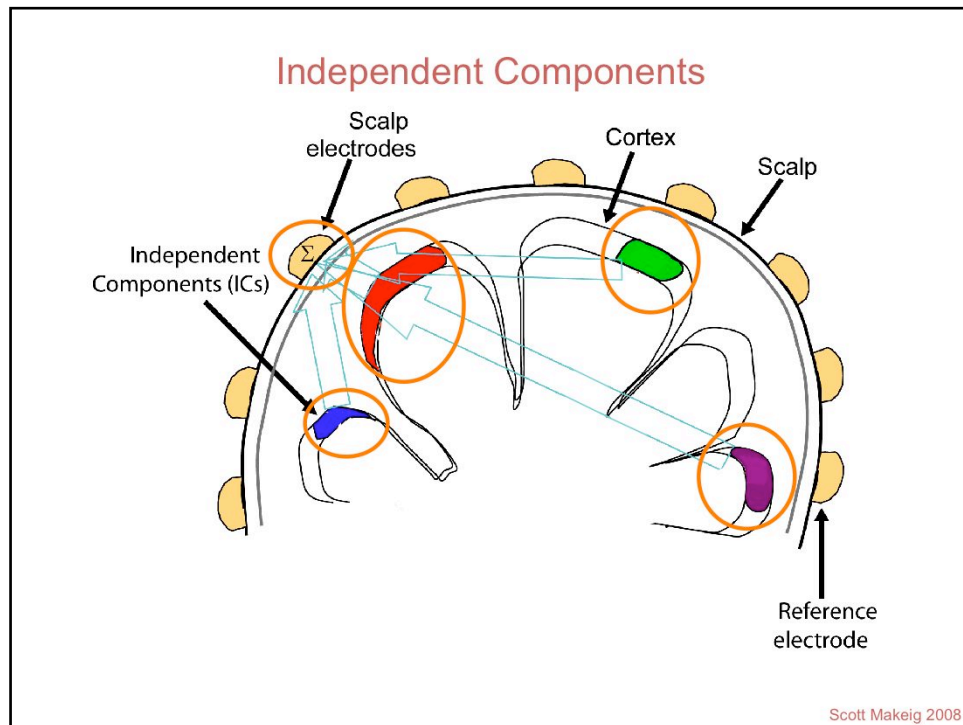
Pairs of subjects alternated playing this game in three conditions: Competitive (normal), Collaborative (against The Computer), and Solo (playing and watching, respectively).



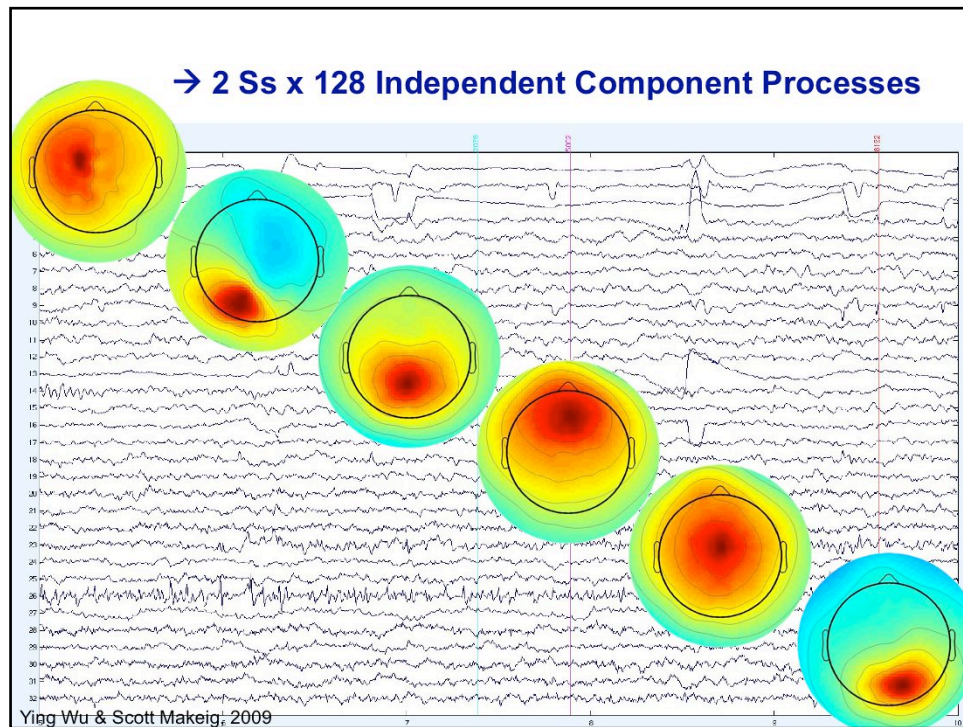
Outline of the Collaborative game condition time line.



