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New objective method to measure fusional vergence

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Fusional vergence movements are driven by disparity and are used to bring the eyes into proper alignment and to maintain this alignment when looking at objects at different distances. Fusional vergence ranges are clinically relevant as they represent the ability of subjects to overcome possible eye deviations[1]. One of the methods to measure fusional vergence in clinics is the smooth vergence test, which involves the use of the Risley prisms mounted in the phoropter. This test has some disadvantages, such as its subjectivity, the fact that the measurement relies on the examiner's expertise, unusual viewing conditions or poor repeatability[2-3]. To solve these limitations, this study proposes a new objective method for the evaluation of positive (base out) and negative (base in) fusional vergence ranges based on the analysis of eye movements recorded using the eye tracker Eyelink 1000 Plus at 500 Hz included in an haploscopic set-up for stimuli presentation. This method has been validated against the clinical smooth vergence test.

A total of 34 adults (23.1 ± 3.1 years of age) participated in this study. Negative and positive fusional vergence ranges were first evaluated with the Risley prisms at 40 cm. Participants were asked to report double vision as the experimenter increased the amount of prim (break point), and recovery of single vision as the prism power decreased (recovery point). Then, negative and positive fusional vergence were measured with the objective method. Vergence movements were stimulated by varying the position of the stimuli displayed on the two screens of the haploscopic set-up. Break and recovery points were determined offline using a custom algorithm based on the analysis of eye movements coded in Matlab (Figure 1).

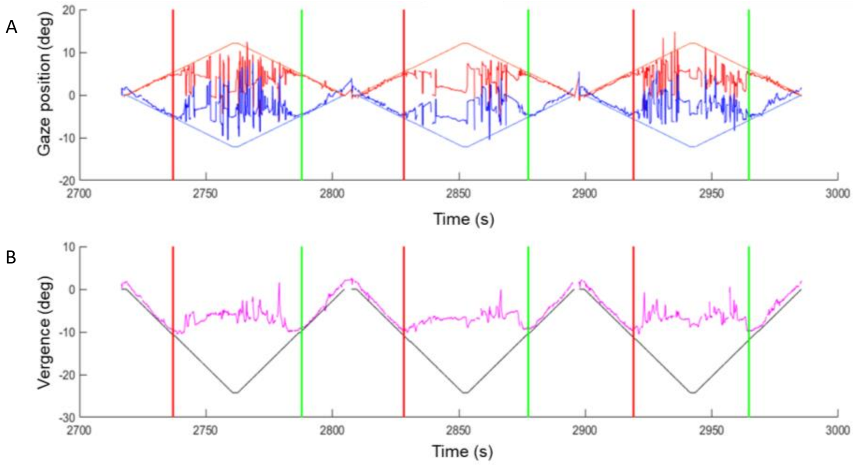

Figure 1: A: Positions of the right (red) and left (blue) eyes during the measurement of negative fusional vergence. The stimuli positions for the right and left eyes are represented by the red and blue straight lines, respectively. B: Vergence (magenta) and the vergence demand created by the stimuli (black). In both plots,

the objective break points (vertical red lines) and recovery points (vertical green lines) are shown. Three repetitions are shown for the same participant.

The results obtained with the two methods are shown in Table 1.

	Objective Method mean ± SD	**Subjective Method mean ± SD**
Base In Break	13.62 ± 4.28 PD	17.88 ± 3.29 PD
Base In Recovery	10.26 ± 4.50 PD	13.02 ± 3.41 PD
Base Out Break	37.37 ± 9.47 PD	27.41 ± 8.90 PD
Base Out Recovery	27.70 ± 9.11 PD	15.66 ± 5.25 PD

Table 1: Mean ± standard deviation (SD) of break and recovery points in prism dioptres (PD) of the negative (base in) and positive (base out) fusional vergence measured with the objective and subjective methods.

Bland-Altman analysis was done to determine the agreement between the break and recovery points measured with the two methods. The mean ± SD of the differences between methods and 95% limits of agreement were -4.25±3.23 PD (-10.60 PD, 2.08 PD) for the base in break point, -2.76 ±4.30 PD (-11.18 PD, 5.62 PD) for the base in recovery point, 9.95±8.89 PD (-7.47 PD, 27.37 PD) for the base out break point and 12.04±2.05 PD (8.04 PD, 16.03 PD) for the base out recovery point.

To conclude, this study showed the possibility to measure fusional vergence ranges objectively. Although the objective method offers numerous advantages, such as the ability to maintain constant measurement conditions across subjects, the two methods cannot be used interchangeably due to the poor agreement between them. With the objective method, wider positive fusional vergence ranges but narrower negative fusional vergence ranges were obtained than with the subjective method. This poor agreement could be in part explained by the different viewing conditions in the two methods. A different contribution of proximal cues could have led to different vergence responses, biased towards more convergence with the objective method in the haploscopic set-up. Future studies are needed to further analyse the different sources of the discrepancy between methods and, if possible, obtain a better agreement.

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