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The representation of the saccade target object depends on visual stability

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During everyday scene viewing, the human visual system faces many challenges. The most frequent disruption of the visual input occurs during saccadic eye movements. Every time we execute a saccade, the perceptual input is disrupted by both saccadic suppression and shifts of objects' retinal locations. Despite these frequent changes, the visual system is quite efficient at representing a stable visual world (i.e. establishing visual stability). We have previously proposed that transsaccadic integration depends on an object-mediated updating (OMU) process (Tas, Moore, & Hollingworth, 2012). According to this view, the representation of the saccade target object depends on visual stability. Specifically, if stability is established, the post-saccadic object is perceived as the continuation of the pre-saccadic object. In this case, the properties of the pre-saccadic object are overwritten by the post-saccadic properties. In contrast, when visual stability is disrupted, the pre- and post-saccadic objects are represented as separate objects. Therefore, the properties of the pre-saccadic object are protected from overwriting. In the present study, we tested this assumption directly. Specifically, we asked whether visual stability modulates the availability of the pre-saccadic object's features for report.

Present Study

In all experiments, a colored saccade target was presented either at the left or right side of fixation (Figure 1A). Participants were instructed to execute a saccade to the target object. Visual stability was manipulated with the intrasaccadic target blanking method (Deubel, Schneider, & Bridgeman, 1996). Specifically, on half of the trials (blank condition), visual stability was disrupted by deleting the saccade target for 250 ms after the initiation of the saccade. On the remaining trials (no-blank condition), the saccade target stayed on the screen throughout the trial. In addition to the visual stability manipulation, on some trials the color of the saccade target was also changed to a new value.

To ensure that visual stability was only influenced by the object's spatiotemporal properties (i.e. blanking), we ran pilot experiments to determine the largest magnitude of color change which would not disrupt visual stability. In separate experiments, the color of the post-saccadic object was changed 30°, 45°, or 75° (Experiments 1, 2, and 3, respectively), either clockwise or counterclockwise in color space. After completion of the saccade, participants were presented with a color wheel and asked to report the color of either the pre- or post-

saccadic object by selecting the appropriate color from the color wheel. If the properties of the pre-saccadic object are overwritten by the post-saccadic properties when visual stability is established, as suggested by the OMU account, participants should have difficulty accessing the pre-saccadic object's color in the no-blank condition. Specifically, participants should be more likely to incorrectly report the post-saccadic color when asked to report pre-saccadic color. However, there should be separate representations for pre- and post-saccadic objects when visual stability is disrupted. Therefore, we expected to find accurate color reports for both pre- and post-saccadic objects in the blank condition.

Results

Figure 1B shows the proportion of color responses as a function of color values, separately for blank and no-blank conditions of each experiment. We fitted participants' color response distributions in the color change trials with probabilistic mixture models (Bays, Catalao, & Hussain, 2009; Golomb, L'Heureux, & Kanwisher, 2014). To test whether the presaccadic color was overwritten by the post-saccadic color under visual stability, we first calculated the probabilities of reporting the target color (Pt), the distractor color (Pd), or a random color (Pr). We ran 2 (stability: no-blank, blank) x 2 (report: pre-saccadic, post-saccadic) ANOVAs separately for Pt and Pd measures. In all three experiments, the main effect of stability, the main effect of report, and the interaction were significant for both Pt and Pd measures ($p < .001$). Pairwise comparisons showed that the probability of reporting a distractor was higher in the no-blank than in the blank condition for trials in which participants were asked to report the pre-saccadic color ($p < .04$). No significant difference was found for post-saccadic color reports.

As converging evidence, we tested whether response distributions were better fit by a bimodal distribution than a unimodal distribution in the no-blank and blank conditions. To achieve this, we ran two separate models (unimodal vs bimodal), separately for each of the four conditions. Comparisons between the models' AIC values showed that in the no-blank condition, the distribution for pre-saccadic reports (green lines in Figure 1B) was better fit by a bimodal distribution than a unimodal distribution ($p < .001$). The fits for the remaining three conditions were better for the unimodal than the bimodal distribution. Together, these results support our prediction that the pre-saccadic color was overwritten by the post-saccadic color when visual stability was established compared to when stability was disrupted. Next, we tested whether the representation of the reported color was affected by the distractor color for trials where participants successfully reported the pre-saccadic color. We ran separate models for each condition with the mean of the main distributions as free parameters. For both 45° and 75° of color changes, reports were significantly shifted towards the distractor values, regardless of visual stability (no-blank or blank) and the reported object (pre- or post-saccadic) ($p < .01$).

Discussion

The present study tested the role of visual stability in the representation of the saccade target object. Consistent with the OMU account, we found when visual stability is established, the initial properties of the saccade target object are overwritten by the properties of the post-

saccadic properties. In contrast, when visual stability is disrupted by spatiotemporal discontinuity, the pre- and post-saccadic objects are treated as separate objects, and both of their properties can be retained and successfully reported. We have also found preliminary evidence that pre- and post-saccadic features may also interact in a more dynamic way: Color reports were shifted towards the non-reported value even when visual stability was disrupted.

References

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Figure 1.

(A) Sequence of events in no-blank (top) and blank (bottom) trials of Experiment 2 (45° of color change). (B) Proportion of color reports as a function of color value in no-blank (top) and blank (bottom) trials of 30°, 45°, and 75° color change experiments.