HUMAN FACTORS OF STEREO DISPLAYS

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Overview

1. Basics of Stereo Vision
   - Horopter
   - Binocular Disparity
   - Panum’s Fusional Area

2. Peripheral Factors
   - Interocular Cross Talk
   - Accommodative-Vergence Mismatch
   - Horopter Shape

3. Contextual Factor
   - Disparity Scaling

4. Cognitive Factor
   - High-Level Cue Conflict
Basics (e.g., Patterson & Martin, 1992; Patterson, 2007, 2009)

Panum's fusional area

Horopter

Fusion and disparity

Fusion
Interocular Cross talk
(Yeh & Silverstein, 1990; Kooi & Toet, 2004)

- One eye’s information leaks into the other eye (produces ‘ghost’ images; degrades stereopsis)
- Reduced limits of fusion (0.5-2.25 deg with 2-7% cross talk; increased discomfort with 5% cross talk)

- Remedy: Keep cross talk less than 2-5%
Accommodative-Vergence Mismatch
(e.g., Patterson, Winterbottom, & Pierce, 2006)

- Accommodate to display screen, but verge to different depths
- Creates eye strain and discomfort at short viewing distances (Hoffman, Girshick, Akeley & Banks)
- Two important issues: Depth of Field, Percival’s criterion
- Depth of Field (1/Depth of Focus)
- Range of distances in the field within which stimuli appear in sharp focus
- Banks et al.: Percival’s criterion for zone of comfort
- Rule to establish whether a patient is going to experience discomfort in binocular vision
- Person should be operating in the middle third of vergence range
TOTAL DEPTH OF FOCUS (ave value) = 1.0 D (Wang & Ciuffreda, 2006); PERCIVAL’S CRITERION estimated from Banks et al.

<table>
<thead>
<tr>
<th>FIXATION DIST</th>
<th>RANGE OF DEPTH OF FIELD OR PERCIVAL’S CRITERION</th>
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<tbody>
<tr>
<td>0.5 m</td>
<td>D.F.: 0.1 m (front) to 0.17 m (behind)</td>
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<tr>
<td></td>
<td>P.C.: 0.1 m (front) to 0.1 m (behind)</td>
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<tr>
<td>1.0 m</td>
<td>D.F.: 0.33 m (front) to 1.0 m (behind)</td>
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<tr>
<td></td>
<td>P.C.: 0.33 m (front) to 0.5 m (behind)</td>
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<tr>
<td>2.0 m (home view)</td>
<td>D.F.: 1.0 m (front) to infinite (behind)</td>
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<tr>
<td></td>
<td>P.C.: 1.0 m (front) to &gt; 5 m (behind)</td>
</tr>
<tr>
<td>3.0 m (cinema view)</td>
<td>P.C.: 2.0 m (front) to infinite (behind)</td>
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Need to present depth intervals within depth of field or Percival’s zone of comfort.

When viewing distance < 2 m, scenes portraying large distances using other cues (e.g., sports, outdoor scenes) will be in conflict with the stereo depth information.

Restricted depth intervals may produce misperceived object size and speed of motion.
Horopter Shape

3D MOVIE PROJECTION SCREEN

Panum’s Fusional Area

LE

RE
Distance Scaling of Disparity Information
(e.g., Patterson & Martin, 1992; Patterson, 2007, 2009)
Predicted depth (Cormack & Fox, 1985a,b): \[ d = \frac{(D \times S)}{(I + S)} \]
## High-Level Cue Conflict: Based on Dual-Processing Accounts of Reasoning (Evans, 2008)

### References

<table>
<thead>
<tr>
<th></th>
<th>“System 1”</th>
<th>“System 2”</th>
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</thead>
<tbody>
<tr>
<td>Schneider &amp; Schiffrin</td>
<td>Automatic</td>
<td>Controlled</td>
</tr>
<tr>
<td>Epstein (1994), Epstein &amp; Pacini</td>
<td>Experiential</td>
<td>Rational</td>
</tr>
<tr>
<td>Chaiken (1980); Chen &amp; Chaiken</td>
<td>Heuristic</td>
<td>Systematic</td>
</tr>
<tr>
<td>Reber (1993), Evans &amp; Over</td>
<td>Implicit/Tacit</td>
<td>Explicit</td>
</tr>
<tr>
<td>Sloman (1996)</td>
<td>Associative</td>
<td>Rule based</td>
</tr>
<tr>
<td>Hammond (1996, 2007)</td>
<td>Intuitive</td>
<td>Analytic</td>
</tr>
<tr>
<td>Hogarth (2001)</td>
<td>Tacit</td>
<td>Deliberative</td>
</tr>
<tr>
<td>Evans (2008)</td>
<td>Implicit</td>
<td>Capacity-limited</td>
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→ **System 1 (Intuitive): Holistic, perceptual**
High-Level Cue Conflict in Immersive Stereo Displays (Patterson & Silzars, 2009)

Intuitive Reasoning: Activated by Immersive Stereo Displays

Cue Conflict: Especially Serious Between Binocular Parallax and Lack of Motion Parallax (Immersive cues)

Cue Conflict: Leads to Discomfort Because Intuitive Reasoning System Attempts to Make Reasoned Sense Out of Conflicted Perceptual Information

Individuals can extract meaning from scenes within 200 msec exposures (Grill-Spector & Kanwisher, 2005; Oliva & Torralba, 2006; Potter, 1976; Thorpe, Fize & Marlot, 1996)
Summary:

1. **Cross Talk**: Keep cross talk less than 2-5%
2. **Acommodative-Vergence Mismatch**: Present Depth Intervals within Depth of Field & Percival’s criterion
3. **Horopter Shape**: Make Display Curvature Equal Horopter Curvature
4. **Distance Scaling**: Calculate Perceived Depth from Scaling Formula
5. **High-Level Cue Conflict**: Make All Depth Cues Congruent (use viewing distances greater than 2 m; add motion parallax)
References


