Individual Differences in Chromatic Discrimination Ability

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Introduction

Colour vision contributes to various behavioural tasks, such as, object recognition, colour naming and detection of biological signals.

Humans are able to perceive different colours because of the presence of three types of photoreceptors, the long- (L), middle- (M), and short- (S) wavelength-sensitive cones. The processing of the signals originating from the cones leads to the formation of three cardinal 'axes', known as luminance, red-green (RG) and blue-yellow (BY) axes.

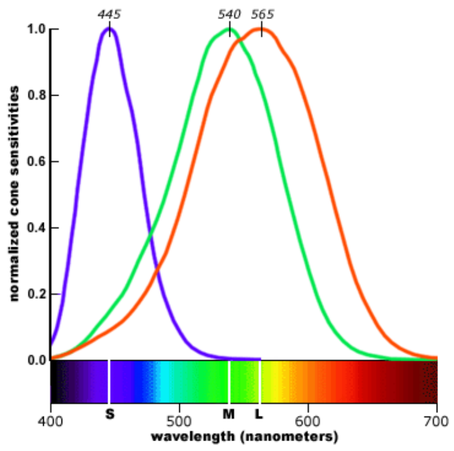

Figure 1: Cone Spectral Sensitivity
The L-cones respond best to red light, the M-cones to green light while the S-cones to blue light.

Aim

- Investigate the individual differences of chromatic discrimination ability due to age and sex
- Test whether there is a developmental lag for the neural mechanism originating from the S-cone pathway (the BY-axis) relative to other mechanisms

Methods

36 volunteers (13 males, 23 females) aged 7 to 73 years old with normal colour vision participated in the Chromatic Contrast Discrimination Task (CCDT). The CCDT is a computer-based task used to assess the ability to detect small targets of different colours against a neutral background.

Stimuli A single-coloured arrow, pointing either left or right is briefly flashed on a computer screen on each trial. The arrow is shown randomly above and below the central fixation point, on a grey background.

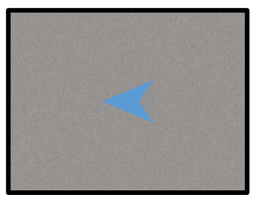

Figure 2: Blue-coloured arrow pointing to left used in CCDT

Design The participant responds whether the arrow points to left or right, by pressing the corresponding 'Ctrl' key. The colour difference between the arrow and the background is varied using a one-up/three-down staircase protocol (Figure 3). Three correct responses in a row makes the staircase go down (i.e. test smaller colour difference) while one incorrect response will take the participant up the staircase. The task ends after 6 reversals or 50 trials are reached in each half-axis. Each participant completes two staircases of each of the axes.

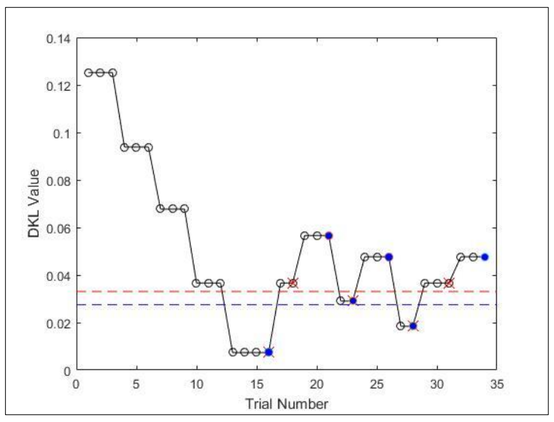

Figure 3: One-up/three-down staircase
Red dotted line signifies threshold obtained from this staircase.
Blue dotted line signifies average threshold from two staircases.

Procedure A participant views the screen through an aperture. I explain the task to the participant. There are five practice trials before the actual trials. Once each axis has finished, the participant takes a short break before continuing with the next axis.

Modification The task is also modified for testing in children. The child is given a choice for each axis (depicted by the image of castle, cave and forest). The child will 'find' Freddy by completing the task.

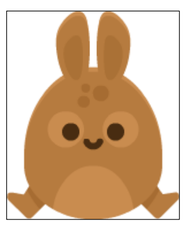

Figure 4: Freddy
Used in modified CCDT

Results and Discussion

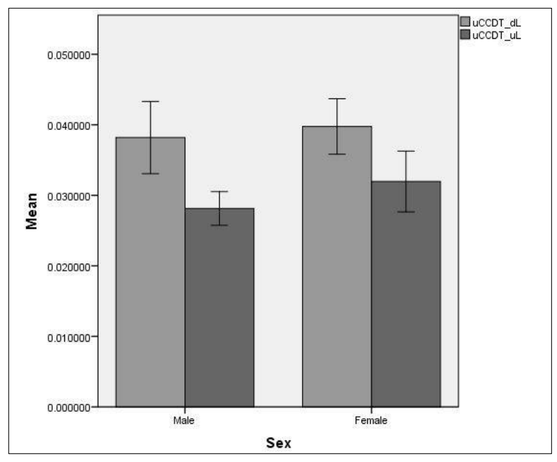

Figure 5: Mean CCDT threshold for luminance axis
There are no significant differences in the mean chromatic discrimination ability in all cardinal directions among males and females.
(Luminance axis thresholds only shown)

