

Cortical alpha as a pre-stimulus top-down mechanism for anticipatory suppression of irrelevant information for complex objects.

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Introduction:

*Top-down modulation is the mechanism by which we enhance neural activity associated with relevant information and suppress activity for irrelevant information, thus establishing a foundation for both attention and memory processes.

*Top-down modulation has been described both when a stimulus is present and when a stimulus is absent. Here we will focus on stimulus-absent top-down modulation and more specifically, anticipation.

*Investigations in nonhuman primates have demonstrated that stimulus-preceding, visual receptive-field specific spectral modulations predict subsequent behavioral efficacy.

α -Background:

*Berger (1929, 1930) observed that... the alpha rhythm, is largest in a state of relaxed wakefulness when eyes are closed and shows a sudden reduction when eyes are opened.

-It was later shown that most primary sensory and motor cortical areas express similar rhythms in phases of temporally reduced information processing during waking.

*Pfurtscheller and Aranibar (1977) coined the term "idling rhythms."

*The origin of the alpha rhythm can be localized within the primary and secondary visual areas of the occipital and partly parieto-occipital cortex. (Ciulla et al. 1999; Hari et al. 1997; Manshanden et al. 2002; Michel et al. 1992; Patel et al. 1999; Williamson et al. 1997).

*The focus of α -band activity moved depending on whether cued locations were in the upper or lower field. Results are consistent with active gating of uncued spatial locations (Worden et al. 2000).

*In the occipital cortex, previous studies correlating EEG alpha amplitudes and metabolic measures have typically found negative correlations among alpha amplitude and blood flow (Sadato et al. 1998), glucose metabolic rate (Danos et al. 2001), and BOLD signal (Goldman et al. 2002; Moosmann et al. 2003).

