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Alpha oscillations support modulation of neuronal excitability to Target and Distractor features in Guided Search

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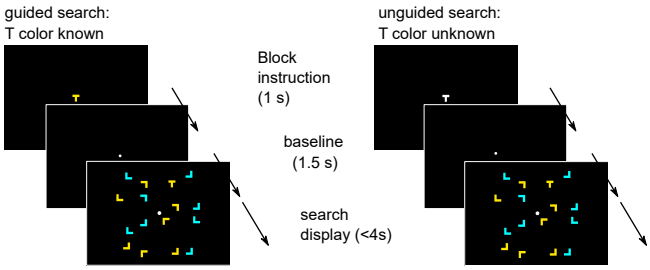
Feature Guidance in Visual Search

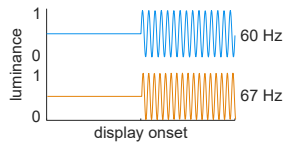
Visual search models have long suggested that search is facilitated by a "priority" map, guiding attention towards items having Target features and away from items having Distractor features[1,2].

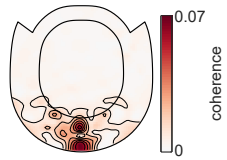
Here, we use to Rapid (Invisible) Frequency Tagging (RFT)[3] to answer the following research questions:

1. Is Guided Search associated with a modulation of neuronal excitability to Target and Distractor features in early visual regions?
2. Are strong pre-search alpha oscillations associated with faster reaction times, as shown previously[4]?
3. Do alpha oscillations impose a global threshold or a targeted inhibition on the known distractors to support the set-up of a priority map?

Visual Search experiment: Rapid Frequency Tagging & MEG

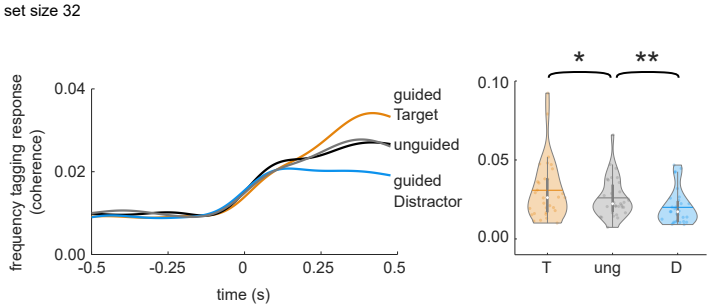






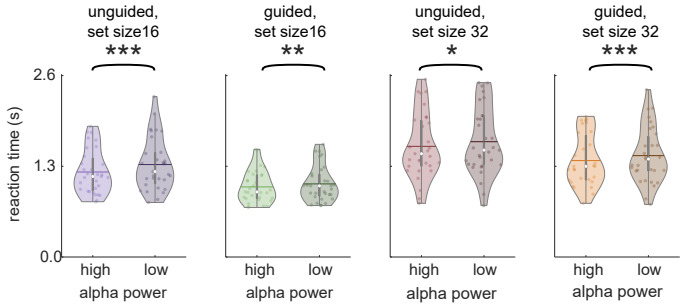
set size: 16 and 32 (randomized over blocks)

Frequency Tagging: Target boosting & Distractor suppression



Neuronal excitability (indicated by RFT response) was significantly enhanced for the guided Target color and suppressed for the guided Distractor color compared to the unguided condition ,for set size 32, but not for set size 16.

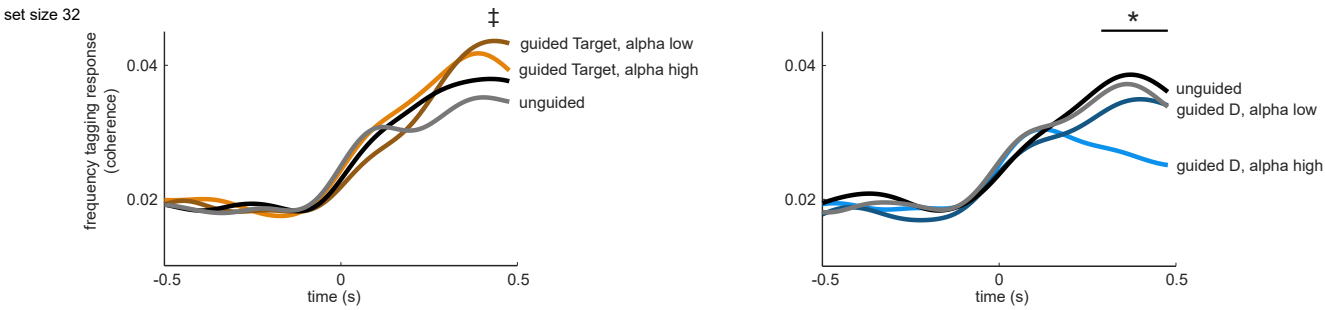
Strong pre-search alpha power predicts faster reaction time



Reaction time per condition, trials sorted into high and low alpha power during baseline (median split) for each participant. Trials with high alpha power are associated with faster reaction time in all conditions.

Wilcoxon signed rank tests: $p < 0.05$ *; $p < 0.001$** and $p < 0.0001$ *** (Bonferroni corrected).

Strong pre-search alpha in Guided Search linked to reduced Frequency Tagging response



Cluster-based permutation tests on the 0 to 0.5 s interval reveals that the magnitude of the frequency tagging response to the Distractor color is significantly reduced for trials with high compared to low pre-search alpha power for set size 32 (500 randomizations; * $p < 0.05$.). Comparison of the RFT response to the guided Target color shows only a trend effect[‡]. There is no difference in coherence between alpha high and low in the unguided conditions or for set size 16. **Control analyses** show that stronger pre-search alpha does not coincide with more saccades or an eye movement bias towards the target color. Participants moved their eyes significantly more in the unguided condition (for both set sizes). Median split on reaction time reveals no difference in coherence between fast and slow trials.

Conclusions

- Guided search (among 32 items) is associated with enhanced RFT response to Target features and a reduced response to the Distractor color in early visual regions.
- In accordance with previous findings[4], power at the individual alpha frequency during baseline predicts faster reaction time.
- Increased pre-search alpha power is associated with a significantly reduced RFT response to the Distractor color. Comparison of the tagging response to the Target color only revealed a trend effect.

Using RFT in combination with MEG, we show that neuronal excitability to Target and Distractor features is modulated in early visual cortex. This is in accordance with a priority map modulating early visual processing[2]. Alpha oscillations support this process by imposing an additional inhibitory modulation on the excitability. While our results speak more strongly in favor of a targeted inhibition of the Distractors by alpha oscillations, the slight reduction in neuronal excitability to the Target color with high alpha power implies that alpha might counteract the Target boosting as well.

References

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4 Pastuszak, A, Shapiro, K. L., Hanslmayr, S. (2018) The role of pre-stimulus alpha oscillation in distractor filtering during a Visual Search task. Journal of Vision, 18.