

The Eyes Have It: Eye Tracking Analysis of Anthropomorphic Car Fronts Using Spatiotemporal Scan Statistics

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EXTENDED ABSTRACT

In marketing research, the use of eye tracking methods is widespread and extends across various contexts, such as the effects of TV advertisements on brand perception during fast forwarding (Brasel and Gips 2008), the impact of certain elements in print advertisements on attention-direction (Rosbergen, Pieters, and Wedel 1997), or the positioning of banners in online-advertisements on advertisement perception (Hervet et al. 2010).

Usually, these studies employ eye tracking data analyses that rely heavily on the definition of regions of interest (ROIs; cf. Duchowski 2007). With this method, regions (most commonly rectangular) are marked to encompass certain parts of the stimulus; from these regions, classical eye tracking metrics are calculated (e.g., the total gaze duration). While heavily used by researchers, classical ROI eye tracking metrics are prone to at least four methodological limitations. First, data quality is closely related to the reliability of the ROI definition, and thus highly dependent upon the researcher's ability to define properly the ROI. Areas within the ROI unrelated to the experimental manipulation may add noise to the underlying signal, indeed an ROI may even consist of subregions that behave in opposing ways. This is a serious downside, especially when considering that there is no convention suggesting how tight ROIs need to be defined. Procedures or further descriptions of ROI definitions are usually not provided by most authors in the literature reviewed. Second, the use of classical filter mechanisms in combination with the ROI method may result in misleading data reduction. Third, it can be argued that the definition of ROIs does not reflect physical realities of the human field of view, which suggests a region of decreasing acuity around the fovea (Irwin 1992). Research findings that participants remember objects without a registration of gazes underscore this problem (Kuisma et al. 2010). Finally, ROI analysis can only discover effects previously hypothesized by the experimenter and thus may miss out on a central benefit of eye tracking. In the current research, we develop a new method relying upon spatiotemporal scan statistics that can overcome the limitations of ROI analysis, by offering a convenient way to analyze and visualize eye tracking data.

Spatiotemporal scan statistics automatically identify clusters of points in a point process that differ from the distribution expected under a baseline condition. These statistics, as implemented in the SaTScan software, are widely used in epidemiology to identify disease clusters (Kulldorff et al. 1998). While these statistics are not explicitly limited to epidemiological settings (Kulldorff 1997), applications in other contexts are rare. The use of scan statistics in eye tracking is novel and promising, as it provides a data driven approach to identify deviant gaze clusters. Implementing the scan statistic to eye tracking data assumes that a point process can account for the distribution of data, such as the Bernoulli model. Gaze points observed under a baseline condition are treated as non-cases, while points observed under an experimental variation are treated as cases. For a certain region in space, the probability of a gaze point being a case can thus be calculated. A likelihood ratio test statistic is calculated on the basis of the observed and the expected case to non-case-ratio (Kulldorff 1997). This procedure is applied to the whole study region by moving around a scanning window systematically in space and time. The window var-

ies in size as it moves across the plane, so that for all points all possible window sizes are tested. The statistical significance of the clusters is then evaluated with Monte Carlo simulation (Kulldorff 1997).

The two methods of eye tracking data analysis, the classical ROI-based approach and our technique based on spatiotemporal scan statistics, are compared in an eye tracking experiment focused on perception of car faces. The theoretical grounding of this research is based on findings on anthropomorphic car fronts and literature on schematic faces regarding threat perception that suggest specific differences in the attention-capture of certain features of a car face. In particular, it is expected that car faces resembling threatening faces are avoided by the viewer in the long run.

Participants looked at a series of car faces for 10 seconds each, and rated them afterwards. Twenty-nine students participated in a 2 (headlights or eyes) $\times$ 2 (lower air vents or mouth) $\times$ 2 (side air vents) within-subjects experiment, whereby each feature existed in a threatening and a non-threatening variant.

Results provide some support for the theoretical expectations of face perception, in that threatening headlights were looked at for shorter periods of time over the whole experiment. Differences between the two eye tracking methods emerged. The ROI technique produced different results depending upon the ROI definition used, and thus clearly illustrates the problems associated with the method. While the scan statistic generally confirmed the key findings of the ROI method, more detailed results were provided by this new method (e.g., with respect to when and where significantly differing gaze clusters emerged). Results also clearly indicate the superiority of the method in terms of visualizing differences in gaze behavior between stimuli.

In summary, while several limitations exist for classical eye tracking analyses that rely on ROIs, these problems do not occur with the data driven approach provided by the scan analysis. In our study, results derived from ROI analysis were partially confirmed by the new method, but clear differences emerged such that greater details could be derived from the scan statistic. Due to the combination of a statistical methodology with a visualization technique, the method is not only attractive to academic eye tracking researchers, but also to marketing practitioners who often rely upon data visualization techniques that do not provide a statistical criterion for hypothesis testing, such as heatmaps. The use of our technique in that field will clearly lead to better practical use of eye tracking data. Finally, our research provides valuable insights for researchers and designers interested in anthropomorphic product design, as the impact of mechanisms of biological preparedness could be demonstrated. In our experiment, threatening and non-threatening car fronts clearly exerted different effects on viewer attention.

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