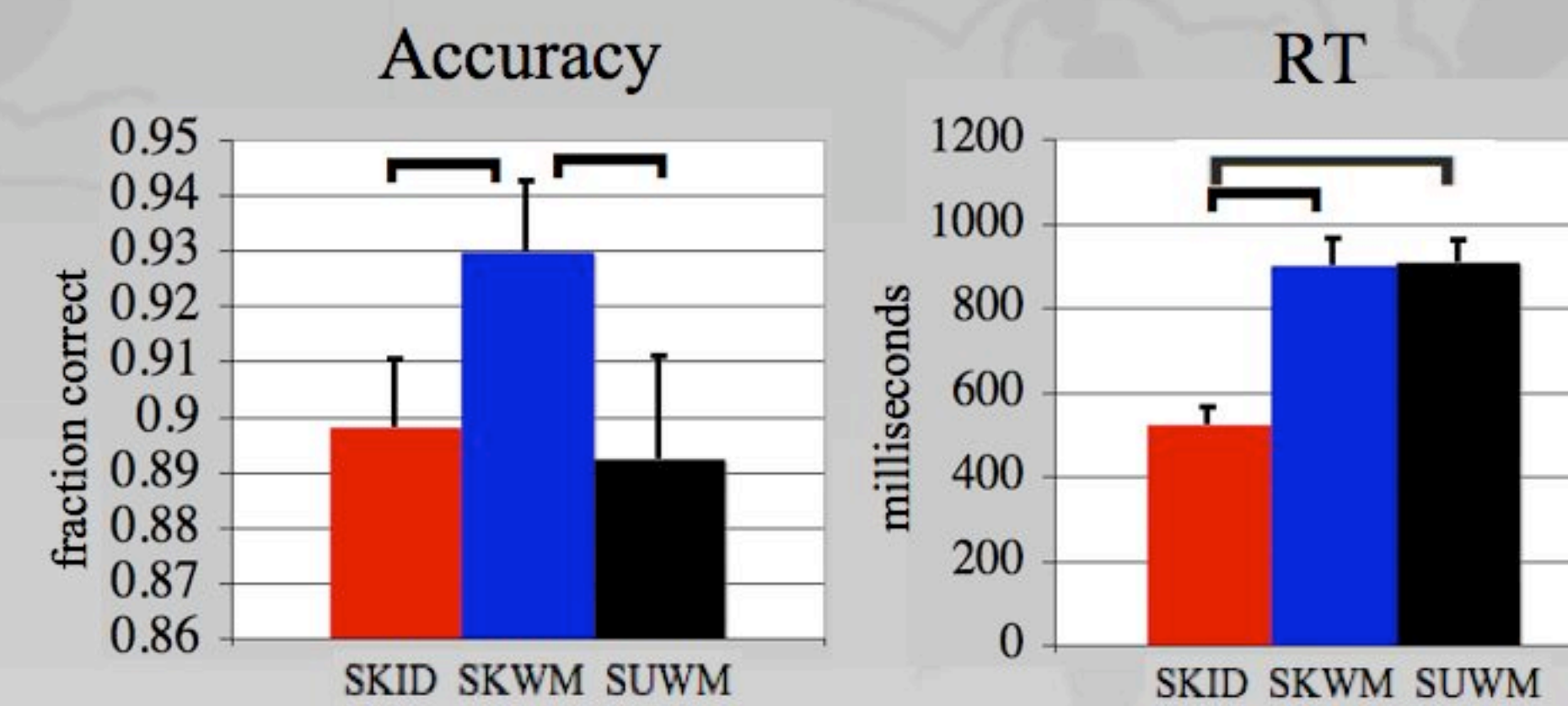
β -Background

*Wrobel et al. (2000) show in the cat that cortico-geniculate feedback has a build-in potentiation mechanism that operates at around the beta frequency and activates thalamic cells thus lowering the threshold