

The best fixation target revisited: new insights from retinal eye tracking

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1. Purpose

During ophthalmologic examinations and in many experiments in vision science, participants are instructed to maintain fixation of a visual target. While maintaining fixation, the eyes are never completely stable and instead make small fixational eye movements, such as microsaccades and drift. The stability of fixation may have clinical relevance^[1-3]. The visual design of the fixation point may however also influence fixational stability, and the amount and spatial extent of fixational eye movements^[4-7]. The influence of fixation point design on fixational stability would be important to understand for clinical and other applications. For instance, when performing retinal imaging using techniques like scanning laser ophthalmoscopy (SLO) or optical coherence tomography (OCT), increasing eye stability with a fixation point may potentially improve the quality of the retinal images, without the need of using complex motion-compensation techniques^[8]. This benefit especially applies for derivatives requiring long acquisition time like wide-field OCT angiography. However, much of the previous work studying the influence of fixation point design on fixational stability used pupil-based eye trackers which have insufficient resolution and suffer from artefacts such as shifts in estimated gaze position due to pupil size change^[9-11] that make them unsuitable for this topic of study. In the presented study, we therefore use a retinal eye tracker which offers superior resolution and does not suffer from the same artifacts to reexamine what fixation point design minimizes fixational eye movements.

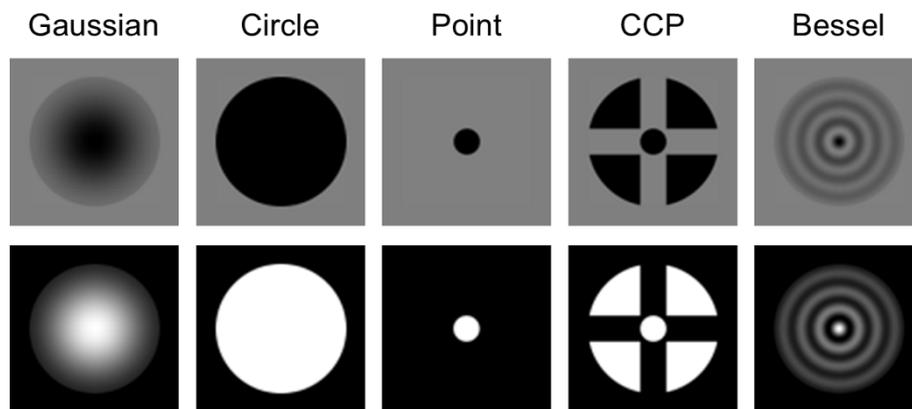


Fig. 1. The five fixation target designs used in the study, each rendered in the black-on-grey (top row) and white-on-black (bottom row) target polarity conditions. CCP refers to the Circle-Cross-Point target.

2. Methods and results

To assess the dynamics of fixation, we used the FreezeEye Tracker (FET)^[12]. This is an SLO-based eye-tracking device featuring rapid (620 Hz) scans of a $3^\circ \times 3^\circ$ segment of the retina. A correlation-based algorithm uses the time-series of scans to calculate eye trajectories with a precision of $0.156'$ (RMS of sample-to-sample distances). The scanner is combined with an optical channel to provide a monocular fixation target (1.02° diameter) with 0.015° resolution. In this study, six participants were shown five fixation targets in two target polarity conditions (Figure 1) while the overall spatial spread of their gaze position during fixation and the characteristics of their microsaccades and fixational drift were examined. We found (Figure 2) that, overall, gaze was more stable for white-on-black than black-on-grey fixation targets. Furthermore, fixation targets with a small central feature (Point, CCP and Bessel) elicited more stable fixation (lower microsaccade and drift displacement, and lower spatial spread [not shown]) but also higher microsaccade rates than larger fixation targets without such a small central feature.

3. Conclusions

In conclusion, there is not a single fixation target that minimizes fixational eye movements. Instead, if one wishes to optimize for minimal spatial spread of the gaze position, microsaccade or drift displacements, we recommend using a target with a small central feature. If one instead wishes to optimize for the lowest microsaccade rate, we recommend using a larger target without a small central feature.

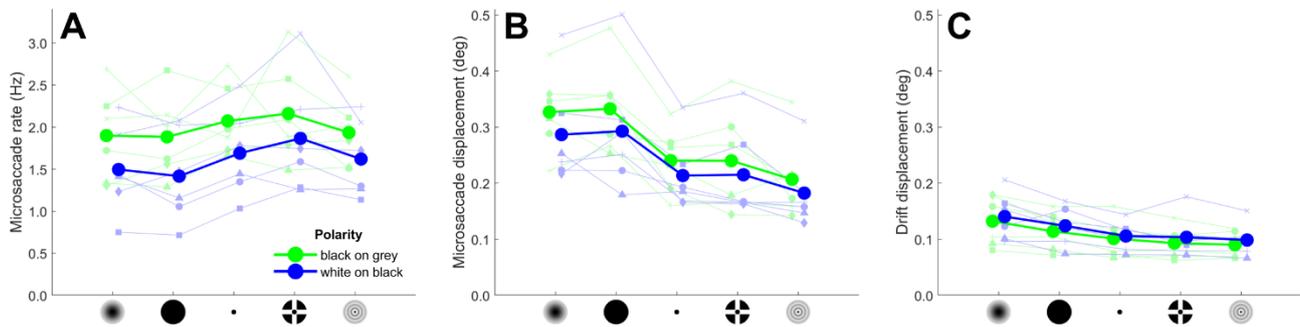


Fig. 2. Fixational eye movement characteristics for the different fixation targets and polarity conditions. Shown are the microsaccade rate (A), microsaccade displacement (B) and drift displacement (C) for each fixation target and polarity conditions, averaged across participants (large, filled circles connected by thick lines). Also shown are the values for the six individual participants (small, faded symbols connected by thin lines). The data for the two polarity conditions are horizontally offset for clarity.

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5. References

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