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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John Hayes, PhD
Jon Engle

**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

- External Symptom Factor (ESF)
- Internal Symptom Factor (ISF)

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

P values ranged from 0.003 to 0.0001 (except for blur)
<table>
<thead>
<tr>
<th>Factor</th>
<th>Symptoms</th>
<th>Inducing Conditions</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESF</td>
<td>Burning, Irritation, Dryness</td>
<td>Dry Eye, Glare, Up Gaze, Small Font, Flicker</td>
<td>Front of eyes, Bottom of eyes</td>
</tr>
<tr>
<td>ISF</td>
<td>Strain, Ache, Headache</td>
<td>Accommodative Stress, Convergence Stress, Stress, Refractive Error</td>
<td>Behind the eyes</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

![Graph showing the relationship between accommodation (Diopters) and convergence (Prism Diopters). The graph includes two lines labeled P and D, indicating the points of interest.](image-url)
Vergence Limits (without accommodating)

- “Blur” lines
Zone of Single Clear Binocular Vision

- ZSCBV
What S3D demands of the audience

- With 4% disparity budget

![Graph showing accommodation and convergence relationships for different activities like TV, Movie, and Game player, with emphasis on only 2/3 Prism Diopter for Game player.]
Considerable individual variation

- “average” ZSCBV
Considerable individual variation

- Esophoria at near
Considerable individual variation

- Esophoria distance and near

![Graph showing accommodation and convergence](image)
Considerable individual variation

- Exophoria at near

![Graph showing accommodation vs. convergence (Prism Diopters)]
Considerable individual variation

- Exophoria distance and near

![Graph showing accommodation and convergence](image-url)
Considerable individual variation

- Narrow vergence ranges

![Graph showing accommodation (diopters) vs. convergence (prism diopters)]
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

1920 pixels

4% disparity budget

77 pixels
What S3D demands of the audience

- With 4% disparity budget

![Diagram showing accommodation and convergence](attachment:image.png)

- Only 2/3 Prism Diopter!
Next Talk: Filming S3D

- How to set the cameras

Inter-Axial Distance (IA)

Cameras

Convergence Angle (CA)