Neural Adaptation to Optical Quality Defects

From an optical perspective the eye is far from perfect. This is a fact that is extensively supported by literature; for instance, Prof. Navarro recently provided us with a fantastic critical review on the various theories behind the different eye models and their flaws.[1] The human eye has considerable amounts of higher-order aberrations even when it is emmetropic,[2] with great inter-individual variability. Besides, higher-order aberrations are still postulated to have a role in the development of the refractive error, although it is not clear the extent to which this may be (see Charman WN for a review).[3]

The known optical limitations of the normal human eye raised the question as to what the impact of these optical imperfections on visual performance is. Neural adaptation to blur has revealed itself as a mechanism which significantly counterbalances image degradation. It has been shown that myopes are less sensitive to refractive error-induced retinal blur,[4] and subjects with greater-than-normal wavefront aberrations are adapted to their specific pattern of image quality degradation.[5]

Higher-order aberrations obviously have an impact on retinal image quality, and high levels of aberrations decrease visual performance, but the range of tolerance seems to be unexpectedly high. Chen et al showed that, in fact, the best visual performance for a given eye is obtained when some aberrations are left uncorrected.[6]

Another question would be how flexible this adaptation is, and in relation to that it has been proven that an improvement in visual performance occurs after extended periods of viewing through optical systems that degrade retinal image quality due to a refractive error,[4] a significant amount of higher-order aberrations,[7] or multifocal compensation,…[8]

There is still much to be known with regards to neural adaptation to optical defects and its role in visual performance, which is of major clinical interest since technology now allows customized compensation in various forms. In the present issue of the Journal of Optometry, Rouger et al aim to give further insight into the impact of higher levels of optical quality defects on everyday living tasks and neural adaptation of keratoconic eyes to their degraded retinal image quality.[9] They show how keratoconic eyes are adapted to their aberrations, performing better in visual acuity measures than non-keratoconic eyes in which the same aberrations had been. Their results agree with previous recent reports, but they also show that adaptation may be detected if the visual performance tests used involve what they call "real-life" visual tasks, such as letter recognition, rather than sinusoidal gratings, whereas other tests do not seem to be sensitive to it.

References

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