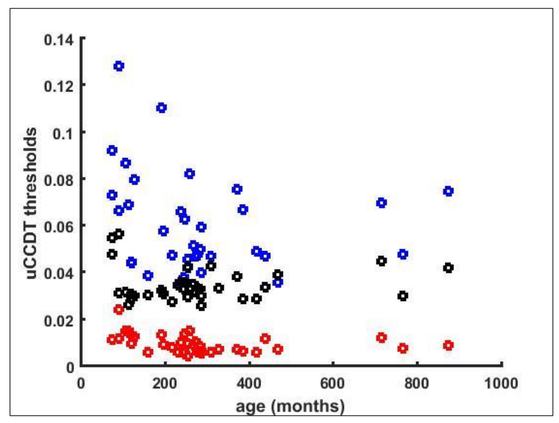

Figure 6: CCDT threshold for all three cardinal axis against age
CCDT thresholds in luminance and RG-axes are lower (better ability) than that in BY-axis across all ages.

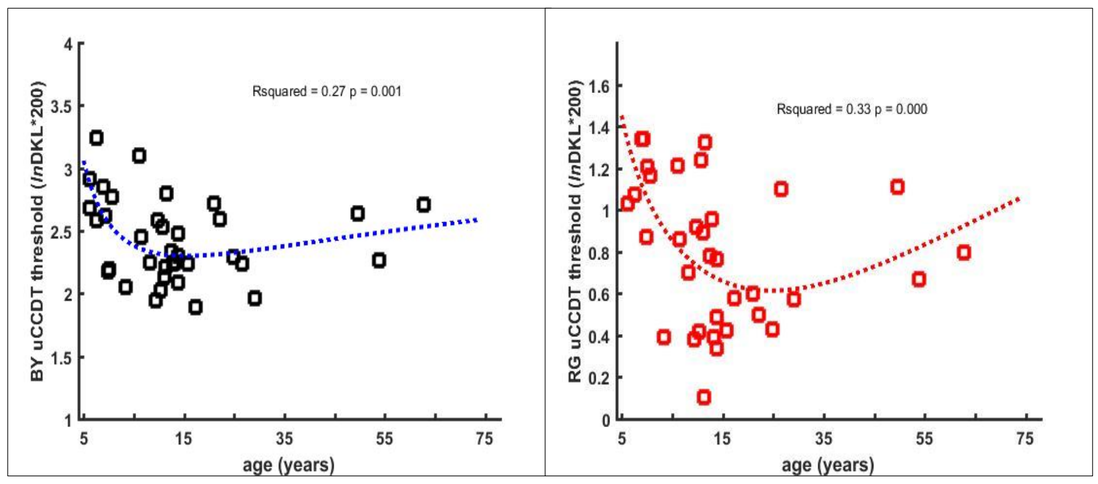

Figure 7: CCDT threshold for blue-yellow and red-green axis against age
Chromatic discrimination improves up to a certain age, and then declines.

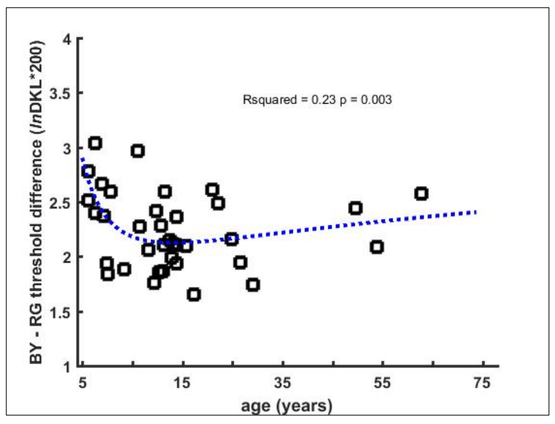

Figure 8: Difference between blue-yellow and red-green CCDT threshold
The difference between BY and RG threshold decreases up to a certain age, and then increases. This may suggest a developmental lag in the S-cone pathway which only contributes to BY colour vision.

Conclusion

- Chromatic discrimination improves with age to about 20 years old, and then declines
- Performances in RG and luminance axes are better compared to BY axis at all ages
- There may be a developmental lag in the S-cone pathway compared to other visual pathways

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