Vision and 3D Displays

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Vision Performance Institute

A research consortium supporting
"Quality Sustainable Vision"

3 D displays


AVATAR
DECEMBER 18 2009 WORLDWIDE
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“Avatar Headache”

- **Headache**
- **Eyestrain**
- **Dry eyes**
- **Nausea**
- **Vertigo**

Home Theatre Study

Yang S, Cooper S, Corriveau P, Doherty R, Sheedy J

- **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

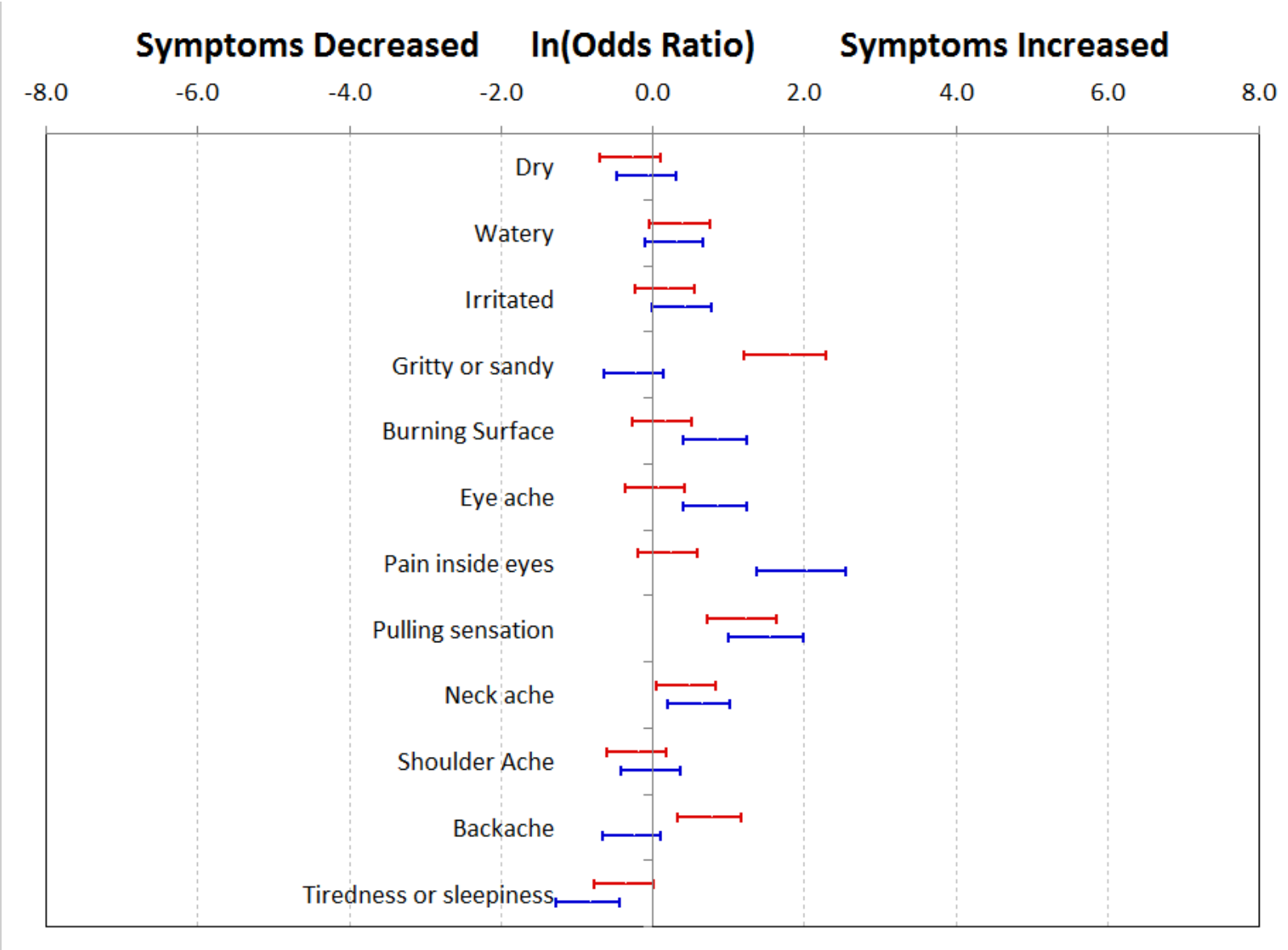


Figure 1. The 95% confidence intervals of the natural log odds ratio for changes in visual and physical symptoms (Red = 2D, n=103; Blue = 3D, n=100). Bars placed entirely to the right of zero (0) indicate symptoms that significantly increased from baseline during or after viewing. Bars completely left of zero indicate symptoms that significantly decreased from baseline.

