Links between acuity, crowding and binocularity in children with and without amblyopia

John Greenwood¹, Vijay Tailor², Anita Simmers³, John Sloper², Gary Rubin¹, Peter Bex⁵, Steven Dakin¹
¹UCL Institute of Ophthalmology, University College London
²Moorfields Eye Hospital, London
³Department of Vision Sciences, Glasgow Caledonian University
⁴NIHR Biomedical Research Centre for Ophthalmology, London
⁵Schepens Eye Research Institute, Harvard Medical School

Amblyopia, the most common cause of childhood visual impairment, is defined by interocular acuity differences, with additional deficits in binocularity/stereo-acuity and elevated foveal crowding (poorer recognition in cluttered visual environments). To better understand amblyopia and the relationship between acuity, crowding and binocularity more generally, we examined each of these performance measures in both amblyopic and unaffected children.

Children, aged 5-8 (n=72), were classified into four groups: controls and those with strabismic, anisometropic, or mixed strabismic/anisometropic amblyopia. We developed a novel videogame-based task with a Landolt-C target modified to resemble Pac-Man. Children indicated target orientation by reporting which of four ghosts (on the screen edges) Pac-Man was facing. Threshold-size (acuity) was measured first, using a modified staircase. Contrast detection and foveal crowding were then measured using target-sizes 3× this threshold. Crowding was quantified as the minimum separation between the target and ghost-flankers required for accurate target-orientation identification. Stereo-acuity was measured using random-dot stereogram ghosts.

While unaffected children generally had equal acuity in each eye, amblyopic children displayed significant interocular acuity differences. The largest interocular differences for crowding were evident in the strabismic and mixed amblyopic groups, though some foveal crowding occurred in both eyes of all children. Despite this variation in range, interocular crowding differences correlated significantly with interocular acuity differences for all groups. Similarly, reduced/absent stereo-acuity was most common with strabismic and mixed amblyopia, though cases occurred in all groups. In all cases, stereo-blindness was further associated with large interocular differences in both acuity and crowding.

Our results demonstrate that interocular acuity differences correlate with both crowding and reduced stereovision, not only for strabismic amblyopia, but also for anisometropic amblyopia and unaffected children where these differences are lower. These findings place amblyopic deficits on a continuum with normal visual development, with important implications for recently proposed "binocular" therapies of amblyopia.