Top-Down Control of Alpha Phase as a Mechanism of Temporal Prediction

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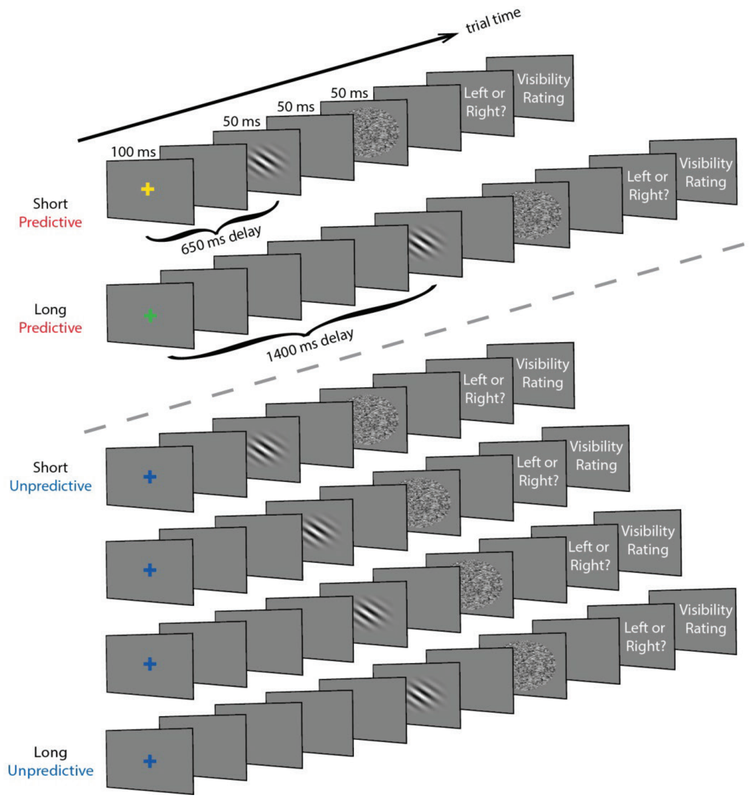
Background

- The phase of posterior pre-stimulus alpha-band oscillations (8-14 Hz) has been shown to influence visual detection (1, 2), the perception of TMS-induced phosphenes (3), and the magnitude of the fMRI response in visual cortex (4).
- Many accounts treat this phenomenon as a product of spontaneous ongoing activity, independent of top-down control.
- **We manipulated temporal prediction as an independent variable, to investigate whether alpha-band phase can be optimally configured by top-down control.**

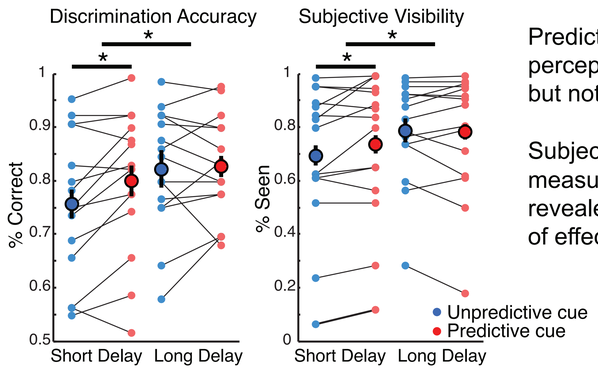
Methods

- Participants (n = 15) were asked to make a non-speeded two-alternative forced-choice orientation judgment of a backwards-masked Gabor followed by a visibility rating on the 4-point perceptual awareness scale while 256 ch. EEG was recorded.
- Colored cues indicated short, long, or unpredictive delays with 100% validity
- 20% of trials were catch trials on which no target was presented.



Behavioral Results

Temporal Predictions Improve Visual Perception



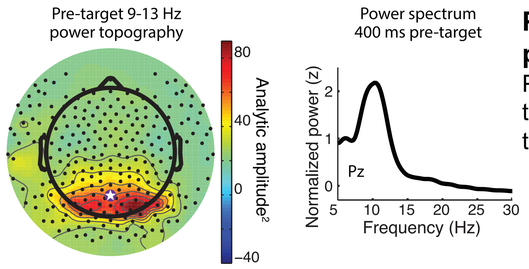
Predictions improved perception following short, but not long delays.

Subjective and objective measures of perception revealed the same pattern of effects.