for visual information transmission. They have also shown that enhanced beta activity is propagated along this feedback pathway solely during attentive visual behavior.

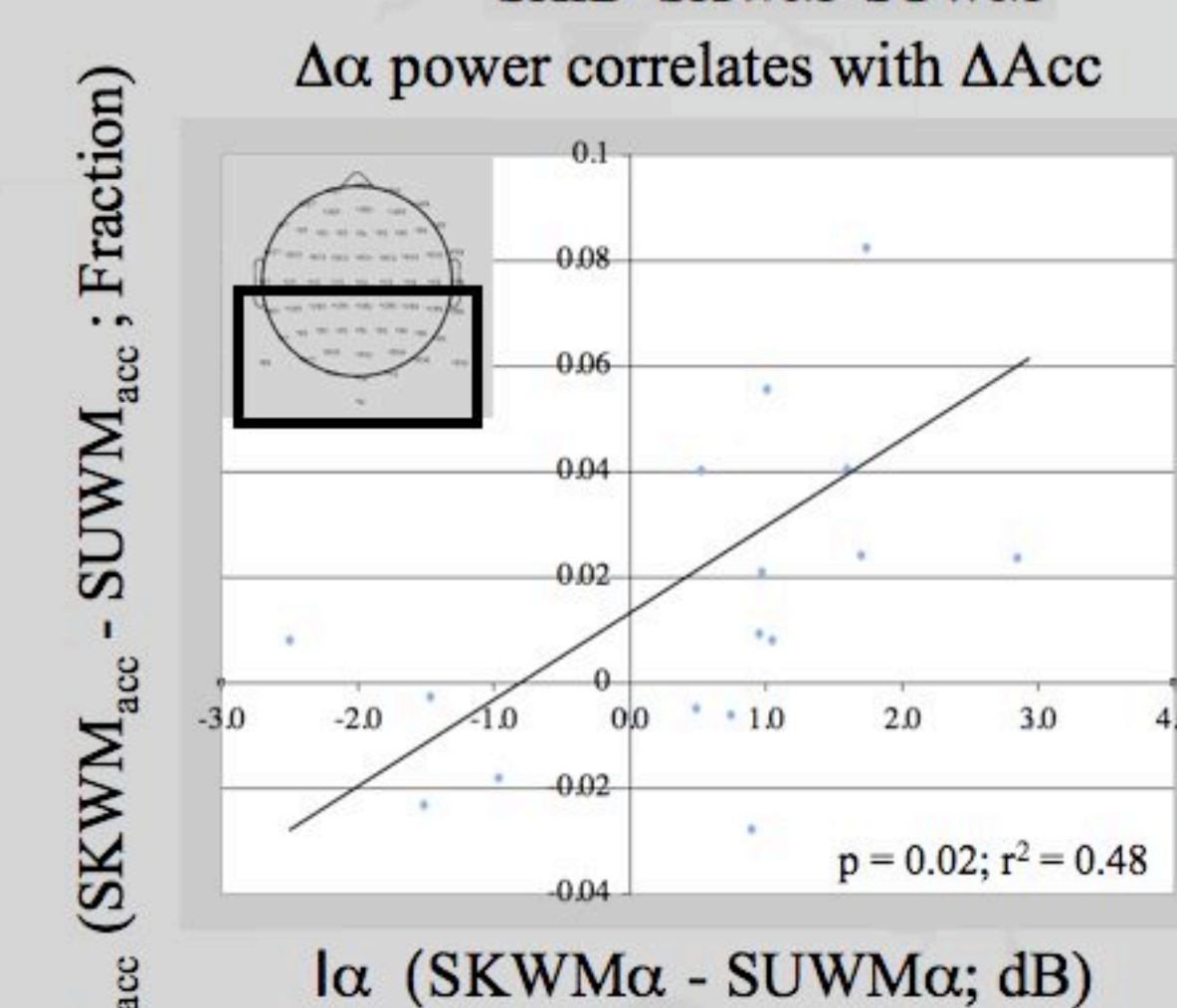
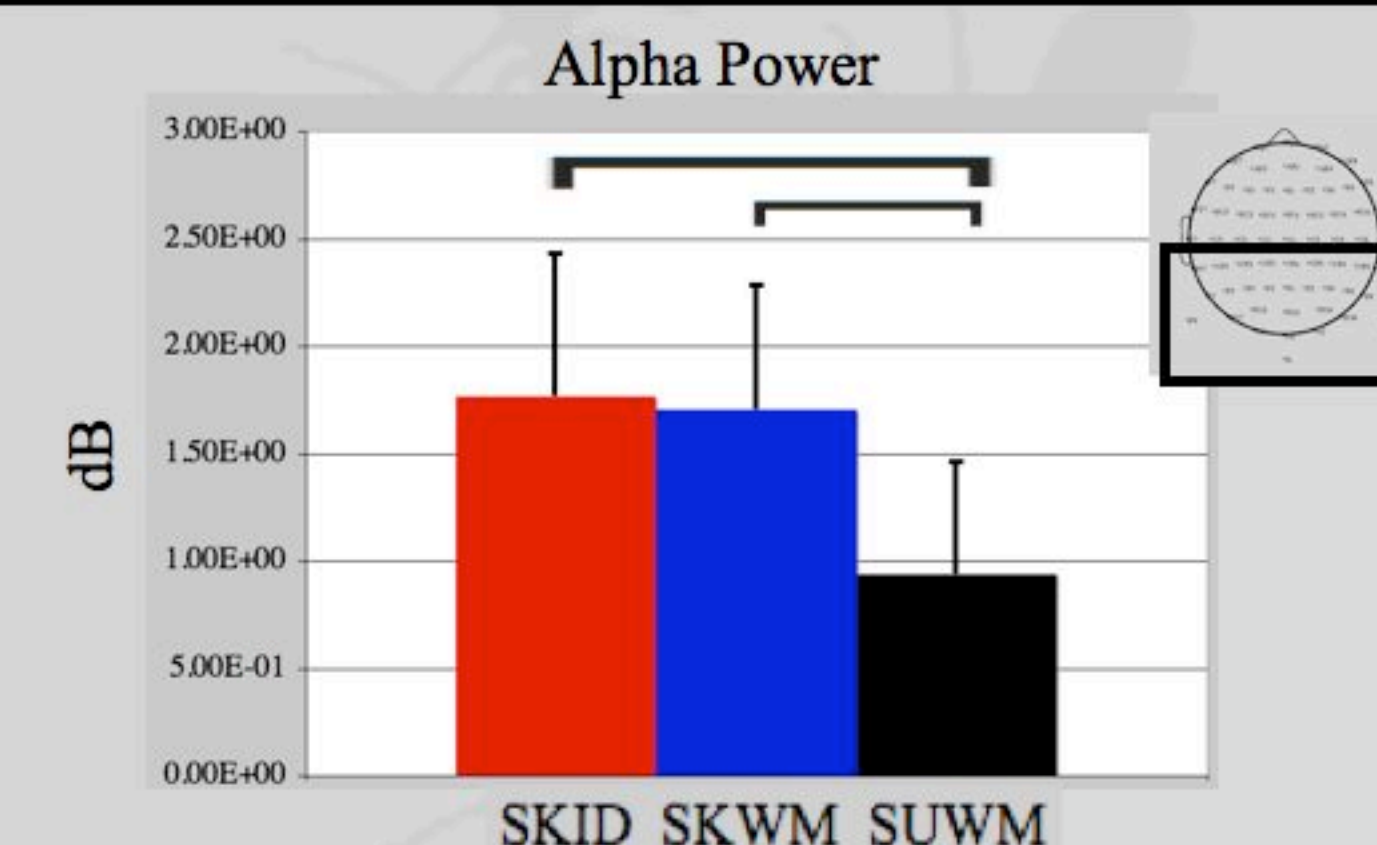
Behavior:

Accuracy:
SKWM > SUWM, SKID

RT:
SKWM, SUWM > SKID



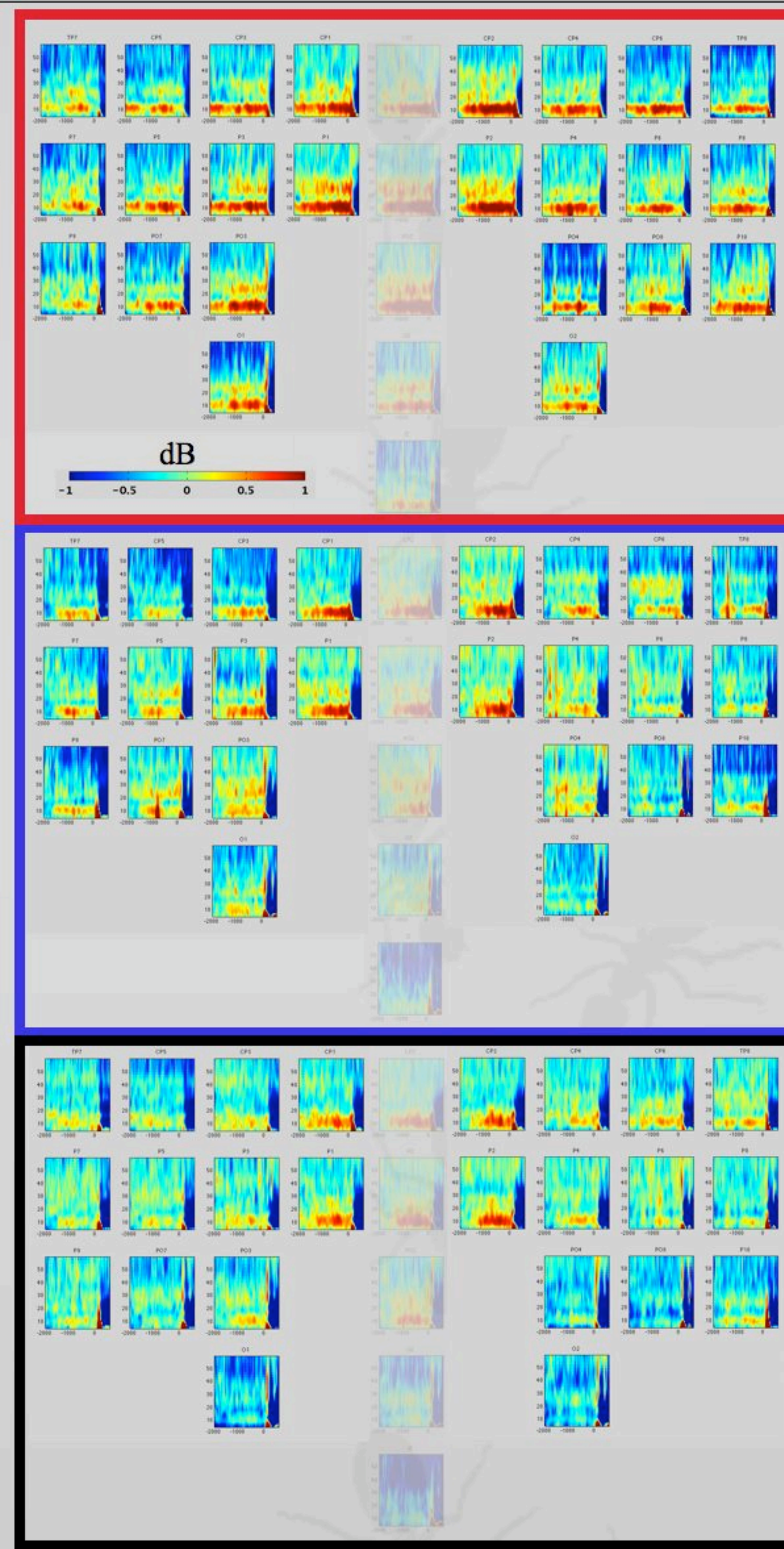
Alpha suppression is increased over the posterior cortex when there is knowledge of stimulus category; correlation with behavior.



*These data provide evidence for increased alpha-band activity in the stimulus-known tasks (versus SUWM) over large areas of neocortex.

*This increase in alpha may result in the pre-stimulus suppression of channels related to irrelevant information and multitasking or task switching.