EEG data were collected from both subjects synchronized by the Biosemi recording system.



In the ICA model for EEG, local field activities within discrete patches of cortex become locally synchronous, producing far-field potentials that are summed at (nearly all) the scalp electrodes. ICA decomposition can be used to separate the projection of these cortical (and also non-brain artifact) source potentials.



The class of independent components (ICs) of most interest are those whose pattern of scalp projections match or nearly match those of a single equivalent current dipole, since these maps scan equally match the far-field projection of a compact cortical area.

Brain dynamics supporting active cognition?

The brain responds to  
the challenge of the moment.

But what **is** 'the challenge of the moment'?

e.g.

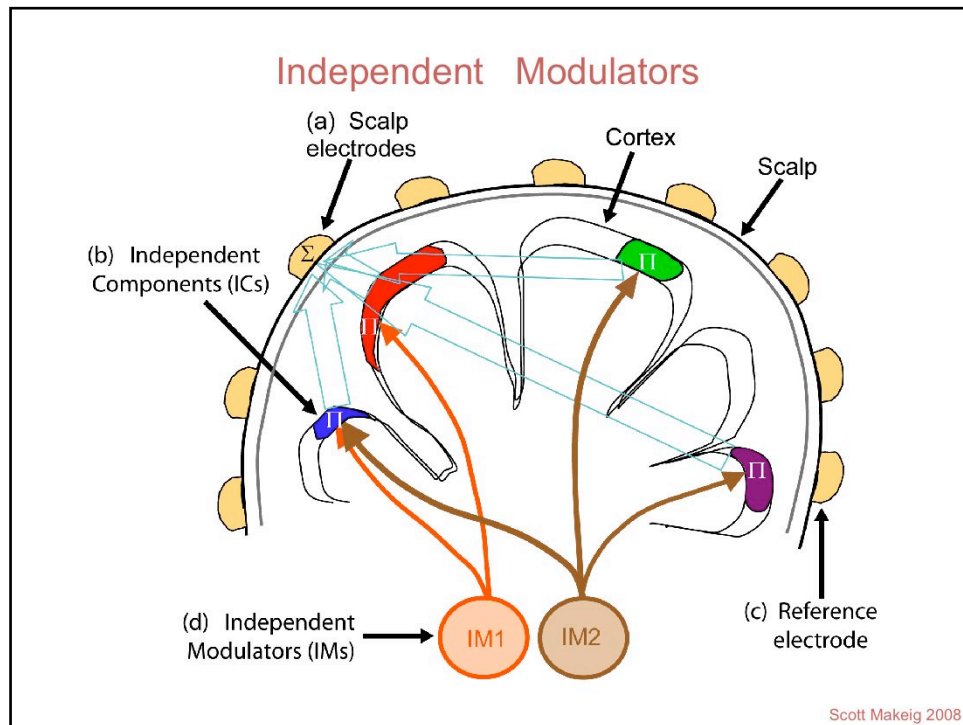
What EEG spectral dynamics are associated  
with *which* events  
and with *which* event contexts?

