Evaluating eye-fixation based reading performance in monovision correction.

Plainis S[1], Ktistakis E[1], Tsilimbaris MK[1,2]

[1] *Laboratory of Optics and Vision (LOV), School of Medicine, University of Crete, Heraklion, Greece*
[2] *Ophthalmology Department, University Hospital of Heraklion, Heraklion, Greece*

Purpose: Simple measures of acuity provide only a partial indication of functional vision of in presbyopia correction. Many complaints from presbyopes originate in reading difficulties, especially under low lighting levels. Here we present a method, based on eye movement analysis, to evaluate reading performance in a presbyopic population using contact lenses (CLs) providing monovision correction.

Methods: Seventeen presbyopic contact lens users (age 51±4 yrs) with normal vision participated in the study. Measurements were performed binocularly with participants wearing disposable single vision CLs: (a) at baseline with both eyes corrected for far (FC), (b) two weeks following monovision correction (MC) with the dominant eye corrected for far. LogMAR acuity for distance and near was measured with ETDRS charts. Reading performance was evaluated using simple paragraphs of about 140 words each (0.4 logMAR print size at 40 cm distance) at two luminance levels (50 and 5 cd/m$_2$). A reading comprehension questionnaire was performed to secure a high level of attention. Eye movements were monitored with an infrared eyetracker (Eye-Link II, SR Research Ltd). Data analysis included computation of reading speed (in wpm), fixation duration, number of fixations per word (fpw) and percentage of regressions. Moreover, frequency distributions of fixations durations were analysed with an ex-Gaussian fitting, a convolution of a normal (with μ as the mean) and exponential (with τ as the mean) distribution, that can characterize its location and shape.

Results: Reading speed showed a significant variability between subjects, which was found to correlate in both the FC an MC conditions with (i) the number of fixations (r equals -0.88 and -0.87, respectively), (ii) the percentage of regressions (r equals -0.65 and -0.79, respectively) and (iii) the mean (τ) of the exponential distribution of fixations durations, which are known to characterise the reading skill of participants. No statistically significant correlation was found with fixation duration and the mean (μ) of the normal distribution of fixations durations. Visual acuity was found statistically significantly better in MC compared to FC condition by 0.34±0.15 logMAR (from 0.36±0.13 to -0.01±0.09 logMAR, p<0.001). Reading speed was also statistically significantly improved on average by 60 wpm, from 189±60 in FC to 249±49 wpm in MC (p=0.001). The improvement in reading speed was mainly due to a decrease in the number of fixations from 1.04±0.30 to 0.89±0.20 fpw (p=0.02), in fixation duration (from 267±48 to 224±28 ms, p<0.001) and in μ (from 200±63 to 169±21 ms, p=0.001). No difference was found in the τ (p=0.28) and in the percentage of regressions (p=0.56). No correlation was found between the improvement in reading speed with visual acuity (r=-0.07)

Conclusions: The study shows that visual acuity improvement with monovision correction cannot predict the improvement in reading speed. This is probably due to the fact that reading is facilitated by parafoveal visual information and that there are considerable individual differences in reading speed between unimpaired adult readers. Evaluating reading performance using eye fixation analysis can result in a more reliable outcome of functional vision in monovision (presbyopia) correction.