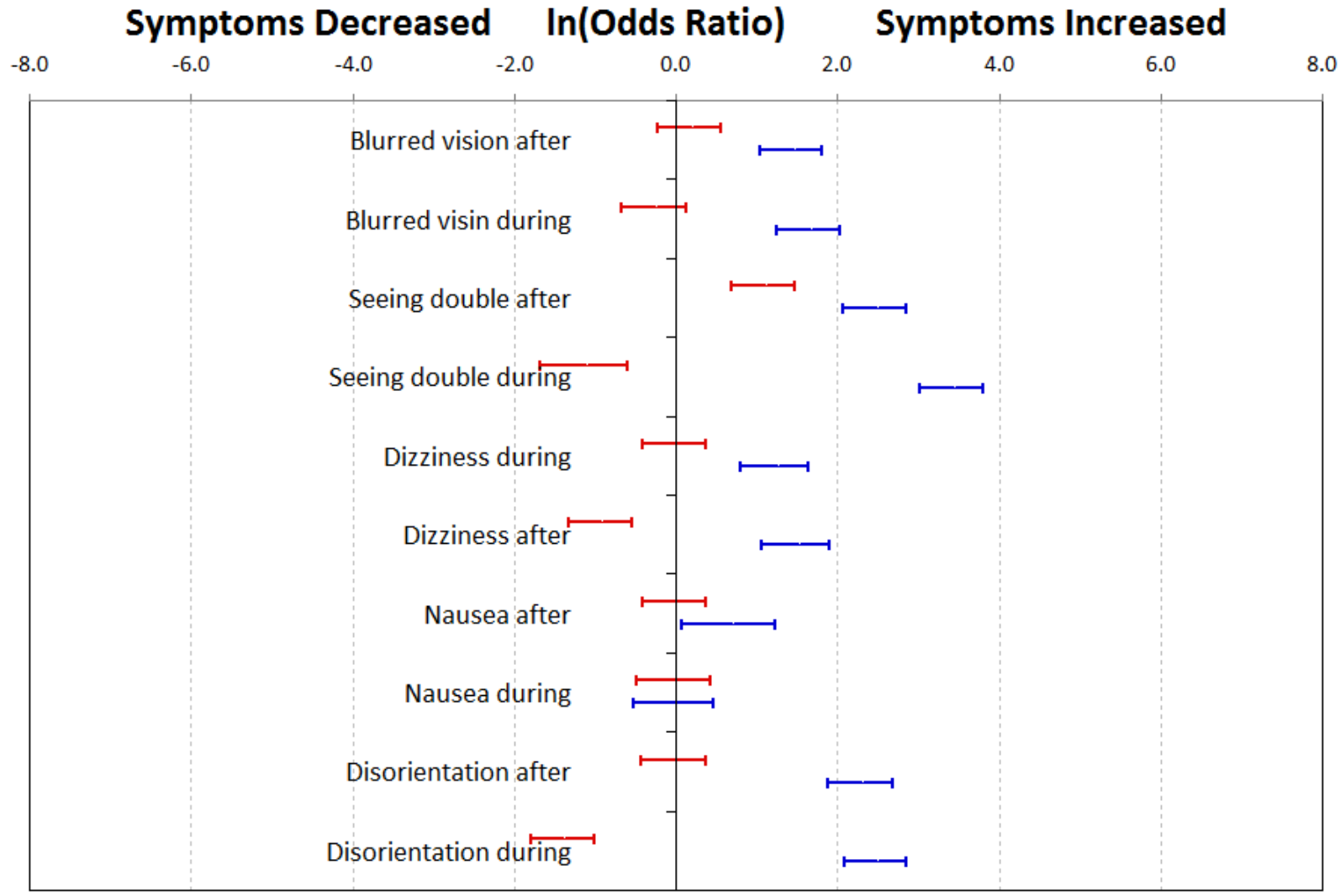
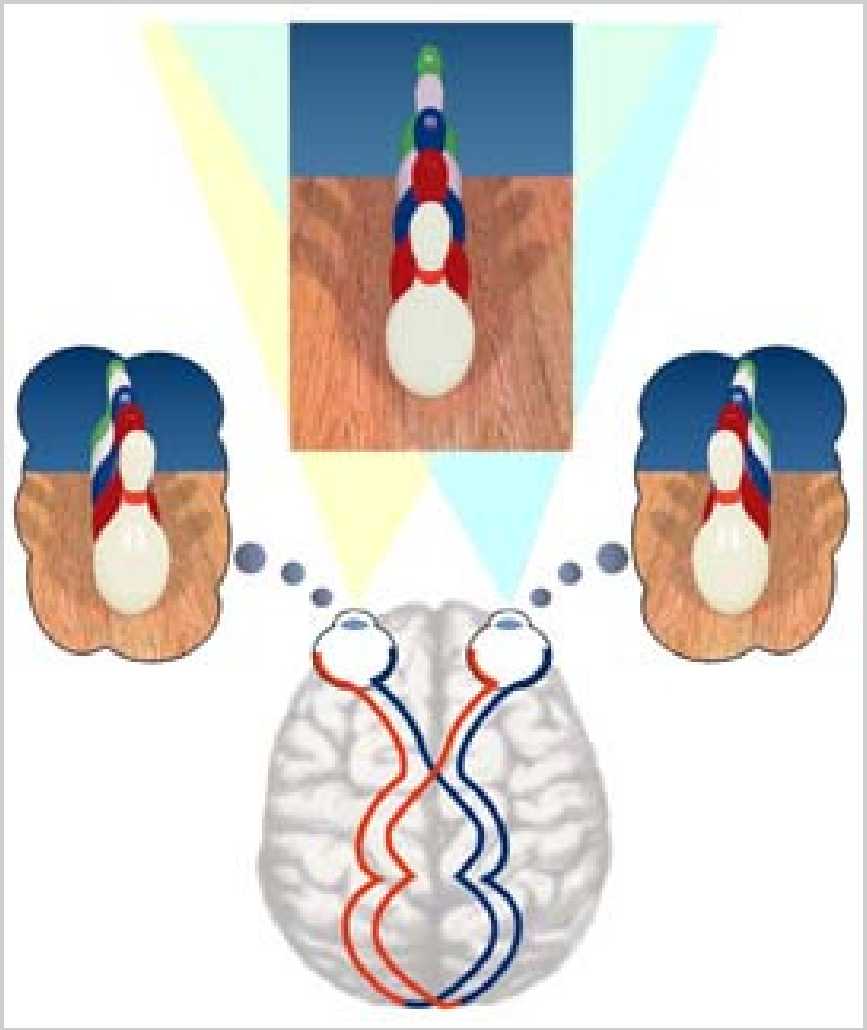


Figure 2. The 95% confidence intervals of the natural log odds ratio for changes in visual quality and motion symptoms (Red = 3D, n=103; Blue = 2D, n=100). Illustrated as in Figure 1.

