Guided Search is associated with modulated neuronal excitability to Target and Distractor features in early visual regions

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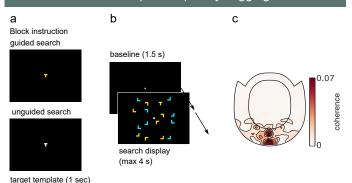
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Feature guidance in visual search

Visual search models have long suggested that search is facilitated by a "priority" or "activation" map, guiding attention towards items having Target (T) features and away from items having Distractor (D) features 1,2. In this MEG study, we use Rapid Invisible Frequency Tagging (RIFT) in a classic Visual Search paradigm, to understand the neuronal mechanisms underlying feature guidance. RIFT is a novel technique to probe neuronal excitability in primary visual cortex (V1)3-5. Hypotheses:

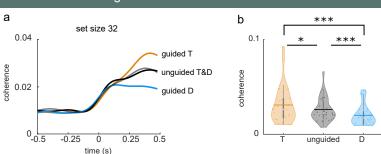
- 1.Neuronal excitability (RIFT) to the T feature is enhanced and response to D feature is reduced in guided (pre-defined T) compared to unguided (undefined T feature search.
- 2. Faster reaction times are preceded by enhanced alpha power. 3.1. Pre-display alpha power reflects a targeted inhibtion and is only enhanced in the guided search condition. OR
- 3.2. Pre-display alpha oscillations impose an untargeted "blanket" inhibition in guided and unguided search.

Visual Search: Rapid Frequency Tagging & MEG

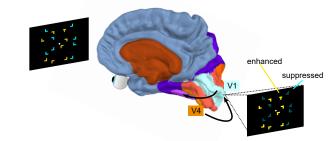


a Instruction at beginning of the block: T color known (guided search) vs randomized (unguided search). b Trial structure. The T and D colors were randomly tagged at 60 and 67 Hz; set sizes (16 & 32) were randomized over blocks. c RIFT response in one participant, planar gradio-

Target features are boosted & Distractor features are suppressed in primary visual cortex

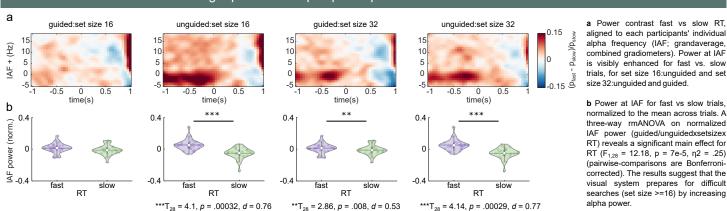


Coherence between MEG signal (gradiometers) and tagging signal for set size 32‡. a The response to the guided T and D color are modulated after \sim 150 ms. **b** Coherence averaged over the 200 ms to \sim 500 ms time interval (minimum reaction time; RT). RIFT response to the known T color is significantly enhanced (T₂₈ = 2.36, p = .025, d = 0.42), and the response to the known D color is significantly reduced ($T_{28} = -4.28$, p = .025). -0.77) compared to unguided search. Consequently, there is a strong, significant difference between the responses to the known T and D (T_{28} = -4.28, p = 4e⁻⁵, d = -0.86; p-values Benjamini-Hochberg-corrected).



Model: Target enhancement and Distractor suppression in V1. The latency of the modulation (~150 ms) suggests that the neuronal excitability in V1 underlies topdown control, e.g. by color-sensitive area V4. Modulation of V1 excitability results in a dimmed retinotopic representation of the items in the D color and an enhanced representation of the items in the T color. Brain regions colored according to the visuotopic PALS atlas97

Stronger pre-search alpha power predicts faster reaction times



Conclusions

We propose that visual search is guided by an interplay of alpha inhibition, boosting of Target features and inhibition of Distractor features. Alpha oscillations impose a pulsed "blanket" inhibition on the upstream signal from V1 along the visual hierarchy. The excitability of V1 neurons is modulated by a higher-order area, e.g., V4, based on whether they encode Target or Distractor features.

Attention will be guided to objects whose representations are strong enough to overcome the inhibition, here, objects sharing the Target color.

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