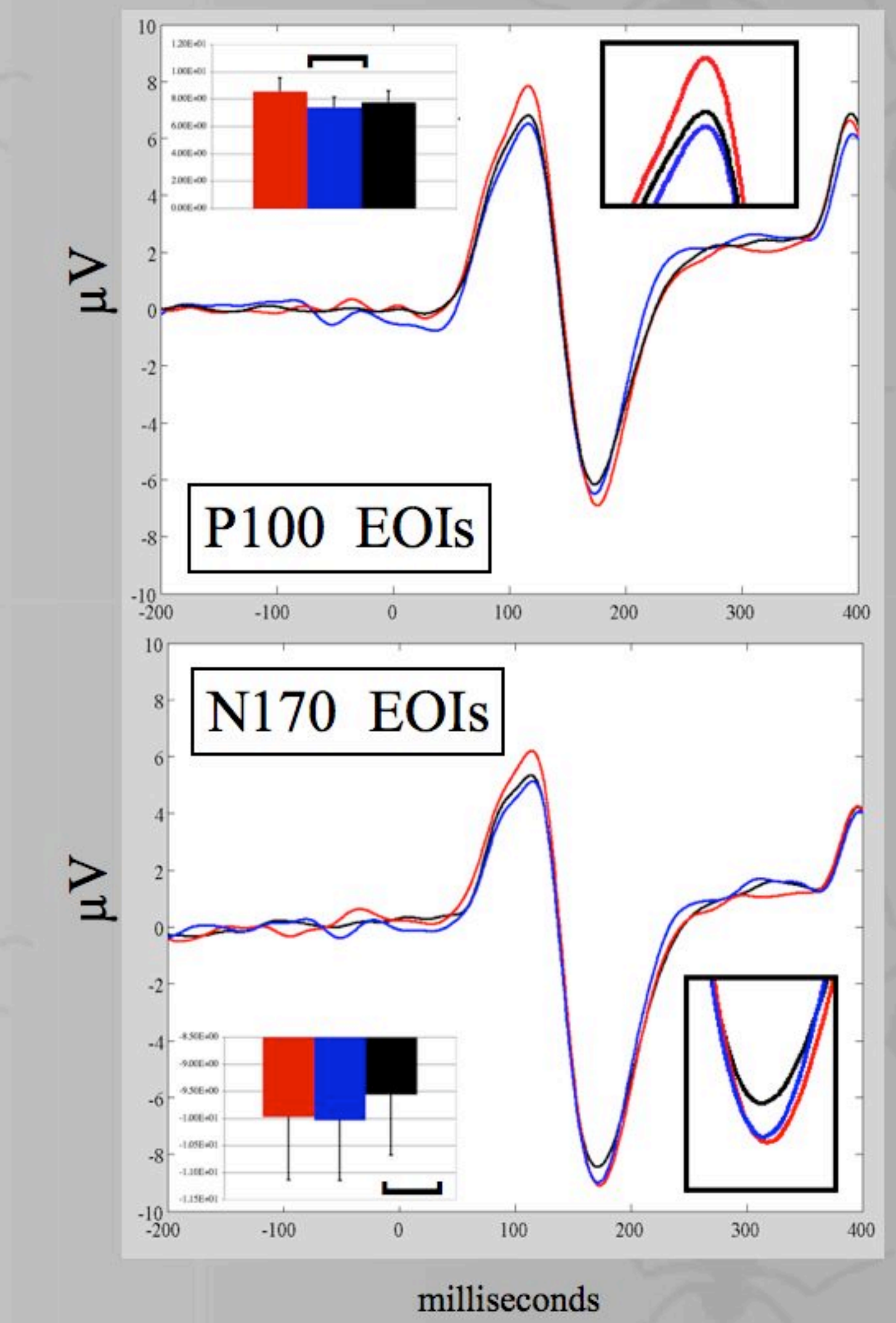
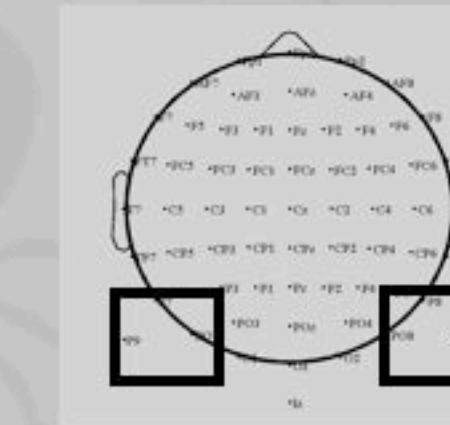
*We hypothesize that this gating mechanism acts to "clean" the thalamic channels for efficient information transfer of peripheral information to face-representing neocortical areas.



ERP Results:

P100 Amplitude:
SKID > SKWM

N170 Amplitude:
SKWM > SUWM



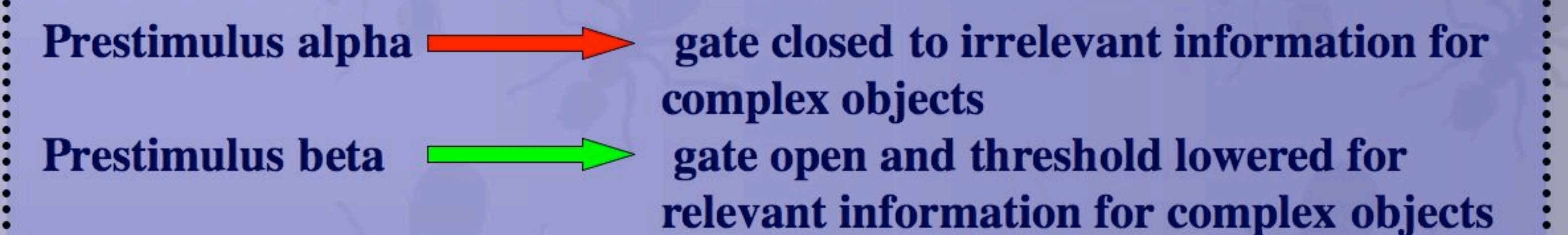
*No correlations were found for ERPs with any behavioral or pre-stimulus measure. We hypothesize that this is possibly due to the complex and likely non-linear interaction between pre-stimulus anticipatory alpha suppression and beta activation which may effect evoked measures.