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)**

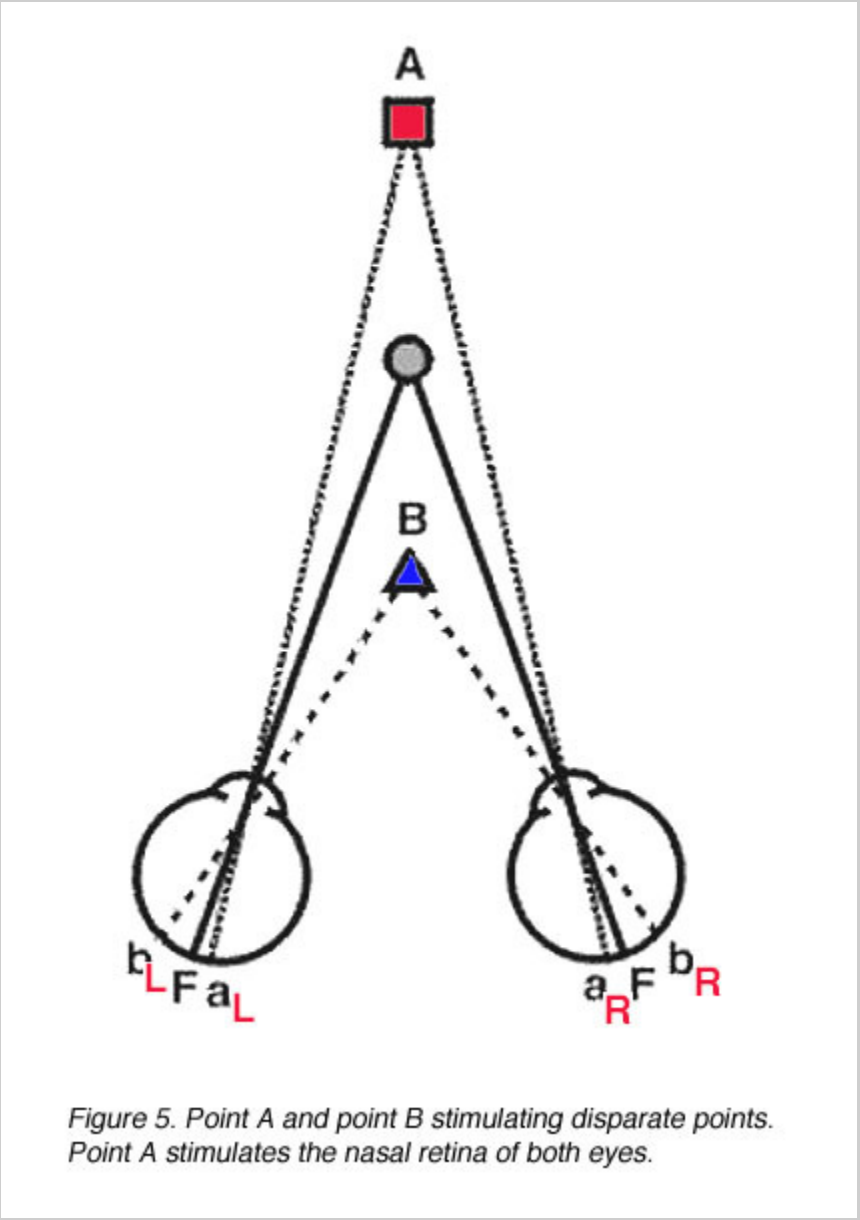
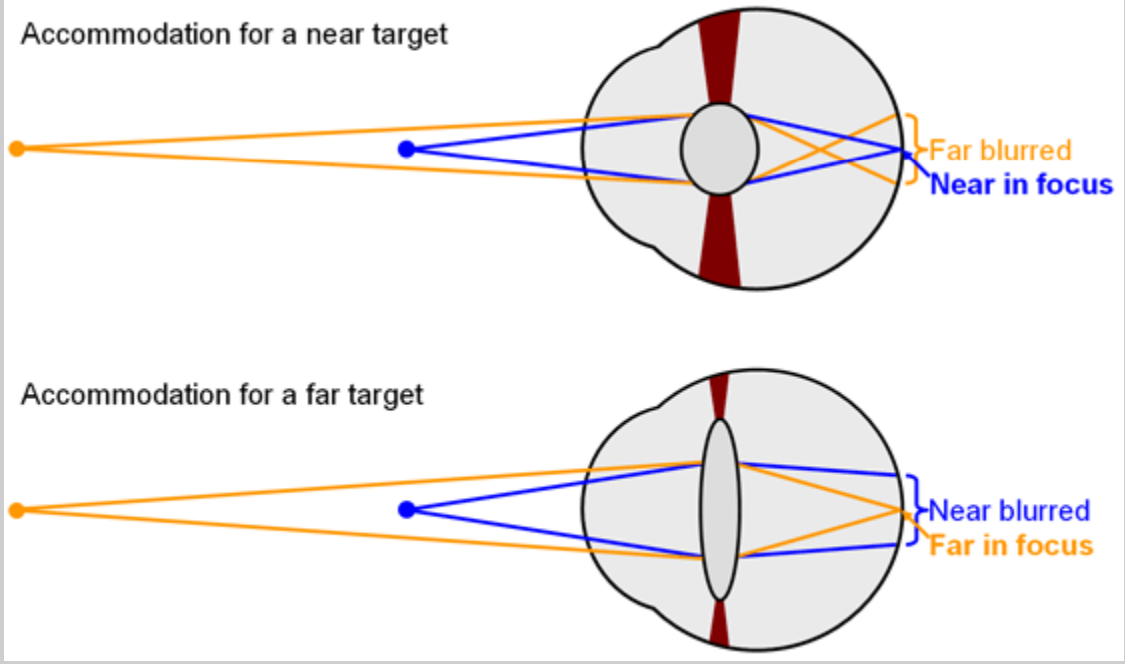