~~≠ Method of Planned Comparisons~~

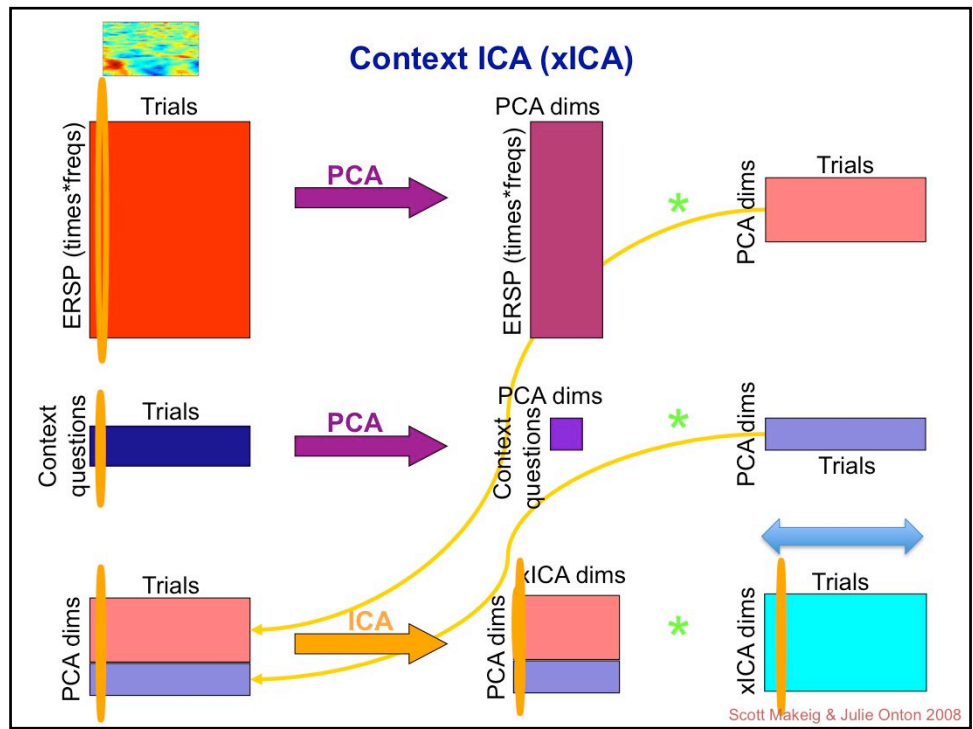
Scott Makeig 2009

Instead of designing the experiment to provide a small number of planned orthogonal contrasts (as in nearly all traditional psychology and other experimental science), we propose a data-driven method for finding modes of brain spectral dynamics that occur in a particular mix of circumstances (e.g., in response to a particular dimension of 'challenge').





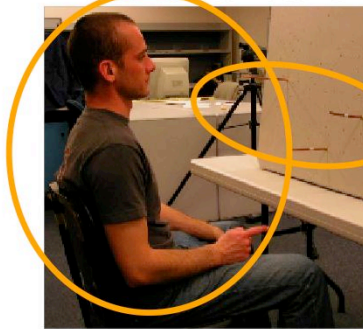
Here, these multiplicative EEG modulator processes are given cartoon representations near the brainstem, where in fact several neuromodulatory systems known to affect changes in the cortical field spectra are known to be centered. However, the log spectral decomposition technique we use is unable to place the locations or physiological nature of the modulator processes we find...



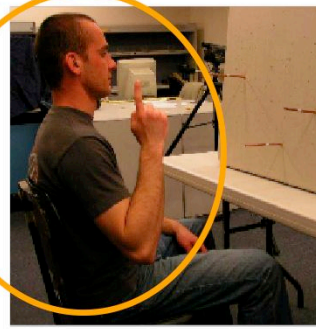
A schematic of the construction and decomposition of the data used for Context ICA...

