What Eye Doctors Know About Vision Discomfort

Jim Sheedy, OD, PhD

Vision Performance Institute
A research consortium supporting “Quality Sustainable Vision”
Visual Discomfort

- Eyestrain
- Asthenopia
  (ICD-9 368.13)
Computers are nice, but....
Reasons for Symptoms

- eye disorder
- environmental disorder
- combination
Visual Symptom Ranking

- 1.37 eye strain
- 2.49 headaches
- 3.08 blurred vision
- 4.40 neck and back aches
- 5.90 photophobia
- 6.86 double vision
- 7.26 after-images
Is All Asthenopia the Same?

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**Purpose:** To determine if particular sensations or their location vary dependent upon a causative condition

**Methods:** 20 subjects read short stories under 8 discomfort-inducing conditions. Latin Square ordering.

<table>
<thead>
<tr>
<th>Inducing Condition</th>
<th>Induction Stimulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refractive Error</td>
<td>Glasses with +2.00 -4.00 X 180 OU</td>
</tr>
<tr>
<td>Convergence Stress</td>
<td>Glasses with +6.00DS OU. Reading material was placed 16.7cm from the eyes and page size was reduced</td>
</tr>
<tr>
<td>Upward Gaze</td>
<td>Reading material was located 20-35 degrees above eye level</td>
</tr>
<tr>
<td>Dry Eye</td>
<td>Manually hold eye lids open</td>
</tr>
<tr>
<td>Accommodative Stress</td>
<td>Alternate sentences read through +/-1.50 lenses</td>
</tr>
<tr>
<td>Small Font</td>
<td>5 point font</td>
</tr>
<tr>
<td>Glare</td>
<td>Peripheral glare sources</td>
</tr>
<tr>
<td>Flickering Light</td>
<td>Strobe light run 15cyc/sec in a dark room</td>
</tr>
</tbody>
</table>
ANOVA with repeated measures results:
All of the individual symptom sensation measures (except blur) were significantly related to inducing condition.
(p values ranged from 0.003 to 0.0001)

Principal factor analysis calculated 2 latent factors:

External Symptom Factor (ESF) and Internal Symptom Factor (ISF)
ESF and ISF grouping of individual symptoms

- p values ranged from 0.003 to 0.0001 (except for blur)

Symptoms: Ache, Blur, Double Vision, Headache, Strain, Tearing, Dryness, Burning, Irritation

Factors: External Symptom Factor (ESF), Internal Symptom Factor (ISF)
### Conclusions:

**Summary findings**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Symptoms</th>
<th>Inducing Conditions</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESF</strong></td>
<td>Burning Irritation</td>
<td>Dry Eye</td>
<td>Front of eyes</td>
</tr>
<tr>
<td></td>
<td>Dryness</td>
<td>Glare</td>
<td>Bottom of eyes</td>
</tr>
<tr>
<td></td>
<td>Up Gaze</td>
<td>Small Font</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flicker</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ISF</strong></td>
<td>Strain Ache</td>
<td>Accommodative Stress</td>
<td>Behind the eyes</td>
</tr>
<tr>
<td></td>
<td>Headache</td>
<td>Convergence Stress</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Refractive Error</td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- There are 2 types of eyestrain
  - **Internal symptoms**
    - Ache or pain felt inside the eye
    - Caused by convergence and accommodative stress, refractive error
    - Caused by eye conditions
  - **External symptoms (dry eye symptoms)**
    - Dryness or irritation on the front of the eye
    - Caused by conditions that compromise the quality of the visual stimulus
“3D Vision Syndrome” (?)

- Eyestrain
- Nausea
- Vertigo

- 3Ds of 3D
  - Discomfort, Dizziness, No Depth
Let’s look at the internal symptoms

• Caused by “stress” to:
  – Accommodation
  – Convergence
Convergence and Accommodation
Real-World relationship

- "Demand" line

1 Prism Diopter = 0.57 degrees
Phoropter

Sphere control

Cylinder control

Prism control
Resting position (fusion-free)

- "Phoria" line

Accommodation (Diopters) vs. Convergence (Prism Diopters)
Vergence Limits (without accommodating)

- “Blur” lines

![Graph depicting vergence limits with accommodation and convergence axes.](image-url)
Zone of Single Clear Binocular Vision

- ZSCBV

Accommodation (Diopters) vs. Convergence (Prism Diopters)
What S3D demands of the audience

- With 4% disparity budget

![Graph showing accommodation versus convergence for different activities like TV, Movie, and Game player. The graph indicates that only 2/3 Prism Diopter is required for Game player.]
Considerable individual variation

- "average" ZSCBV

![Graph showing accommodation and convergence relationship]
Considerable individual variation

- Esophoria at near
Considerable individual variation

- Esophoria distance and near

![Graph showing accommodation vs convergence]
Considerable individual variation

- Exophoria at near
Considerable individual variation

- Exophoria distance and near
Considerable individual variation

- Narrow vergence ranges

![Graph showing accommodation and convergence with labels Bl, P, D, and Bl on the graph. The x-axis represents convergence (Prism Diopters) ranging from -10 to 40, and the y-axis represents accommodation (Diopters) ranging from 0 to 3.]
What Eye Doctors Know

- Accommodative and/or vergence stress cause symptoms (internal)
- Exophoria is typically more comfortable than esophoria
- Convergence is much easier than divergence
- There is considerable variation in phoria and ZSCBV across patients
What does this likely mean for S3D?

- S3D shows accommodative/vergence demands not encountered in the real world
- Although deviation from real life is small, a portion of the audience has difficulty - resulting in symptoms
- It is likely that those with already compromised systems are those who have symptoms
Disparity budget

- The percentage of the horizontal dimension that is allocated to disparity

Hi Definition display

| 1080 pixels | 4% disparity budget |
| 1920 pixels |

77 pixels
What S3D demands of the audience

- With 4% disparity budget

![Graph showing accommodation and convergence](image-url)
Next Talk: Filming S3D

- How to set the cameras

Inter-Axial Distance (IA)

Cameras

Convergence Angle (CA)