Supplemental Material

Using an open-source tablet perimeter (Eyecatcher) as a rapid triage measure in a glaucoma clinic waiting area

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1. Eyecatcher Technical Details

1.1. Stimuli

Targets were Goldmann III ($0.43°$ diameter) circles, presented for 200 ms against a uniform 10 cd/m^2 grey background (corrected for uniformity). The edges of the stimuli were spatially-ramped using a 2-D Gaussian low-pass filter ($\sigma = 2.85$ px). This smoothing was applied to avoid hard contours, which can provide in inadvertent detection cue, independent of stimulus contrast[1]. Target luminance was fixed at -6 dB on the HFA scale: a value intended to reflect a 'clinically meaningful' loss of visual sensitivity. Absolute target luminance was therefore approximately 18 cd/m^2, but varied by visual field location, depending on prior normative data[2]. Luminance was controlled using photometric measurement made at 24 uniformly-spaced screen locations (ColorCal MK II colorimeter; Cambridge Research Systems, Cambridge, UK). Two-dimensional tensor-product linear-interpolation was then used to compute the appropriate calibration for every screen location (pixel).

1.2. Viewing distance & gaze location

An inexpensive ~50 Hz eye-/head-tracker (Tobii EyeX; Tobii Technology, Stockholm, Sweden) was used to position each stimulus relative to the current point of fixation, and to determine whether the participant looked at it (see §1.6). Viewing distance was not strictly controlled, but head-location was monitored continuously, and estimated viewing distance used to dynamically scale the size and location of each stimulus prior to presentation.

1.3. Test grid

From the user's point of view, stimuli could appear anywhere on the screen. However, in practice, the stimuli on test trials were drawn from an underlying retinotopic grid of 22 locations (**Fig 1B** of main manuscript). This grid included 11 of the 20 most informative 24-2 locations identified by Wang & Henson, 2013[8] (the remaining 9 locations could not be accommodated within the spatial extent of the screen).

1.4. Test Trials

Each grid location was tested a minimum of 2 times, and until either: the stimulus was responded to twice (Hit), or the stimuli was not responded to on more than two-thirds of trials (Miss). This meant that each location was tested 2–4 times, with a stimulus that was 'hit' once having to be 'missed' three times to be scored a Miss. This strategy was used in part to counteract the fact that the underlying eye-tracking technology and/or classification-algorithm was more likely to result in a false-negative ('lapse') than a false-positive ('lucky guess').

1.5. Ancillary Trials

In addition to test trials, a substantial number of ancillary trials were employed to: measure false-positive response rate, measure false-negative response rate, calibrate the eye-tracker, and to encourage refixation in instances where the user was 'stuck' fixating one corner of the screen. Data from these ancillary trials are not reported, but they contributed substantially to the reported test durations.

Jones PR, *et al. Br J Ophthalmol* 2020;0:1–6. doi: 10.1136/bjophthalmol-2020-316018

1.6. Scoring Hits

A stimulus was judged to have been seen (Hit) if the participant's gaze fell within approximately 3° of the target for more than 100 msec, within 1.5 seconds of target onset. The exact size of this 'area of interest' varied, however, depending on stimulus eccentricity. Furthermore, a number of additional algorithms were used to preclude false-positive responses (e.g., due to 'searching' behaviors) or false-negative responses (e.g., due to calibration error, or a stimulus being presented during a saccade). These additional technical details are described in more detail elsewhere (*Jones, TVST, in press*).

1.7. Novel Features

Although Eyecatcher v2.0 is functionally similar to an earlier version of the test reported previously[7], the code used in the present study was rewritten from scratch, and included a number of modifications designed to improve speed, accuracy, and usability. This included algorithms designed to abort trials if the participant appeared to be 'searching', and to delay stimulus presentation until the eye was open, tracked, and relatively still. Stimulus duration was also fixed to match SAP (and to discourage searching behaviors), and participants were given audiovisual feedback when a target was correctly fixated. One particularly important innovation was that all of the eye-tracker calibration was performed within the test itself (i.e., no additional, manufacturer-supplied calibration was performed). This reduced the length of the overall procedure substantially, and means that reported test duration reflects the 'true' duration, including calibration. Note that calibration is a key challenge for eye-movement perimeters, and one which has severely limited completion rates and test performance in the past[3]. As such, particular attention was paid to this aspect of the test, and a number of novel solutions were developed (see §1.8, *next*).