## Simple Reaching Task

Horizontal start

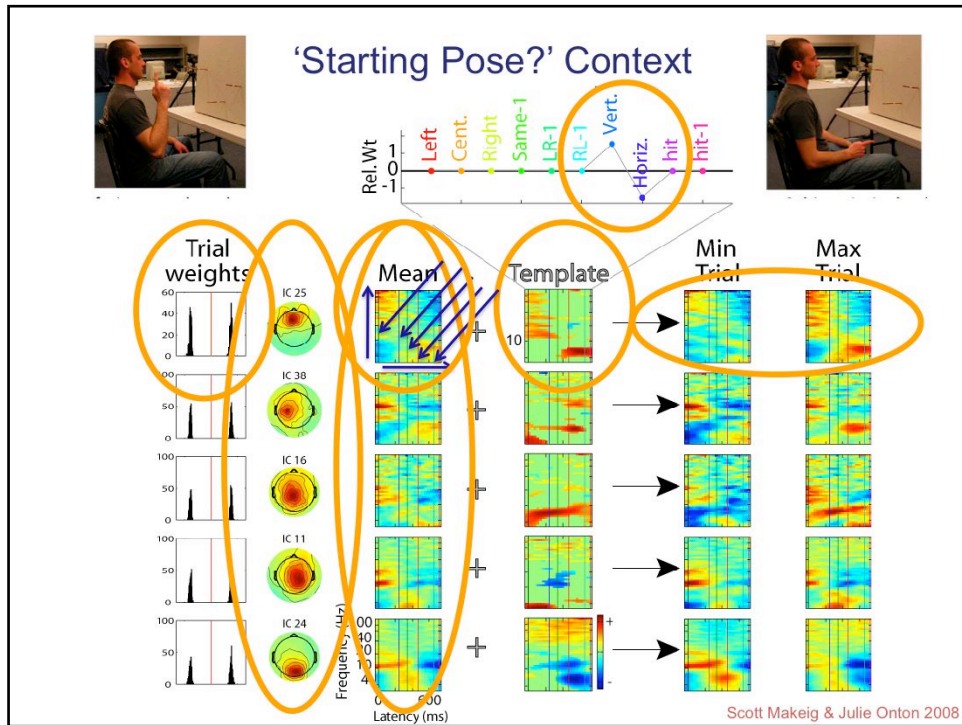


Vertical start

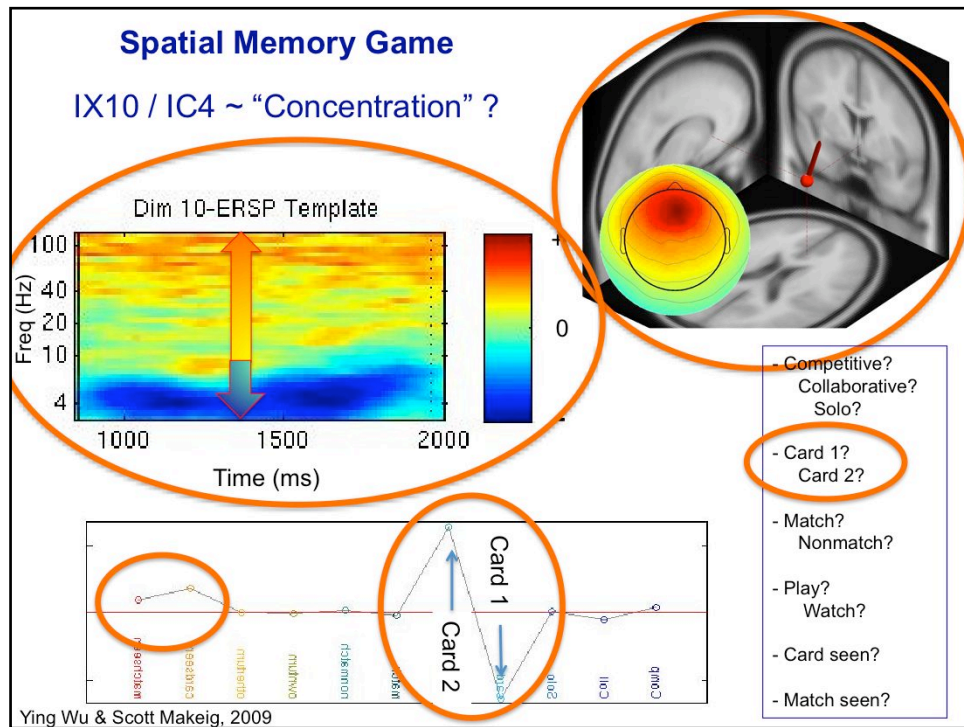


Makeig, Poizner et al., 2006

A simple example: The subject assumed either of two starting positions, then attempts to touch the LED (among 3) that lights up. Performed in the dark without visual feedback, this is difficult.