Conclusions:

- 1) Subjects performed the SKWM task more accurately than the SUWM task.
- 2) There is more pre-stimulus alpha-band activity across posterior and parietal regions of the neocortex during knowledge of stimulus category than when stimulus category is unknown.
- 3) This difference is pre-stimulus alpha activity correlates with the difference in accuracy.
- 4) Subjects that were more accurate, displayed an overall increase in pre-stimulus synchronization within the alpha and beta ranges on all tasks.
- 5) In addition, SUWM high-performing subjects display significantly higher pre-stimulus beta synchronization.

These results, along with consideration of the literature, suggest a model of thalamo-cortical gating in which anticipated relevant information channels are primed for sensory transmission to the neocortex via an increase in pre-stimulus beta synchronization. Via alpha synchronization, the channels related to information that is anticipated to be irrelevant are suppressed and inhibited from supporting sensory transmission to the neocortex.

This model has been proposed in several iterations previously including spatial cueing. (Worden et al. 2000). These results extend the literature in that we show evidence for a similar mechanism for the processing of complex objects.



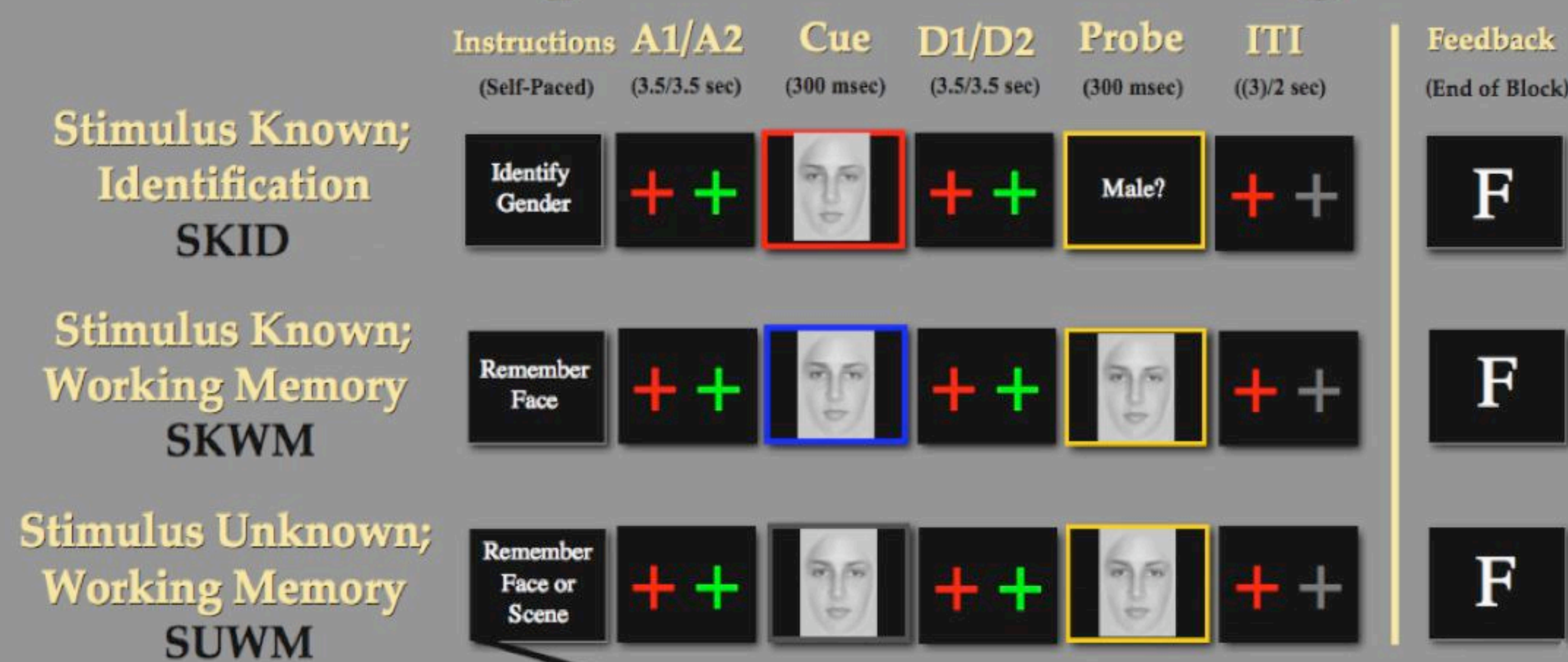
Methods:

Electrophysiological signals were recorded from 20 subjects average age 24.9 (+/- 3.97) years (10 males) with Ag/AgCl electrodes from custom 75-electrode cap systems. 64 EEG channels will be selected and referenced to linked mastoids or balanced non-cephalic derivations. Trials with excessive peak-to-peak deflections, amplifier clipping or excessive high frequency (EMG) activity will be excluded prior to analysis. Signals will be amplified and digitized at 16-bit resolution using appropriate sampling rates (typically 256-512 Hz/channel). Anti-aliasing filters are used during data acquisition. A variety of different sampling rate and bandpass combinations are available ranging from DC (with PC-controlled capacitance discharge to minimize amplifier drift) to 5,000 Hz. Typical band passes for long-latency components will be .01-100 Hz. The EEG will be continuously digitized at a sampling rate at least 2 times that of the low-pass filter to prevent aliasing. Data will be digitally band-pass filtered off-line to enhance the signal/noise ratios of the components of interest.

