Viewer Symptoms & Preferences
- Comparing 3D TV displays

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Vision Performance Institute
A research consortium supporting “Quality Sustainable Vision”
Different TV Technologies
Quality vs. Comfort
Can we have both?
Study Design

- 3D TVs (55”, 1920 x 1080, 120Hz)
  - Samsung 55D7000
  - LG 55LW6500

- N = 60
  - 19 M, 41 F
  - 18-36 yr old, avg. = 24.23
  - VA 20/25 or better for both eyes
  - SA better than 60” (most 20” ~ 40”)

Procedures

• Visual Acuity Threshold,
  • 2D and 3D Landolt C
• Contrast Sensitivity Threshold,
  • 2D and 3D Landolt C
• Step-Vergence:
  • Ability to quickly fuse convergent or divergent image
• Stereo Acuity Threshold
  • WIRT dot diamond
• Depth Perception/Float Localization
• Subjective Questionnaires:
  • 2D vs small and large 3D image quality
  • Pre- and post- moving viewing discomfort
  • Side-by-side TV comparison
## Image Quality Questionnaire 1

### How was the cross-talk (ghosty images around objects)?

**2D**

<table>
<thead>
<tr>
<th>TV 1</th>
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### The overall clarity of the image was:

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Visual/body discomfort questionnaire
pre/post movie viewing

(100 severe discomfort)

• My eyes felt tired
• My eyes felt irritated or had a burning sensation
• My eyes felt strained or it felt like there was a pulling sensation around my eyes
• I felt eye ache or pain inside of my eyes
• My eyes were dry or watery
• I experienced blurry vision
• I saw multiple images (double vision)
• I saw images move, jump, or swim on the screen
• I felt fatigue or sleepiness
• I had difficulty switching focus between near and far
• I experienced a headache
• I experienced dizziness
• I felt disoriented or had a sense of vertigo
• I experienced nausea
• I had neck discomfort
• I experienced general physical discomfort

(100 highly immersed)

• The object look real as they move through space
• I felt like I was part of the movie
• I felt engaged in the movie I viewed
• I lost track of time while viewing the movie
• I feel I can watch this TV for a long time
The objects look real as they move through space
Side-by-side TV Comparison questionnaire (0: poor/disturbing -- 100: excellent/imperceptible)

General display quality (in 3D mode):
- The color displayed were...
- How was your perception of jagged edges?
- How was the cross-talk (ghost images around objects)?
- The display flickering was...
- The overall clarity of the 3D was...

3D presentation display quality
- The perception of depth was...
- The perception of motion smoothness was...
- What was your sense of immersion?

Viewing comfort (in 3D mode):
- The viewing angle was...
- Satisfaction with a tilted head position?
- The weight of the glasses was...
- The edges of the glasses frames were...
- Your overall satisfaction of the glasses is...

Tolerance (in 3D mode):
How long do you think you can watch this TV without feeling discomfort? (none, little, some, a lot, infinite)

Preference:
Final television preference: (TV1 vs. Neutral vs. TV2)
Example: Side-by-side TV comparison

The colors displayed were:

TV 1  Very Poor  Poor  Average  Good  Excellent
TV 2  Very Poor  Poor  Average  Good  Excellent

How was your perception of jagged edges?

TV 1  Disturbing  Distracting  Noticable  Faint  Imperceptible
TV 2  Disturbing  Distracting  Noticable  Faint  Imperceptible

How was the cross-talk (ghosty images around objects)?

TV 1  Disturbing  Distracting  Noticable  Faint  Imperceptible
TV 2  Disturbing  Distracting  Noticable  Faint  Imperceptible

The display flickering was:

TV 1  Disturbing  Distracting  Noticable  Faint  Imperceptible
TV 2  Disturbing  Distracting  Noticable  Faint  Imperceptible

The overall clarity of the 3D was:

TV 1  Very Poor  Poor  Average  Good  Excellent
TV 2  Very Poor  Poor  Average  Good  Excellent
The perception of depth was:

TV 1 Very Poor Poor Average Good Excellent

TV 2 Very Poor Poor Average Good Excellent

The perception of motion smoothness was:

TV 1 Very Poor Poor Average Good Excellent

TV 2 Very Poor Poor Average Good Excellent

What was your sense of immersion?

TV 1 Very Poor Poor Average Good Excellent

TV 2 Very Poor Poor Average Good Excellent

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Satisfaction with a tilted head position?

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The weight of the glasses were:

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The edges of the glasses frames were:

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Your overall satisfaction of the glasses:

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How long do you think you can watch this TV without feeling discomfort?

**TV 1**  None  Little  Some  A lot  Indefinitely

**TV 2**  None  Little  Some  A lot  Indefinitely
Final television preference:
Visual Acuity (Landolt C)

- 2D > 3D
- Mode x TV:
  - 2D: Active better than Passive
  - 3D: n.s.
  - Active: 2D > 3D
  - Passive: n.s.
Contrast Threshold: Low contrast Landolt C

- Threshold contrast level:
  - 2D: Active better than Passive
  - 3D: n.s.
  - Active: 2D > 3D
  - Passive: 3D > 2D
Step-Vergence Test Accuracy
(Wirt 4 Dot with alternate convergence-divergence displays)

- Overall: faster response switching time in passive system
Display Quality Assessment: Ghosting

- Noticeable Ghosting
  - Larger ratings = less noticeable ghosting (better image quality)
  - See Ghost Image in 3D more than in 2D
  - 3D images: less ghosting on passive TV
  - 2D image: n.s.
- Interaction:
  - Active: exist, regardless of image size
  - Passive: Perceived in small image, but not in large image

![Bar chart showing ghosting ratings for different conditions]
Display Quality Assessment: Clarity

- Image Clarity
  - 3D: Large 3D better on passive; n.s. for small 3D
  - 2D: n.s.
  - Interaction:
    - Active: 2D > large 3D image > small 3D image
    - Passive: large 3D image > 2D > small 3D image
No statistically significant differences between TVs:

- Pre- vs Post- Movie Viewing: No difference on any symptoms or factors
- Stereo Acuity Levels
- Depth Perception/Float Localization
Side by Side comparison

- Active: n.s. rating preferences
- Passive preferences:
  - Color
  - Clarity
  - Motion Smoothness
  - Immersion
  - Viewing Angle
  - Viewing Time
Side by Side Comparison

- **Glasses: Passive**
  - Overall preferred glasses
  - Lighter weight
  - Frame edge less disruptive
Final TV Preference: Passive TV
## Results Summary

<table>
<thead>
<tr>
<th>Active</th>
<th>Passive</th>
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<tbody>
<tr>
<td>• Contrast Threshold in 2D</td>
<td>• Final TV preference</td>
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<tr>
<td>• VA Threshold in 2D</td>
<td>• Subjectively rated with better: color, clarity, motion smoothness and</td>
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<td></td>
<td>immersion</td>
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<td>• Preferred glasses (weight and frame edge)</td>
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<td>• Less disrupted by head tilt and viewing angle</td>
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<td>• Longer viewing time before discomfort subjectively predicted</td>
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<td>• Contrast threshold better in 3D</td>
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<td>• Faster vergence reaction times</td>
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