The contributions of foveal versus extrafoveal vision to visual search in real-world scenes

Evidence from eye movements

◆ **Boundary extension effect during long-term isolation and repeated testing**

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Boundary extension (BE) is the tendency to remember scenes as if they included information beyond the boundaries (Intraub and Richardson, 1989 *Journal of Experimental Psychology: Learning, Memory and Cognition* **15** 179-187). We measured the changes in BE effect during isolation experiment (105 day space-flight simulation in Mars-500 project). During the isolation the participants were limited only to the interiors of the simulation module. The participants (N=6 in isolation group, N=12 in control group) were shown 48 picture pairs of natural scenes with close-up/wide (CW) conditions balanced and they rated the second picture on 5-point scale (close-up, same, further away). Both groups were tested 4 times during 3 months interval. In both groups usual BE-specific patterns were observed during the Test 1. In the end of isolation we found the differences in CW condition: in control group the BE effect was still present but significantly smaller compared to the original effect in Test 1, but in the isolation group the BE effect persisted. We found no effect of scene depth (distant vs near objects; based on participants' ratings).

[Supported by Czech Science Foundation grant (P407/10/P607)]

◆ **The contributions of foveal versus extrafoveal vision to visual search in real-world scenes:**

115 **Evidence from eye movements**

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What is more important when searching for an object in a real-world scene: foveal vision or extrafoveal vision? This question was assessed in an object search experiment where gaze-contingent display changes created artificial foveal and extrafoveal scotomas. In a 2×3 design, the type of scotoma (foveal vs extrafoveal) was crossed with three different window sizes (radii: 1.6, 2.9, and 4.1 deg). Gaze-centered scotomas were created on the fly by blending the original colored scene photograph and a blurred version of it into each other via a spatial Gaussian weight mask. Overall, search times were longer when the scene outside the gaze-centered aperture was blurred (extrafoveal scotoma) than when the information inside the aperture was blurred (foveal scotoma). There was an additional effect of window size as search times increased (foveal scotoma) or decreased (extrafoveal scotoma) with increasing window size. Based on the eye-movement records, these overall differences could be related to particular sub-processes of search. Compared to the control condition, participants made longer or shorter saccades when searching the scene with a foveal or extrafoveal scotoma, respectively. It is concluded that extrafoveal vision is more important than foveal vision during object search in natural scenes, due to the importance of saccade target selection.

◆ **How text attracts attention during real-world scene viewing**

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The present study investigated (1) whether text objects attract visual attention more strongly than non-text objects and (2) what visual features of text objects affect the allocation of attention. We selected text and non-text objects in the eye-movement database compiled by Judd et al. (2009 *IEEE International Conference on Computer Vision (ICCV)*), in which real-world scene stimuli were presented to subjects for three seconds in a free viewing task. The LabelMe [Russell and Torralba, 2008 *International Journal of Computer Vision* **1**(3), 77, 157-173] database was used to localize and classify text and non-text objects. The results suggest that text objects have a shorter first-acquisition time, higher fixation-landing probability, and shorter minimum fixation distance than non-text objects. Remarkably, this advantage is virtually non-existent for text objects below a certain size, even when the text is still clearly readable. Besides the finding of greater text objects attracting attention more strongly, a temporal eye-movement analysis also revealed that this advantage lasts longer with greater eccentricity of objects. Regarding the visual features of objects, we found that luminance contrast of objects influences minimum fixation distance for both text and non-text objects, but saliency (Itti and Koch, 2000 *Vision Research* **40** 1489-1506) only affects non-text objects but not text objects.