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# A Novel Paradigm for Vision Functionometry in Glaucoma

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Although standard automated perimetry is traditionally used to assess visual function loss in conditions such as glaucoma, it may have a poor relationship to alterations in ability to perform activities of daily living. Here we describe a novel approach to vision functionometry -- investigating the active use of visual information in more complex visual environments. For this purpose, we developed an active visual search task in which subjects saccade freely across the screen to detect matching object pairs in an evolving display, while we record their eye movements and high-density electroencephalographic (EEG) signals.

In the experiment, 4 sizes of Gabor patches with 4 possible different angles of stripes were presented to the screen (20 inch LCD monitor, 60 cm distance from the eyes) (Figure 1A). Five Gabor patches, positioned at random across the screen, were always visible on a gray background. Every 1.5 seconds, a new Gabor patch appeared while the oldest one disappeared. The subject's task was to actively search for the infrequent (15% probability) occurrence of a pair of patches matching in size and orientation. The subject pressed a button whenever they identified a matching pair. There were 285 trials containing paired targets. Infrared eye-tracking data was obtained from left eye while 205-channel EEG data were recorded.

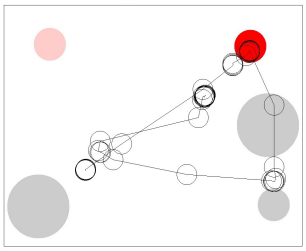

*Figure 1. Eye gaze scan path beginning at the appearance of a Gabor patch (red disk) matching a currently displayed patch (pink disk). In this trial the subject failed to note or respond to the match.*

Overall response accuracy was 87% and mean reaction time was 959 ms (SD 321 ms). Smaller Gabor patches, and longer distances between the paired targets were associated with lower response accuracy and longer reaction times. Figure 1 shows an example gaze trajectory when the subject missed the target. EEG analysis using multivariate analysis of independent component processes in successful Hit trials revealed that information flow from primary visual cortex to right superior temporal gyrus decreased at 230 ms, then reversed direction and polarity near 512 ms (Figure 2). Following mean reaction time, information flow from left parietal to right prefrontal cortex increased.

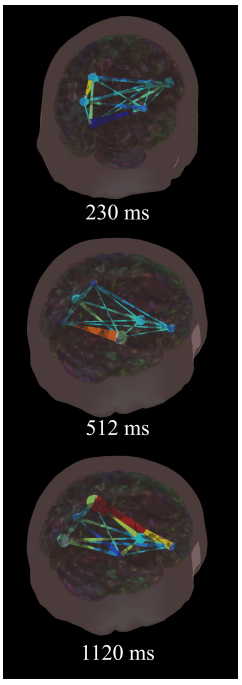


*Figure 2. Information flow arrows (thick to thin) between six independent component source processes at three latencies following appearance of matching stimuli correctly detected by the subject.*

We confirmed that target size and target pair distance controlled the subject's performance, and the interactions between primary visual cortex and superior temporal cortex may support active visual search behavior. Glaucoma patients compensating for either frank or incipient visual field loss may be expected to produce more saccades, shorter fixations, and/or altered distributions of saccades and fixations, together with alterations in EEG activity associated with stimulus onsets and saccadic eye movements.