EEG Results

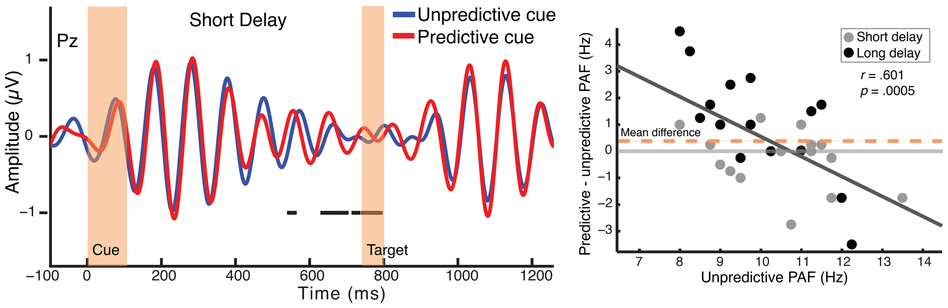
Pre-target alpha signal

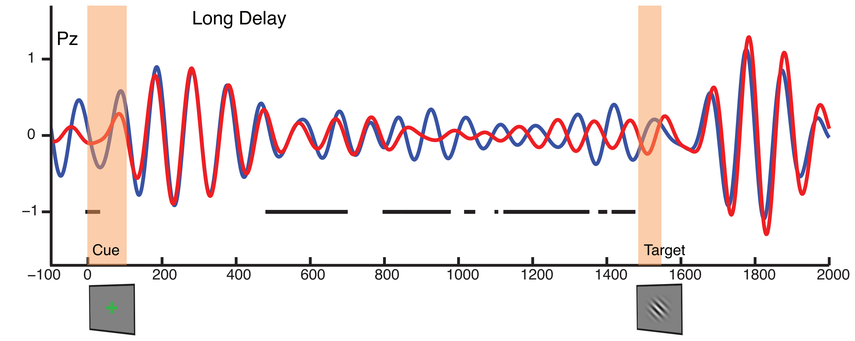
Power spectrum and topography of data from -400 ms prior to target onset reveal a clear peak in alpha with a posterior scalp distribution. Electrode Pz, used for analysis, is indicated with a star.



Temporal Cueing Modulates Alpha Phase

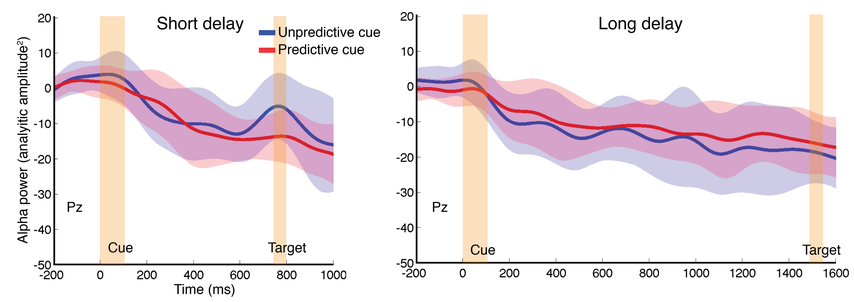
Predictive cueing alters the phase of alpha oscillations prior to target onset at short and long delays. This may be achieved by a modulation of the peak alpha frequency (PAF) prior to target onset, as individuals with slower pre-target PAF tended to speed up following predictive cues, and vice versa.





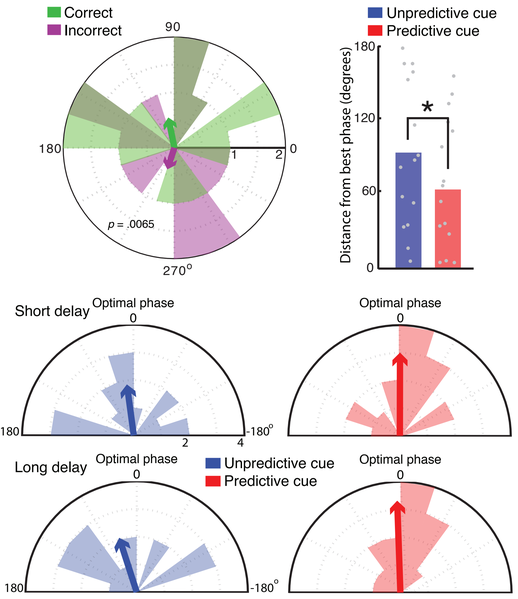
Differences in alpha *power* cannot account for phase effects

No significant differences in alpha power between predictive and unpredictive cues were observed across the entire delay period of both short and long delay trials.



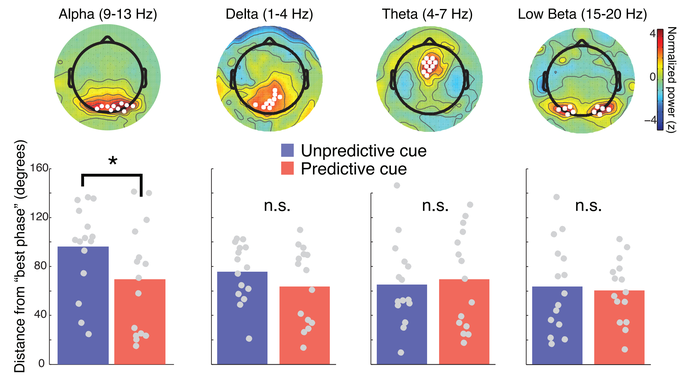
Predictions bias pre-target alpha towards an optimal phase for perception

Performance was associated with a particular alpha phase at target onset. Temporal cueing biased alpha phase at target onset towards each individual's "best phase".



Frequency specificity of effects

Pre-target phase bias was also present in alpha, and absent in other common frequency bands, when analyzed at electrode clusters defined by maximal pre-target power in each band.



Conclusions

- Predicting when a target will appear in a visually demanding discrimination task can improve perception.
- Temporal predictions are accompanied by a shift in the dominant alpha frequency prior to target onset, the direction of which is dependent on PAF during unpredictive trials
- The phase angle of alpha at target onset predicts successful orientation discrimination, revealing an optimal phase for visual processing, and temporal predictions bias the phase of alpha towards that optimal for each individual.
- **The phase of alpha oscillations has an active role in information processing, serving as a mechanism for the implementation of the top-down control of visual processing based on temporal predictions.**

References

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