Fixation disparity is a small vergence error—typically less than 25 arcmin when measured subjectively with nonius lines14, and up to 60 arcmin or more when measured objectively with eye-trackers15. This application demands an extremely precise and accurate eye gaze position prediction, making calibration quality a crucial issue5. In studying fixation disparity, researchers prefer to apply a monocular calibration6-14. Only two relevant studies applied a binocular calibration15,16. Still debates exist—is there really a difference between monocularly calibrated and binocularly calibrated fixation disparities? The theoretical background shows that both monocular and binocular calibration procedures may affect the binocular eye gaze position prediction (Figure 1).

The aim of our study was to evaluate the effect of the calibration procedure on fixation disparity measurement. We predict a difference in the objective fixation disparity measurement obtained after the monocular calibration (the monocularly calibrated fixation disparity) compared with the binocular calibration (the binocularly calibrated fixation disparity); in most cases, we expect the monocularly calibrated fixation disparity to be larger than the binocularly calibrated fixation disparity.

Method

The position of both eyes was recorded in 19 participants (a median age of 23 years; 20–39 years) with the ViewX Hi-Speed binocular video-based eye-tracking system (500 Hz; SMI, Germany). We created a monocular calibration procedure (Figure 2) and applied inverse prediction 17 to calculate the eye gaze position (Figure 3). Precision of calibration was evaluated by calculating standard deviation (SDcal) of the predicted eye gaze position18; the recorded digital values of the dark pupil centre in the eye image; ŷ—the calculated digital values of the dark pupil centre; n—number of calibration targets; β—the slope of the linear regression line.

Each participant had three calibration sessions on separate days with 4 minutes of practice (2 minutes to familiarize the participant with the eye-tracker and 2 minutes of reaction time to the calibration targets), after the dot scanning task (11 black points, size 0.5°, presented for 1 s, one point at a time, from left to right in 16° area; the sixth point was presented in the middle of the screen). After excluding data with large SDcal (over 25 arcmin) and SDcal values over 30 arcmin, the remaining data appeared more frequently (p < .001) during monocular calibrations (67.7 ± 0.8%) than during binocular calibrations (38.3 ± 0.6%).

Results

The position of both eyes was recorded in 19 participants (a median age of 23 years; 20–39 years) with the ViewX Hi-Speed binocular video-based eye-tracking system (500 Hz; SMI, Germany). We created a monocular calibration procedure (Figure 2) and applied inverse prediction 17 to calculate the eye gaze position (Figure 3). Precision of calibration was evaluated by calculating standard deviation (SDcal) of the predicted eye gaze position18; the recorded digital values of the dark pupil centre in the eye image; ŷ—the calculated digital values of the dark pupil centre; n—number of calibration targets; β—the slope of the linear regression line.

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Conclusions

The objective fixation disparity differs depending on whether the calibration is performed monocularly or binocularly, and this difference depends on the individual’s fixation disparity. Both types of calibration have advantages and drawbacks. Binocular calibrations are easier to perform, since they require less time and do not require a dichoptic presentation of calibration targets. Monocular calibration is more difficult to perform resulting in less precise calibration results than binocular calibration. However, binocular calibrations will typically underestimate the magnitude of the fixation disparity and only monocular calibrations are physiologically valid in the sense that the resulting fixation disparity is determined relative to the assumed center of visual direction.

Reference