1.8. Eye-tracker Calibration

At the start of the test, participants were directed to fixate a salient central target (a cartoon face), which then moved slowly to five additional locations around the screen. To ensure that each location was fixated (and to allow participants the opportunity to close their eyes or look away), a log-likelihood classifier was used. This required horizontal gaze estimates to be roughly proximal to the target before proceeding. Vertical gaze location was ignored, as this was found to be less reliable (i.e., more variable) in uncalibrated eyes. Standard algebraic regression was then used to find the second-order polynomial surface that best predicted the 'true' gaze coordinates, given the observed gaze coordinates (minimizing least-square Euclidean error). Fits were made recursively, with aberrant gaze-estimates from the first fit excluded from the second. The entire calibration procedure was repeated if there were insufficient data points remaining to make a robust estimate, however due to the use of the log-likelihood classifier this seldom, if ever, happened in practice. During the test itself, this calibration was further updated following every successful target fixation, such that the calibration became progressively more accurate as the test progressed (a novel 'bootstrap' procedure).

1.9. Code

Eyecatcher v2.0 was coded in MATLAB R2016a (The MathWorks, Natick, USA) using Psychtoolbox v3.0.11[4]. Limited resources and outstanding technical challenges (in particular, the need for a photometrically calibrated display), currently prevent us from making the test widely available as a downloadable 'app'. However, for technically minded readers, the complete source-code for Eyecatcher v2.0 is freely available online, under a non-commercial license, at: github.com/petejonze/Eyecatcher. As detailed elsewhere[5], the online code also supports threshold estimates using ZEST[6] (i.e., if attempting to provide a like-for-like replacement with SAP). However, thresholding was not used in the present study, as we expect that a rapid, fixed luminance (suprathreshold) is sufficient for the purposes of triaging new referrals.

Jones PR, *et al. Br J Ophthalmol* 2020;0:1–6. doi: 10.1136/bjophthalmol-2020-316018

2. Supplemental Figures and Analyses

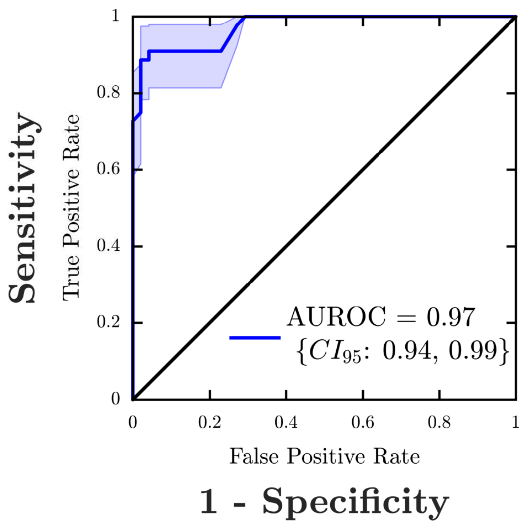

Fig S1. ROC analysis of sensitivity and specificity: The ability of Eyecatcher to discriminate individuals with moderate or advanced field loss (MD < -6 dB; $N = 24$) from those who are visually normal (MD > -2 dB; $N = 22$). AUROC: area under the receiver operating characteristic.

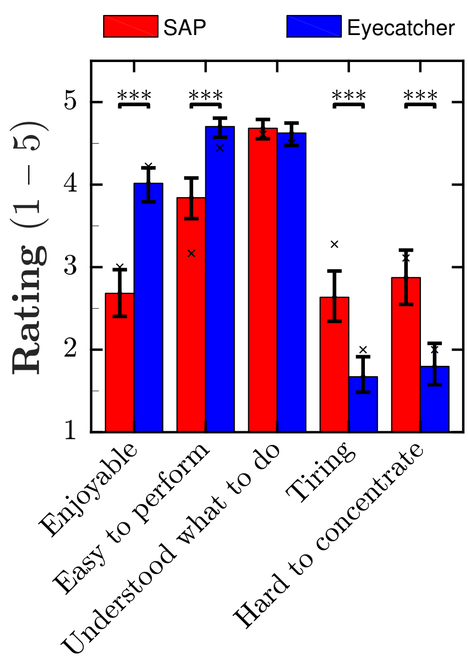

Fig S2. Group-mean [$\pm 95\%$ CI] usability scores for Eyecatcher (*blue*) versus conventional SAP (*red*). 1: Strongly Disagree, 5: Strong Agree. Responses were similar to those in our previous pilot work[7], the results of which are also shown here for comparison (*black crosses*).

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Supplemental References

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