Evaluation of Tablet-Based Methods for Assessment of Contrast Sensitivity on Mobile Touch-Screens

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Motivation: SANS

Risk of Spaceflight Associated Neuro-ocular Syndrome (SANS)

Short Title: SANS
Element: Human Health Countermeasures (HHC)
Evidence: Report
Risk Master Logic Diagram: Not Available
Point of Contact: Michael Stenger

Risk Ratings and Dispositions per Design Reference Mission (DRM) Category

<table>
<thead>
<tr>
<th>DRM Categories</th>
<th>Mission Duration</th>
<th>Operations</th>
<th>Long-Term Health</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LxC</td>
<td>Risk Disposition</td>
</tr>
<tr>
<td>Low Earth Orbit</td>
<td>6 months</td>
<td>3x2</td>
<td>Accepted</td>
</tr>
<tr>
<td></td>
<td>1 year</td>
<td>3x2</td>
<td>Accepted</td>
</tr>
<tr>
<td>Deep Space Sortie</td>
<td>1 month</td>
<td>3x1</td>
<td>Accepted</td>
</tr>
<tr>
<td>Lunar Visit/ Habitation</td>
<td>1 year</td>
<td>3x2</td>
<td>Accepted</td>
</tr>
<tr>
<td>Deep Space Journey/Habitation</td>
<td>1 year</td>
<td>3x4</td>
<td>Requires Mitigation</td>
</tr>
<tr>
<td>Planetary</td>
<td>3 years</td>
<td>3x4</td>
<td>Requires Mitigation</td>
</tr>
</tbody>
</table>

Orthostatic pressure and gravity

Figure from wikipedia page "Space Medicine," attributed to NASA.
Effects on the eye

Effects on the eye

**Fig. 4.** Post-flight MRI picture of the eye showing optic disc edema (central vertical arrow), globe flattening (short vertical arrows) and optic nerve sheath distension (horizontal arrows).

*Source: NASA.*

Goals

- Rapid vision assessment for daily use
- Simple hardware with low up-mass
- Approach: contrast sensitivity on Apple iPad
What is Contrast Sensitivity?

From http://www.telescope-optics.net/aberrations_extended.htm
The double-sweep grating
Early public appearances

- Described for use in optical testing (Washer & Rosberry, 1951)
- Shown at 1964 OSA meeting (Robson & Campbell)
- Appeared in "Mach Bands" by F. Ratliff (1965)
- Appeared in "Visual Perception" by T. N. Cornsweet (1970)
- IOVS cover image, 1978-1982
Jeff's idea for a rapid test

- Display sweep grating on touch screen
- Use finger to indicate edge of visibility
- Advantages: portable, fast (1-2 seconds for entire curve)
- Problems: unknown criterion, motor noise, cheating, reduction of phase uncertainty

Repeatability
The present study: validate against other methods

- Traditional quick-and-dirty: method of adjustment
- The gold standard: 2AFC
- Gabor patch stimuli
Method of adjustment

- Variable-contrast static Gabor patch
- Subject swipes up or down to increase or decrease contrast
- Adaptive contrast increment/decrement
- Effectively a yes/no experiment with 50 trials
- DEMO
Adjustment data psychometric function
Parabolic fit to adjustment thresholds

log sensitivity

log spatial frequency (cyc/samp)
Two-alternative forced choice (2AFC)

- Gabor patch pulsed with a Gaussian temporal contrast window
- Two temporal intervals indicated by audio tones
- Stimulus presented in one of the two intervals
- Subject indicates stimulus interval with response buttons
- 2-to-1 staircase with adaptive step size
- DEMO
Staircase raw data

S3
0.125 cyc/samp
2AFC staircase trials

log contrast

Trial number
2AFC data psychometric function

![Graph showing 2AFC data psychometric function](image-url)
Parabolic fit to 2AFC thresholds
The updated swipe method

- 15 slightly different images presented
- Subject is shown swipe, can accept or redo
- DEMO
Parabolic fit to swipes
Comparing the methods
Comparing the methods

![Graph showing log sensitivity vs. log spatial frequency (cyc/samp) with lines for 2AFC, Adjustment, and Swipe, and a label "S10".]
Comparing the methods

![Graph showing log sensitivity vs. log spatial frequency. The graph compares different methods including 2AFC, Adjustment, and Swipe. The x-axis represents log spatial frequency (cyc/samp) ranging from -3 to 0, and the y-axis represents log sensitivity ranging from 0 to 3. The graph includes a peak at the center for S7.](image-url)
Comparing the methods

![Graph showing log sensitivity vs log spatial frequency for different methods: 2AFC, Adjustment, and Swipe.](file:///Users/jmulliga/working/public_html/home/presentations/hvei20/compare4.htm)
Comparing the methods
Comparing the methods
Comparing the methods
Comparing the methods
Summary

- 2AFC estimates greater sensitivity than adjustment
- Swipe method estimates more sensitivity still?
- SF differences may be explained by temporal factors
- Swipe method variability comparable to 2AFC
- Caveat: more efficient 2AFC methods available e.g. QuickCSF, Lesmes et al.
Conclusions

- The swipe method is a viable choice for CSF estimation
- Accuracy probably sufficient for longitudinal monitoring
- Gamification?

THANKS FOR LISTENING!