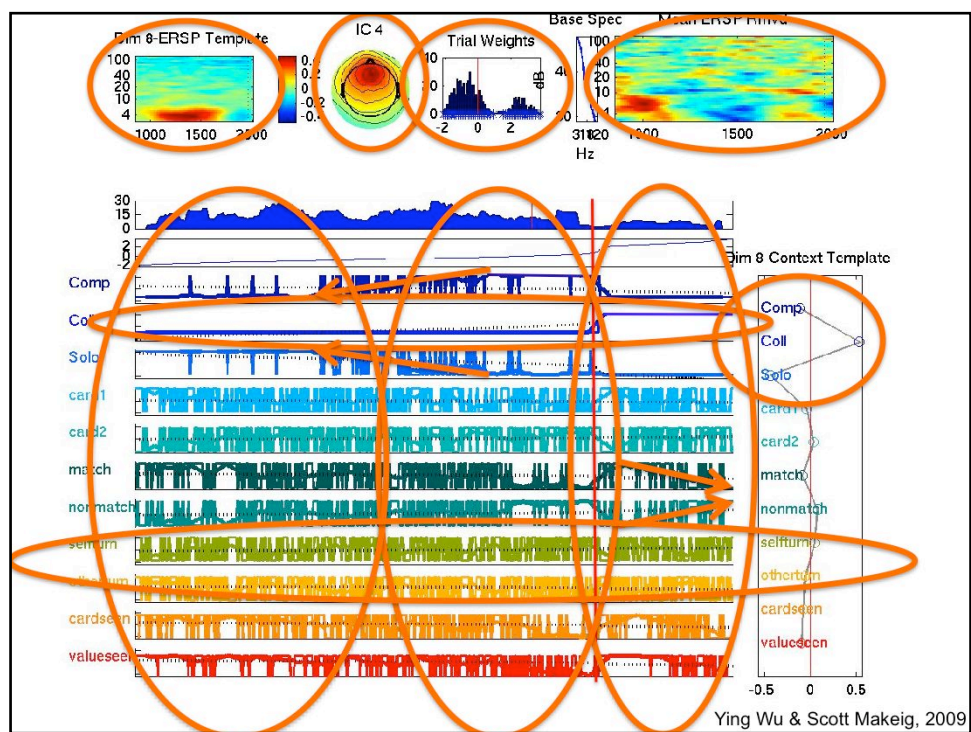


A set of context factors that load only on which starting pose the subject used. The xICA process begins by removing the mean log trial spectrogram to focus on the trial to trial variations around that (log) mean.

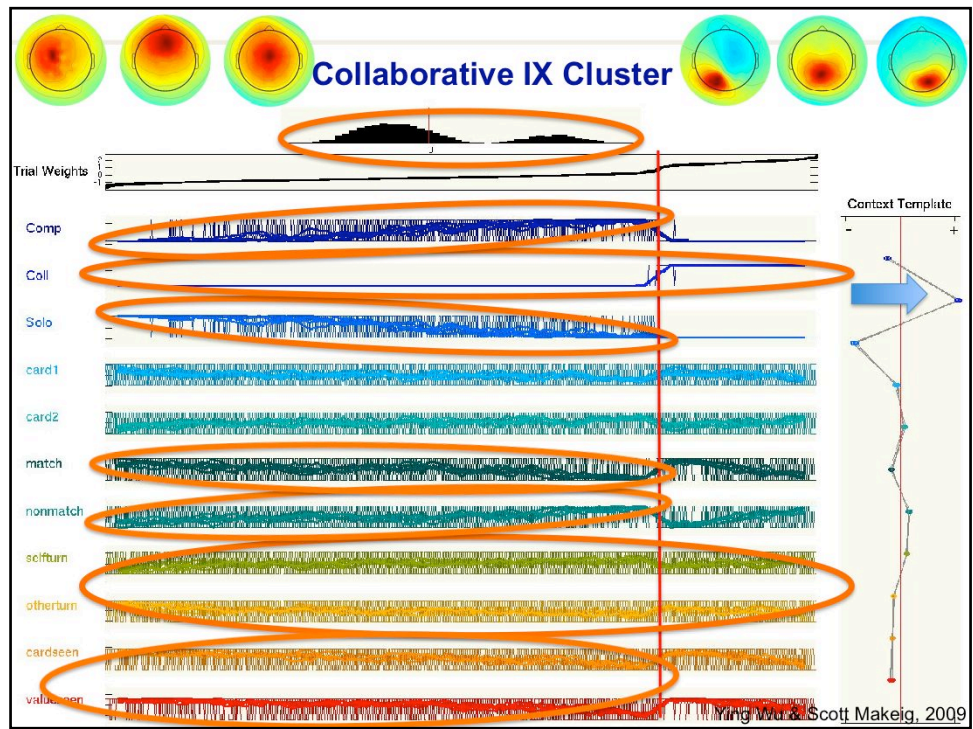


One context factor for one IC in the Concentration game experiment. Here, an IC with equivalent dipole in medial ventral pre-frontal cortex shows a shift from (~5-Hz) theta activity to broadband high-frequency activity when viewing Card 2 of each trial.



