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Optimizing the information transfer of near-eye displays

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14. ABSTRACT
Introduction. A Head Mounted Display (HMD) is unlike all other displays fixed to the head, making eye movements the sole option to scan the display (since head movements have no effect on the ocular image position). While the largest saccades easily exceed 50 deg, naturally occurring saccades typically stay within 15 degrees. While attractive for many applications, a HMD may therefore form a liability: large-FoV HMDs are known to cause eye-strain and the rate of information uptake is expected to decrease towards the edges. In addition, aniseikonia (a common visual deficit) is expected to cause eye strain and limit the readability of large FoV binocular HMDs. Hence, as the FoV of a HMD increases, its screen layout needs to optimize overall display readability by preventing clutter while taking common optometric conditions into account.
Methods. We measured the ability of 12 subjects to quickly determine the orientation (vs) of a target T surrounded by 4 randomly oriented (up, down, left, right) flanker Ts as a function of 1) target-flanker spacing or crowding (small /medium/large), 2) flanker polarity, and 3) eccentricity (15/30/45 deg). Visual comfort was assessed with questionnaires. All 12 subjects scored normal on relevant optometric tests (stereopsis, visual acuity, Awaya aniseikonia test, phoria). In some conditions, an aniseikonic lens placed in front of one eye optically enlarged the image by 2%, simulating a common optometric condition. The additional delay caused by the presence of the four flankers is adopted as the Crowding component of the reaction time.
Results. Reaction time increased with crowding, symbol eccentricity, and decreased with opposite target-flanker polarity (all p values < 0.001). Contrary to our expectations, reaction time decreased after a break, suggesting saccadic motility improves over time. Eye strain showed a small increase with ec

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"Optimizing the information transfer of near-eye displays"

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Abstract

Introduction. A Head Mounted Display (HMD) is unlike all other displays fixed to the head, making eye movements the sole option to scan the display (since head movements have no effect on the ocular image position). While the largest saccades easily exceed 50 deg, naturally occurring saccades typically stay within 15 degrees. While attractive for many applications, a HMD may therefore form a liability: large-FoV HMDs are known to cause eye-strain and the rate of information uptake is expected to decrease towards the edges. In addition, aniseikonia (a common visual deficit) is expected to cause eye strain and limit the readability of large FoV binocular HMDs. Hence, as the FoV of a HMD increases, its screen layout needs to optimize overall display readability by preventing clutter while taking common optometric conditions into account.
Methods. We measured the ability of 12 subjects to quickly determine the orientation (T vs ⊥) of a target T surrounded by 4 randomly oriented (up, down, left, right) flanker T's as a function of 1) target-flanker spacing or 'crowding' (small /medium/large), 2) flanker polarity, and 3) eccentricity (15/30/45 deg). Visual comfort was assessed with questionnaires. All 12 subjects scored normal on relevant optometric tests (stereopsis, visual acuity, Awaya aniseikonia test, phoria). In some conditions, an aniseikonic lens placed in front of one eye optically enlarged the image by 2½%, simulating a common optometric condition. The additional delay caused by the presence of the four flankers is adopted as the 'Crowding component' of the reaction time.
Results. Reaction time increased with crowding, symbol eccentricity, and decreased with opposite target-flanker polarity (all p values < 0.001). Contrary to our expectations, reaction time decreased after a break, suggesting saccadic motility improves over time. Eye strain showed a small increase with eccentricity ($p < 0.037$). Compared to the Same polarity condition, Opposite polarity reduced the Crowding time by a factor of 2.3 ($p< 0.001$). The Crowding times can be described as an extension of Fitts' law. Unexpectedly, the mild aniseikonia condition doubled the Crowding time ($p< 0.001$) and caused the highest level of eye strain ($p< 0.001$).
Conclusions. These results suggest that ocular motility is trainable. The dynamics of HMD information uptake resembles Fitts' law. For all eccentricities and target-flanker spacings, the Crowding time more than halved in the opposite polarity condition, while it doubled due to the addition of just 2½% aniseikonia.
Practical implications. Initial training reduces eye strain. A 30 deg Field-of-View can be a compromise between maximal overall symbology uptake and minimal eye strain. Even users with mild aniseikonia are likely to experience problems while reading a large FOV HMD. 'Polarity decluttering' can significantly enhance symbology legibility.

List of Publications and Significant Collaborations that resulted from your AOARD supported project:

Kooi, F.L., Toet, A., & Hoving, S. (2019). Visual processing of symbology in head-fixed large field-of-view displays. In: Vision Sciences Society 19th Annual Meeting (VSS 2019) (p. 85):Vision Sciences Society doi: 10.6084/m9.figshare.8053580

Toet, A., & Kooi, F.L. (2019). Controlling readability of head-fixed large field-of-view displays. In: Vision Sciences Society 19th Annual Meeting (VSS 2019) (p. 146):Vision Sciences Society doi: 10.6084/m9.figshare.8053547

Hoving, S. (2018). Visual Comfort of the Head Mounted Display in the F35. M.Sc. Thesis, University Utrecht, Faculty of Social and Behavioural Sciences, Utrecht The Netherlands.

Tan, J (2019). The effect of contrast dissimilarity on target detection and identification in peripheral vision. M.Sc. Thesis, University Utrecht, Faculty of Social and Behavioural Sciences, Utrecht The Netherlands.

Attachments: the abovementioned publications + the accompanying posters

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