The time-frequency decomposition was acquired via Morlet wavelets and induced activity was calculated by discarding phase information prior to averaging over trials. Pre-stimulus measurements were baselined to an early-anticipation window. Prestimulus band power was determined as the average power over the time window (-500 to +50 ms). Frequency ranges were: Alpha band (8-13Hz) and Beta band (15-25Hz).

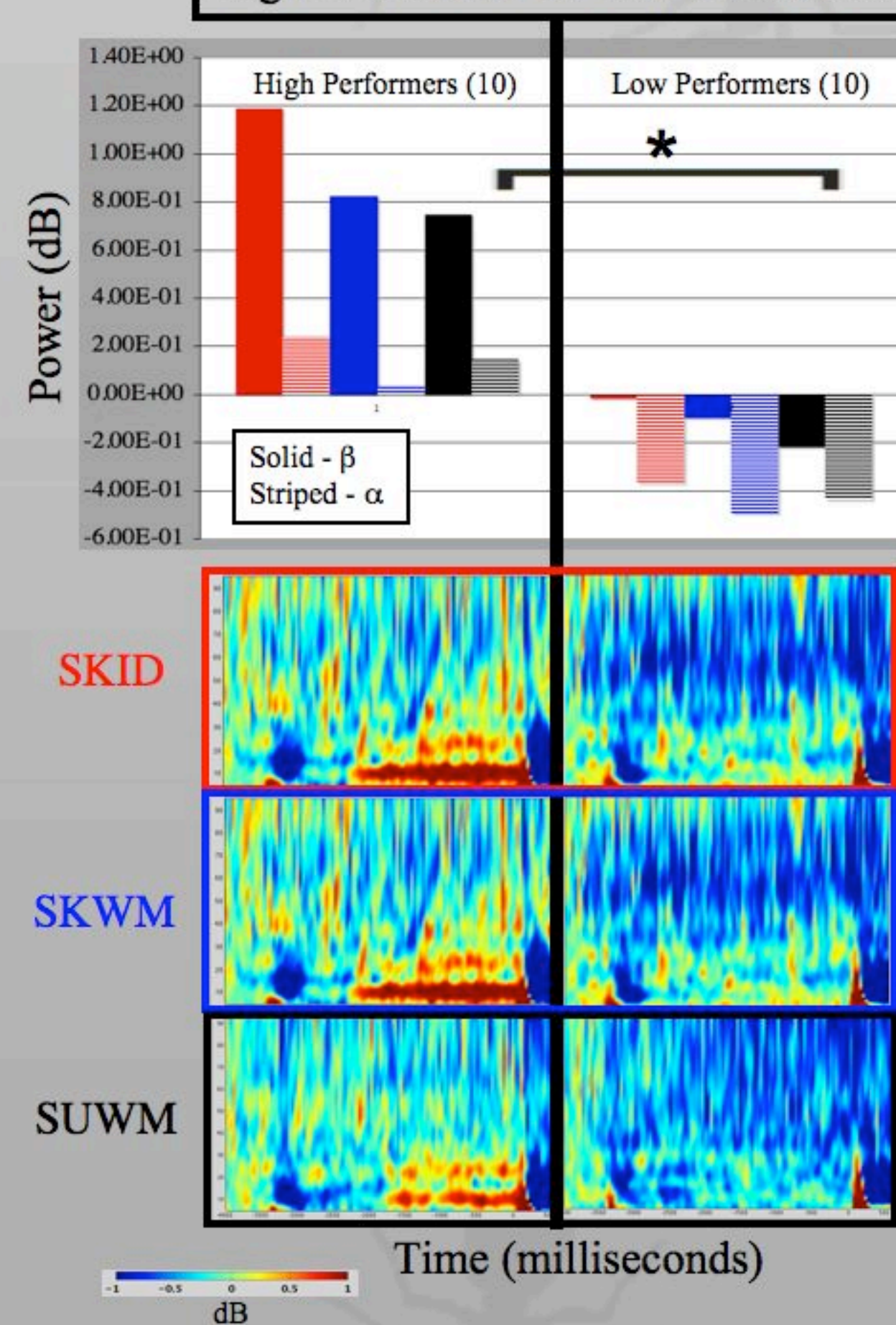
Accuracy and reaction times were recorded and all participants also received a post-experiment memory test to record incidental long-term encoding of the stimuli that may differ in a task-specific manner. Participants also complete a post-hoc experimental questionnaire to assess cognitive strategy.