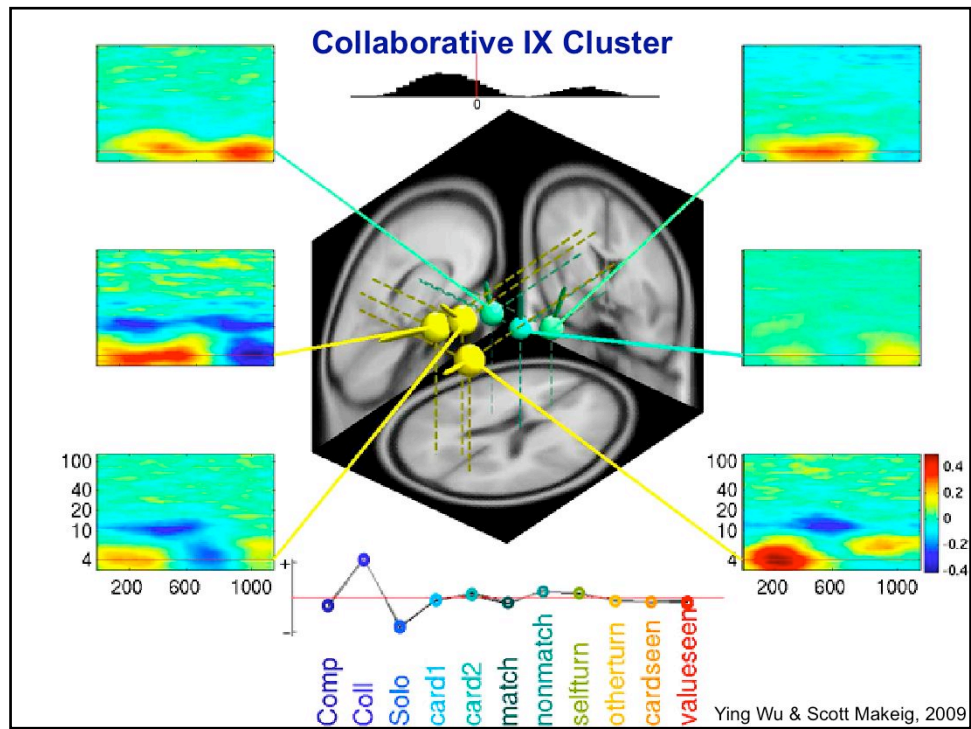


Another subject 'context-image' plot ...

