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Characteristics of saccades when testing the near point of convergence

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Abstract

Purpose : To analyze the amplitude, direction and rate of small saccades as a function of vergence demand when testing the near point of convergence.

Methods : Participants were asked to fixate binocularly on a 2mm crosshair (equal to 0.29 deg at 40 cm), moved by a stepper motor along the midline at a constant velocity of 2 cm/s. The target made three complete cycles between 40 and 2.8 cm. Eye position was registered with the EyeLink 1000 Plus (SR Research). Besides the built-in calibration, custom calibration procedures were carried out at different distances due to the required wide range of convergence angles. Participants were asked to press a key when they experienced diplopia and when they recovered single vision. Saccades were detected with the unsupervised clustering method (Otero-Millan et al., 2014). Similar results were obtained using the Engbert-Kliegl (2003) velocity-threshold-based method.

Results : The participants were 11 young adults (mean age \pm SD: 25.4 \pm 2.2 years). A total of 1554 saccades were detected with an amplitude ranging from 0.12 to 12.26 deg (median 0.48 deg). Saccades followed the main sequence ($R=0.95$, $p<0.001$). Saccade amplitude increased significantly with vergence demand ($R=0.60$, $p<0.001$) but the direction of vergence movement had no significant effect ($p=0.224$). Both vertical and horizontal saccades (± 22.5 deg from vertical or horizontal) increased in amplitude with vergence demand (vertical: $R=0.56$, $p<0.001$; horizontal: $R=0.62$, $p<0.001$), although higher inter-subject variability was found with vertical saccades. The directions of saccades differed significantly from a uniform distribution ($p<0.001$, Hodges-Ajne test), with more

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horizontal than vertical saccades and with more upwards than downwards vertical saccadic components. Average saccade rate was 1.34 ± 0.66 Hz and did not differ significantly as a function of the vergence direction ($p=0.158$). However, the mean saccade rate decreased to ~ 0.5 Hz at the closest target distance.

Conclusions : Saccade characteristics change with vergence demand. The greater amplitude and lower saccadic rate at close distance might be explained by the more rapid change of vergence demand and the greater angular size of the fixation target at near than at far. The high prevalence of upward saccades might reflect the tendency of some normal subjects to exhibit an upbeating vertical nystagmus, which increases in amplitude with vergence demand according to our results.

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