

Attention enhances sensory processing in human extra-striate visual cortex

Farshad Moradi, Christof Koch

Computation and Neural Systems program, California Institute of Technology, Pasadena, CA 91125

farshadm@caltech.edu

Selective attention evokes fMRI response in visual areas as early as LGN and V1 even in the absence of retinal input, but it is unclear whether stimulus-dependent activation also increases with attention. Here, we tried to dissociate stimulus-dependent attentional effects from changes in baseline BOLD response by directing subjects attention either before, or after, a peripheral grating is displayed. Two square-wave gratings were displayed in upper screen quadrants at 10 degree eccentricity. A cue instructed subjects to attend to either one of the two gratings, or---more frequently---to a foveal attention demanding task. The cue appeared either 400 ms before, or 250 ms after, the onset of the stimuli. If the target was one of the gratings, observers reported whether it is tilted to the right, or to the left. By varying the orientation of the grating we examined whether or not pre-cuing improves discrimination compared to post-cuing.

Single neuron recordings in monkeys and human visual event related potentials indicate that facilitation of neural responses to stimulation mainly occurs in extra-striate cortices, and not much in V1. Consistent with those results, we demonstrate that if attention is deployed before the peripheral target is displayed, V4 response and subjective discrimination are both enhanced compared to when the targets appears first. Contrariwise, attending before the target appears does not enhance V1 activity.

These findings are in agreement with the hypothesis that attention facilitates subsequent sensory processing by increasing neural gain in extrastriate cortex. A simple gain cascade model that assumes selective attention increases both the gain and the baseline BOLD activity in V1, V2/VP and V4 was used to explain the results (Fig 1). Our suggested model has four features: 1) in the absence of attention, gain is less than one, therefore the response to the peripheral pattern decays as it travels from V1 to V4 (Fig 2c). 2) Pre-cueing increases the gain, thus the response increases from V1 to V4 (Fig 2a). 3) In the post-cue condition, gain increases after the initial feed-forward activity has subsided. Therefore the increase in the baseline signal dominates the BOLD response (Fig 2b). 4) Discriminability depends on the onset (t_0), and duration (t_1-t_0) of the attentional window with respect to the time constant of the decay of activity (τ ; Fig 2d). The model not only fits the data well, but also explains how variability of the duration of the integration window (Fig 3a, two sample distributions) could manifest as a relationship between V1 BOLD activity and discriminability (d') for near threshold stimuli (Fig 2b, c.f. Ress, Backus, & Heeger Nat Neurosci 2000).

Figure 1

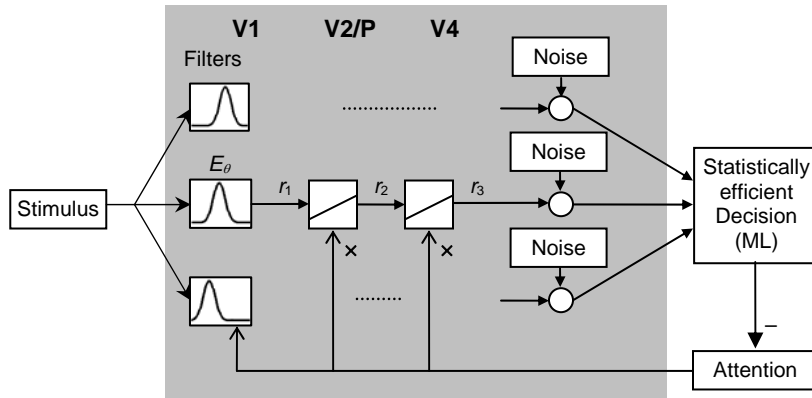


Figure 2

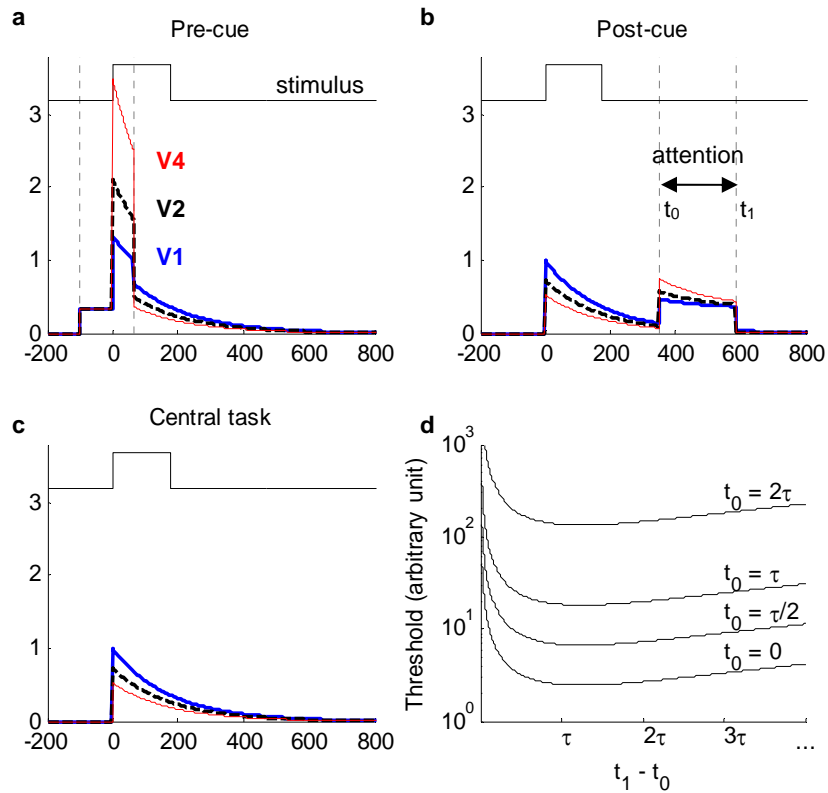


Figure 3