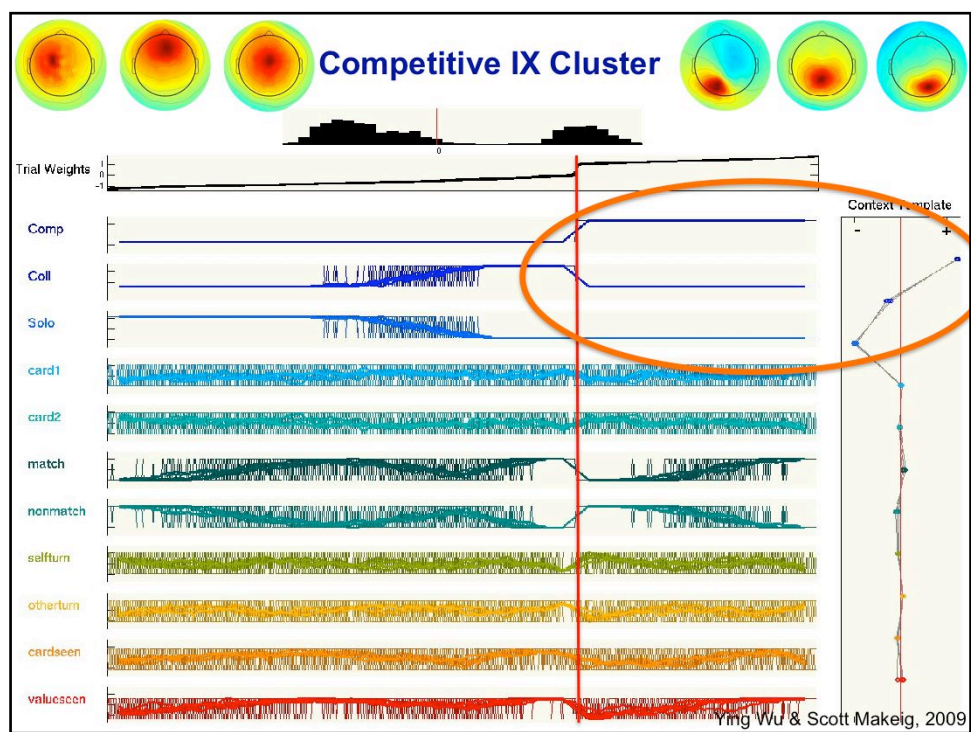


The same context for 6 components from the same subject.... Note the regularities.

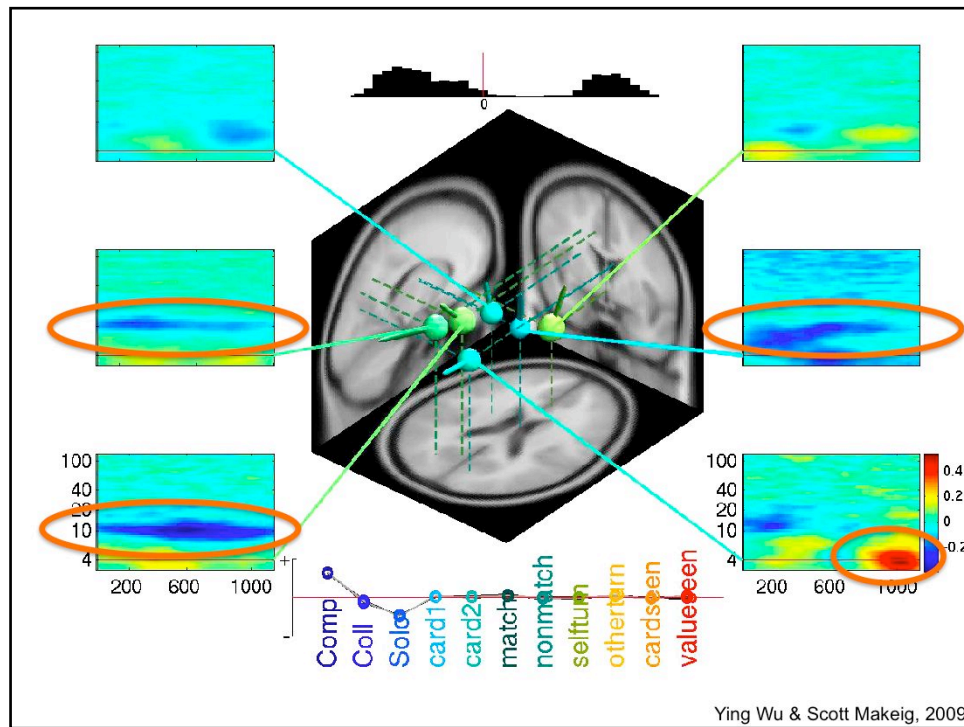




Dipole locations and time/frequency templates for each of the 6 components in the previous slide. From an animation of shifts in 4-Hz power during the trials that was associated with this context factor. ...



Context-image plot for a context factor (same subject and ICs) that positively loaded on Competitive game playing. Again, note the trial-to-trial regularities in the degree and polarity of the template pattern that was present in each trial ('Thus in this sense, the EEG is nearly noise-free ...')



Context time/frequency templates for the same context cluster ... Note the early alpha suppression in posterior components, and brief theta increase in the right occipital component just before the win/lose information is to be delivered. (lower right) ...

**Model the distributed brain dynamics supporting active cognition during learning.**

Identify the characteristic modes of trial-to-trial variability in distributed brain activity linked to differences in learning:

- Success in learning
- Stage of learning
- Individual differences in learning
- Online monitoring & support of learning.

Scott Makeig, Feb. 2009

Conclusions (oriented toward learning)...