AGE-RELATED CHANGES IN SPATIO-CHROMATIC CONTRAST SENSITIVITY AT MESOPIC AND PHOTOPIC LIGHT LEVELS

Maliha Ashraf* Rafał Mantiuk Jasna Martinović
Sophie Wuerger Minjung Kim Helen Saunderson

UNIVERSITY OF LIVERPOOL | UNIVERSITY OF CAMBRIDGE | UNIVERSITY OF ABERDEEN

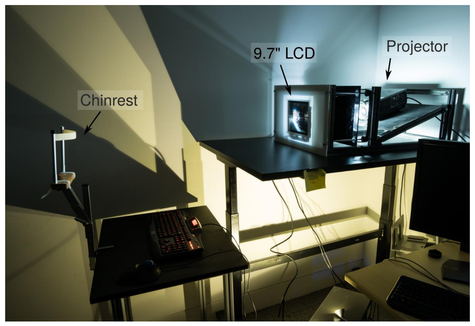
BACKGROUND

Human visual system undergoes various changes with age including loss of photoreceptor sensitivity, reduction in pupillary area, increase in ocular media density, and neuronal cell death.

Physiological and neural changes in the visual system with age also lead to changes in contrast sensitivity. Various studies have shown age-related changes in spatio-chromatic contrast sensitivity.

Our study investigates the senescence of spatio-chromatic sensitivity including the effect of adapting light level using a high dynamic range (HDR) display under normal viewing conditions.

1 APPARATUS



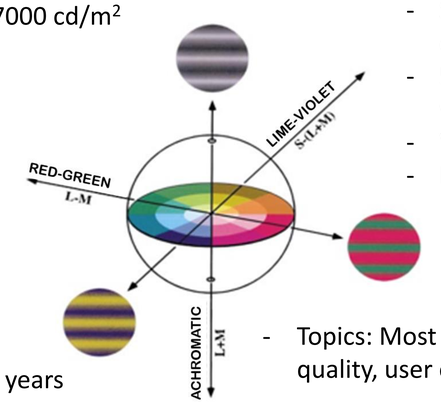
HDR DISPLAY SYSTEM

- Custom-built HDR displays
- Peak luminance: 4,000 cd/m^2
- Consisting of an LCD panel and a DLP backlight
- Size: 2048×1536 px
- Maximum contrast: 1,000,000:1

2 METHODOLOGY

STIMULI

- Gabor patches with fixed number of cycles
- Spatial frequencies: 0.5, 1, 2, 4, and 6 cpd
- Color modulations: (1) Black-white; (2) Red-green; (3) Lime-Violet
- Mean background luminances: 0.02, 0.2, 2, 20, 200, 2000, and 7000 cd/m^2



PSYCHOPHYSICAL TASK

- 4AFC QUEST-based detection task
- Initial contrast threshold estimate using method of adjustment
- Single mean background luminance for each session to ensure adaptability
- 5 spatial frequencies and 3 color directions interleaved within each session
- Viewing distance: 91 cm
- Display size: 12.5 x 9.4 visual degrees

OBSERVERS

- Color normal observers
- 20 young participants; mean age: 33 years
- 20 older participants: mean age: 65 years

FOCUS GROUP

- 2 focus groups with 3, and 4 observers aged above 60 respectively
- Topics: Most important display attributes w.r.t to perceived image quality, user experience, display adaptability

3 RESULTS

GENERAL TREND

- Contrast sensitivity:
  - Increases with background luminance up to around 200 cd/m^2
  - Declines after 200 cd/m^2 in luminance channel
  - Becomes constant after 200 cd/m^2 in chromatic channels

