Development of Contrast Sensitivity in children using a novel child-friendly method

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Background
- There exists disagreements on the time course of the development of contrast sensitivity in children. This knowledge may influence decisions about when and if a treatment method is useful in children[1].
- This disagreement is due to lack of a robust, child-friendly measure of the CSF.
- Bayesian adaptive estimation (e.g., the qCSF[2]) provides faster and more robust measures of CSF. However, this has not been tested in children yet.

Aims
- Quantifying the development of CSF in children aged 4 – 14 years.

Methods
Participants: 59 children aged 4-14 years and 28 adults (see Fig 5 for age distribution). Participants had normal or corrected-to-normal vision and had no history of non-refractive visual impairment.

Stimuli: Horizontal Gabor patches: ranging from 2 to 30 cycles per degree (cpd) in Spatial Frequency, and from 0.0001 to 1 in Michelson Contrast. The Gabor patches were presented at 3.8º eccentricity.

Procedure: Four alternative forced choice (AFC) detection. Participants completed the same test using two different algorithms: a weighted staircase (the reference standard) and QUEST+ (the novel comparison).

Test Algorithm: A 3-parameter CSF model with a 2D stimulus space fitted using QUEST+[2] (see Fig 2 for details). The key advantages of the QUEST+ algorithm are that it: 1. provides rapid and flexible estimation of the parameters of a psychophysical model, 2. using prior information, advises the user on the most appropriate stimulus to present and testing termination time, 3. determines the maximally informative stimulus on each trial, 4. fits arbitrarily complex models. Our (MATLAB) implementation of QUEST+ is freely available at: https://github.com/patejone/QuestPlus.

Results
Benefits of our novel test in comparison to conventional methods
There were no significant differences in CSFs acquired using QUEST+ and the adaptive staircase after 50 trials (~2 minutes), providing substantive speed benefits in comparison to the traditional staircase method (~12 minutes). In addition, Estimates were more reliable with the QUEST+ than with the traditional staircase method. This was true for all 3 parameters and both age groups, although children’s measures were consistently less reliable than adults.

Development of contrast sensitivity
Based on the CSFs acquired using our novel child-friendly method, there were significant differences in contrast sensitivity at low frequencies (i.e., 2 to 5 cpd) across children and adults.

Discussion
Bayesian adaptive methods allow CSF estimates to be made in children. Specifically:
- CSF estimates were more reliable than traditional psychophysical methods.
- Robust estimates could be made in children aged 4 to 14 in only 50 trials (~2 mins).

Adults are better at detecting low contrast Gabor patches at low spatial frequencies (i.e., 2 to 5 cpd), even when compared to children older than 9 years old.

Development of peak contrast sensitivity was larger than the amount of individual variability within age groups. However, there were no significant differences between the peak frequency and rate of CSF fall-off between children and adults.

Future Work
We are currently evaluating the feasibility of making CSF estimates in children with inherited retinal dystrophies (i.e., achromatopsia).

If you are interested in using this test for your own projects then please get in touch (m.farahbakhsh.16@ucl.ac.uk).

References