3 D displays
“Avatar Headache”

- Headache
- Eyestrain
- Dry eyes
- Nausea
- Vertigo
Home Theatre Study


- To compare symptoms between 2D and 3D viewing of the same movie

- Sponsored by Intel Corporation
Procedures

- Two hundreds and five adults (44% female, averaged 36.6 years of age)
- Wore habitual optical correction
- Randomly assigned to 2D or 3D viewing groups.
- Samsung 55” HD3D LCD TV
- 17 item questionnaire before and after viewing
Figure 1. The 95% confidence intervals of the natural log odds ratio for changes in visual and physical symptoms (Red = 2D, n=103; Blue = 3D, n=100). Bars placed entirely to the right of zero (0) indicate symptoms that significantly increased from baseline during or after viewing. Bars completely left of zero indicate symptoms that significantly decreased from baseline.
Figure 2. The 95% confidence intervals of the natural log odds ratio for changes in visual quality and motion symptoms (Red = 3D, n=103; Blue = 2D, n=100). Illustrated as in Figure 1.
Depth sensation in the real world

- Each eye sees the world from a slightly different viewing angle
- The brain interprets this as depth.

http://www.vision3d.com/images/bb.jpeg
Viewing different distances in the real world

- Convergence
- Accommodation (eye focus change)

Figure 5. Point A and point B stimulating disparate points. Point A stimulates the nasal retina of both eyes.

http://webvision.med.utah.edu/imageswv/Space5.jpg
Changing viewing distance

- Accommodation

Changing viewing distance

- Convergence

Virtual 3D

- Separate images need to be shown to each eye
- In order to view different depths,
  - Convergence is required,
  - but accommodation must remain the same
Real 3D

- Blur is a stimulus
- Disparity is a stimulus
- Proximal is a stimulus
Virtual 3D

- Blur is not an appropriate stimulus
  - In fact, it may hinder because it can be inappropriate
- Disparity is a stimulus
- Proximal is probably weaker
Inappropriate blur

- When the blur is inappropriate for the intended depth,
  - then the perception of depth in space can be distorted.

Appropriate blur

- When the blur is appropriate:
  - reaction time to depth stimuli is reduced
  - Spatial distortions are reduced
  - Fatigue and discomfort are reduced.

Virtual 3D viewing

- Optimal human response to virtual 3D requires different, and varying, accommodation/vergence ratio than encountered in real 3D.
The relationship between convergence and accommodation

Donder’s Line is the real world
The zone shows the areas of flexibility

Image courtesy of VISERG, Loughborough University
AC/A and C/AC

- Accommodation can drive convergence
  - AC/A is $4^\circ/D$ (mean)

- Convergence can drive accommodation
  - CA/C is about $0.5D/6^\circ$
    - Schiemann and Wick

- And they vary by person
Which link is strongest?

- A normal viewing distance of 40 cm requires
  - 2.5 D of accommodation (less because of depth of field)
  - 15° of convergence
- It takes 30° of convergence to induce 2.5D of accommodation
- It takes 3.75 D of accommodation to induce 15° of convergence
- Neither one is strong enough to induce the necessary amount of the other
- This creates a convergence/accommodation “space” within which
  - disparity and proximal cues drive the eyes to fuse, and
  - blur and proximal cues drive them to accommodate.
Vergence, Accommodation, and Visual Symptoms in 3D Viewing

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Vision Performance Institute
A research consortium supporting “Quality Sustainable Vision”
Testing Setup
Variance in Vergent Response

![Graph showing variance in vergence response over time intervals (every 18 mins) for 3D and 2D conditions. The graph displays the standard deviation of vergence amplitude (Δ) with error bars indicating variability.]
Variance in Accommodative Response

![Bar chart showing variance in accommodative response across different time intervals (every 18 mins). The chart compares 3D and 2D conditions.](chart.png)
How should the visual system respond to 3D?

- Vergence without accommodation?
- Does accommodation always accompany vergence changes?
- Do all subjects react the same?
  - Almost certainly not
- Which subjects are having symptoms?
Optometrists regularly test the accommodation and convergence zone (ZSCBV)

- NRC and PRC are changes in vergence with no change in accommodation
- NRA and PRA are changes in accommodation with no changes in vergence
Symptoms related to Accommodative Disorders

- near blur
- post-work distance blur
- slowness of focus changes
- eyestrain
- general ocular discomfort
Symptoms caused by binocular vision disorders

- eyestrain
- eye fatigue
- general fatigue
- intermittent blurry vision
- losing one’s place while reading
- double vision
For digital displays, glasses are used to send a different image to each eye.
开启不伤眼的3D新视纪
“不闪式3D硬屏”
发布会

LG Display

购买3D电视时
请认准不闪式3D硬屏

不闪式3D详情请登陆
http://en.ipsked.com查询
Glasses and the image separation method can add further stress to 3D viewing

- Another optical element
- Reduce brightness by at least 50%
- Can be physically uncomfortable
- Awkward for people who need glasses to see clearly
2 methods to show different images to each eye

- Using polarized glasses
- Seeing visual information for left eye & right eye at a time.

- Using shuttered glasses
- Seeing visual information for left eye & right eye sequentially.

Film Patterned Retarder

Polarized Glasses

1st frame

2nd frame

Shutter Glasses
Shutter glasses (SG)

- DLP technology
- Flicker
- Complex timing
  - “Cross-talk”
FPR 3D glasses

- Polarized Glasses

- QWP : Quarter Wave Polarizer

- Film Patterned Retarder

- QWP

- Polarizer

- • QWP : Quarter Wave Polarizer
Polarized glasses vs shutter glasses

- Less flicker
- Lighter & more comfortable
- No battery & driving circuit.
- Less cross talk
- Higher Brightness
- Curved lenses
3D without glasses
3D without glasses

Philips' 3D Solutions
3D without glasses

- Locating the pupils
- 6 cm apart
- Cameras
- Kinect
3D Vision Clinic

- New Beaverton clinic
  - May/June opening
- Dedicated room for testing
- Public service
- Coordination with VPI research
Vision Performance Institute

A research consortium supporting “Quality Sustainable Vision”

5th Annual Research Conference

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Pacific University Campus
Forest Grove, Oregon