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How to apply preattentive visual properties in information visualization

Preattentive processing of visual information is processed automatically on the entire visual field, and it is performed before any conscious attention arrives to the display (Ware, 1999). A typical reaction time (RT) in preattentive processing is less than 10 milliseconds (ms) per item versus a typical RT of 40 ms or more in non-preattentive processing (Treisman and Gormican, 1988). Hence, it is quick and effortless to make inference without loading any capacity on working memory. Preattentive processing is at the low level visual system, but its properties can guide viewers' attention to salient items in a display and perform high-level analysis tasks. This is a good new for Information visualization designers, as they can utilize preattentive visual properties to help users effectively extracting information in complex data. This article will discuss applications of few preattentive features in information visualization.

Preattentive feature is the unique feature that would "popout" in the visual field. Not every preattentive features have equivalent "popout" effect. But color is undoubtedly one of the strongest attributes to guide attention to area of potential interests (Wolfe and Horowitz, 2017). A key application of color is in medical images, which are conventionally displayed in grayscale, since individual regions of similar density can be easily located. However, color images provide preattentive features (i.e., tumor shows in red patch) that direct users' attention to the abnormal areas which might not be immediately apparent in a grayscale, due to weak contrast.

Within each preattentive feature, the degrees of "popout" effect is also different (Ware, 1999). The preattentiveness of color depends on the degree of difference to the surroundings. The larger difference, the more likely a color will pop out (Callaghan, 1989). One method of maximzing perceived color difference is linear separation techique: the target colors should be linearly separatable from its distractor colors on a color space (D'Zumura, 1991; Figure 1). The technique can be particularly useful we need to highlight certain points from large scatterplots. We should select color green or purple, rather orange and purple as the distractors if the targets are in red.

Unlike color, luminance onset (flicker) is a "probable" preattentive feature (Wolfe and Horowitz, 2017), because it does not have a certain definition. Generally, flicker refers to a repeating on-off pattern applied to an image or an object. Coherent flicker is easier to be detected than non-coherent flicker (Huber and Healey, 2005). For example, a on-off pattern flicker at same onsets t = 0ms, 60ms, 120ms, 180ms, … is more likely attract attention than a pattern at different onsets t = 0ms, 60ms, 80ms, 120ms, ... (Huber and Healey, 2005). Huber et al. (2005) explains that is because the visual system cannot group different onsets together. Flicker could be annoying in static visualization, but it is an effective guidance of dynamic information. For example, when users are analying real-time stock trading information, flicker will make new and important price changes stand out.

Preattentive features can be processed quickly and effortless by visual system, and they will immediately pop out in the visual field. The information visualization designers should apply these attributes to help users prioritize their attention towards the areas of interests. Preattentive features have different degrees of "popout" effect. Color is undoubtedly one of the top preattentive feature, but careful selection is requried to maximize the effect. We should use strong preattentive features (i.e., color) before weak ones (i.e., flicker) where ease of search is important.

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Figure 1.

Points are linearly separable *Points are not linearly separable*

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