Anticipation EEG Paradigm

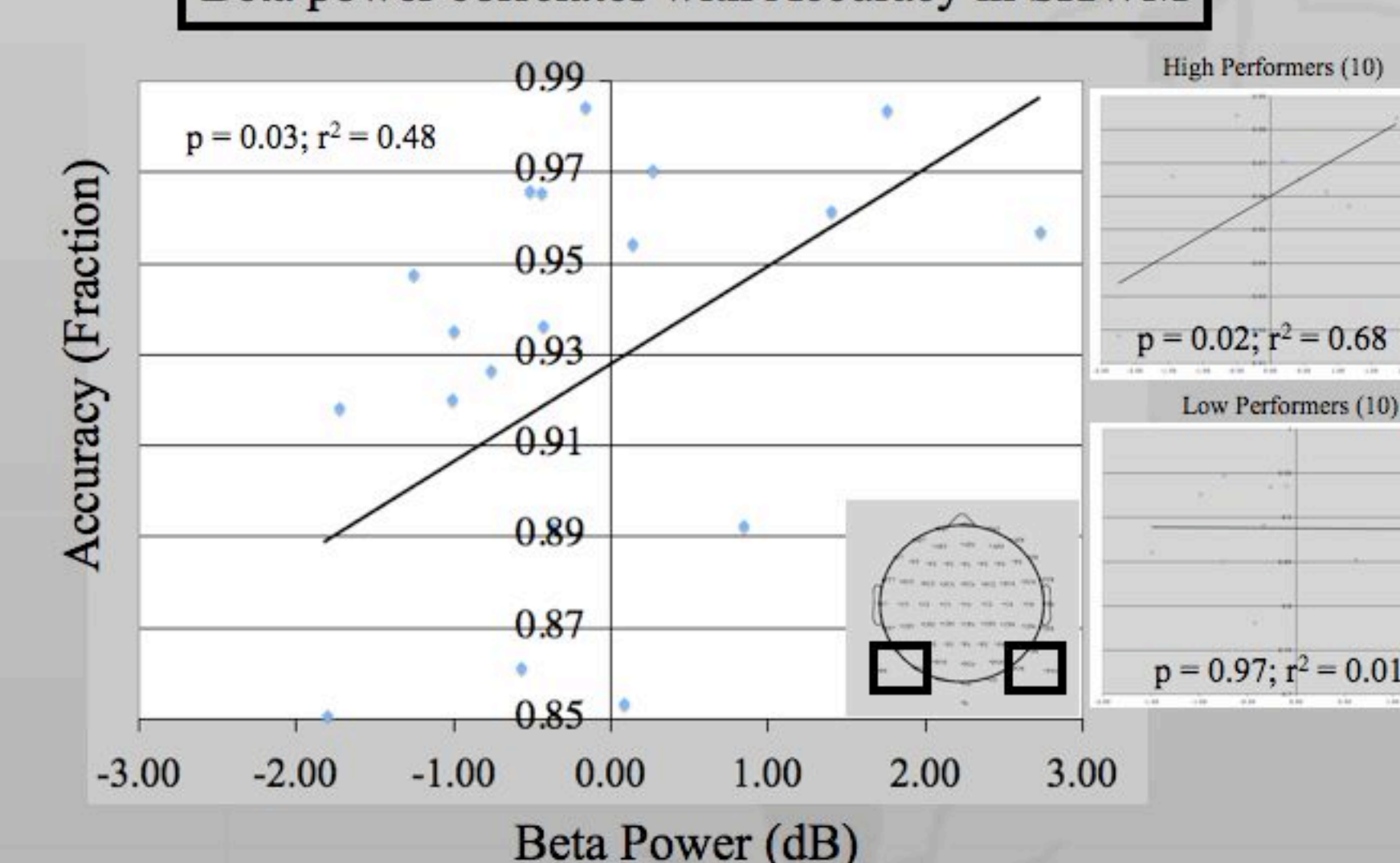


Trial Info: 12 trial types (2 SKID, 4 SKWM, 4 SUWM)
Each trial (cue & response) = ~18 sec.
36 trials per run: ~10:48 min
8 runs (2 SKID, 2SKWM, 4 SUWM)
Total = (8*10:48) = 86:24 minutes

High Performers vs. Low Performers



Beta power correlates with Accuracy in SKWM



*High performers display increased pre-stimulus synchronization across all bands compared to lower performers

*High performers' (and the group's) pre-stimulus beta activity correlates with performance on the SKWM task.