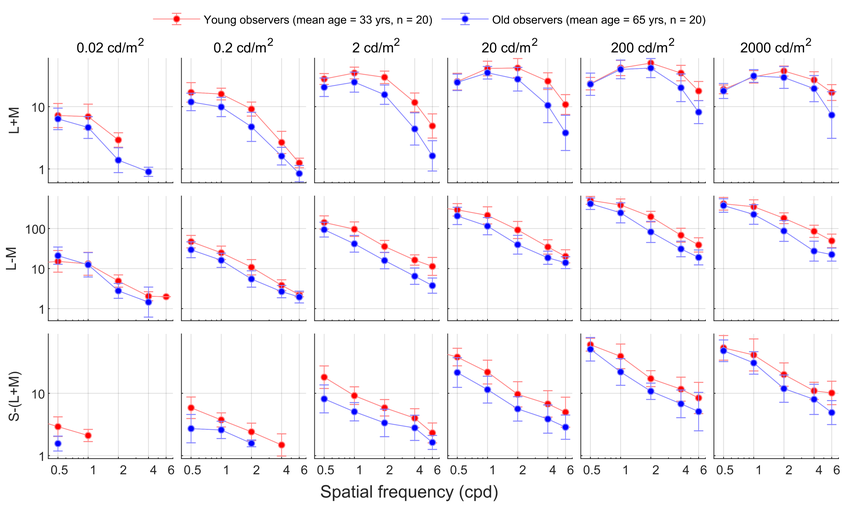


Figure 3. Comparison of mean contrast sensitivity measurements (error bars: standard deviation) from younger and older observers' age group.

AGE DEPENDENCE

- Sensitivity of younger observers is roughly 0.3 log units higher than older observers
- The difference is roughly constant across colour directions and light levels
- In achromatic channel, older observers show larger decline in sensitivity for higher spatial frequencies at high photopic light levels
- Peak sensitivity and cut-off frequency of CMFs decrease with age
- Rate of decrease in peak sensitivity and cut-off frequency is luminance dependent

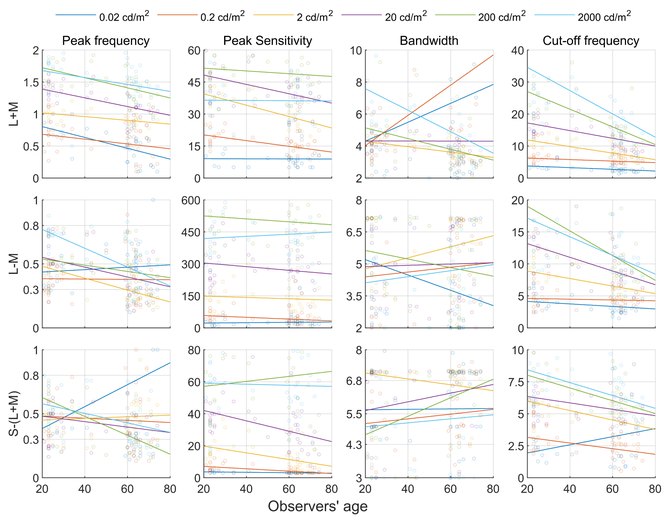


Figure 4. Linear regression lines fitted to age vs. the optimized values of the log-parabola parameters.

4 CONCLUSIONS

- Both chromatic and achromatic contrast sensitivities are affected by age
- At lower luminances, the effect of age is frequency-invariant
- At higher luminances, sensitivity of higher spatial frequencies are deteriorated with age more than that of lower frequencies

5 FUTURE WORK

- Investigating and predicting suprathreshold sensitivity in observers of different age groups
- Developing a computational model with spatial frequency, stimulus size, background luminance, and observer age as parameters
- Developing an application for orthoptic assessment for people in older age groups

[1] Hardy, J. L., Delahunt, P. B., Okajima, K., & Werner, J. S. (2005). Senescence of spatial chromatic contrast sensitivity. I. Detection under conditions controlling for optical factors. *JOSA A, 22*(1), 49-59.
[2] Sloane, M. E., Owsley, C., & Alvarez, S. L. (1988). Aging, senile miosis and spatial contrast sensitivity at low luminance. *Vision Research, 28*(11), 1235-1246.
[3] Pokorny, J., Smith, V. C., & Lutze, M. (1987). Aging of the human lens. *Applied optics, 26*(8), 1437-1440.

This research has been supported by:
EPSRC EP/P007503
Apple Inc
Summer vacation bursary program

EPSRC Engineering and Physical Sciences Research Council

Special thanks to Kristof Santa and Olivia Kingston for collecting valuable data