Figure 5. Point A and point B stimulating disparate points. Point A stimulates the nasal retina of both eyes.

http://webvision.med.utah.edu/imageswv/Space5.jpg

Changing viewing distance

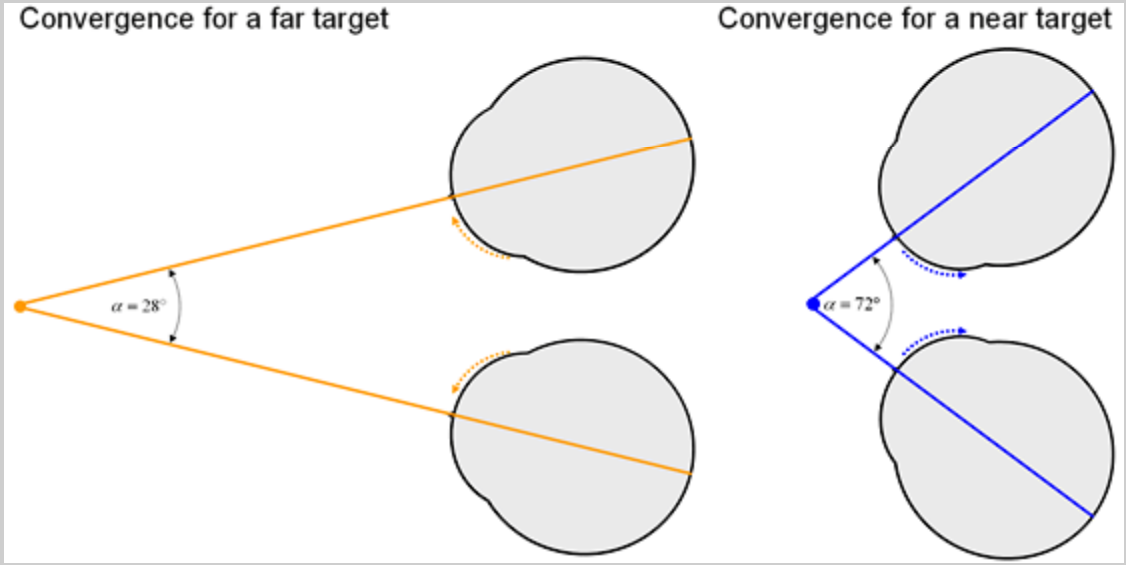
- **Accommodation**



http://www.sapdesignguild.org/editions/edition9/images/accomodation.png

Changing viewing distance

- **Convergence**



http://www.sapdesignguild.org/editions/edition9/images/accomodation.png

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.**
  - **Watt, Akeley, Ernst, Banks. Focus cues affect perceived depth. J Vis (2005) 5, 834-862.**

Appropriate blur

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

- **Hoffman, Girshick, Akerley, Banks. Vergence-accommodation conflicts hinder visual performance and cause visual fatigue. J Vis (2008) 8(3).**

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

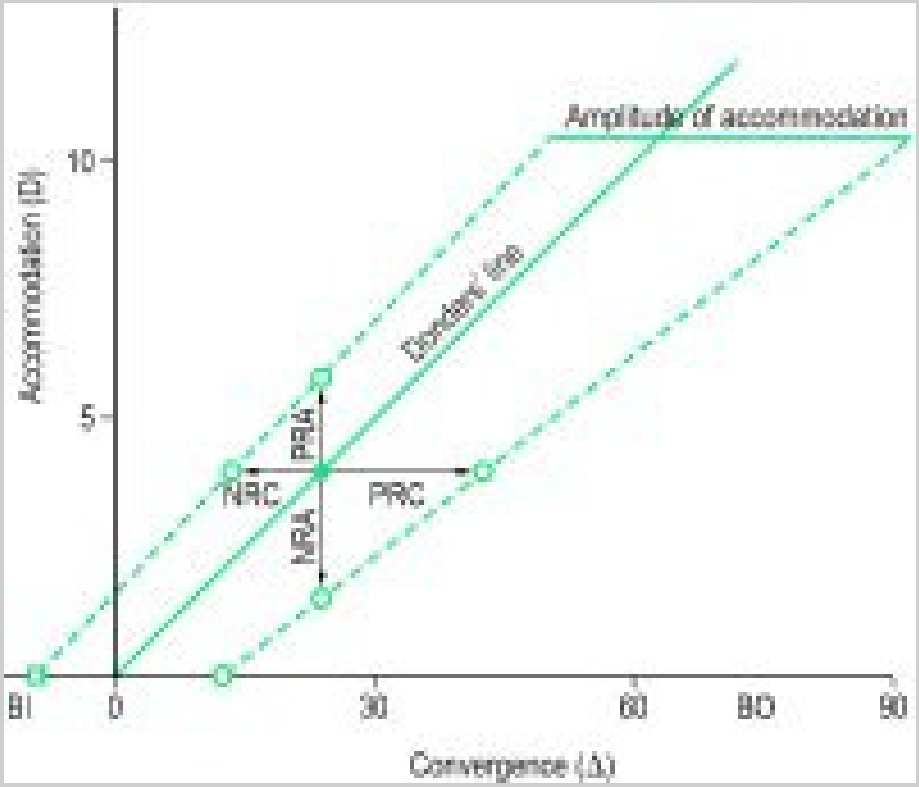


Image courtesy of VISERG, Loughborough University

AC/A and C/AC

- **Accommodation can drive convergence**
  - **AC/A is 4^/D (mean)**
    - **Morgan MW. Clinical measurements of accommodation and vergence. Am J Optom 1944;21:301-313**
- **Convergence can drive accommodation**
  - **CA/C is about 0.5D/6^**
    - **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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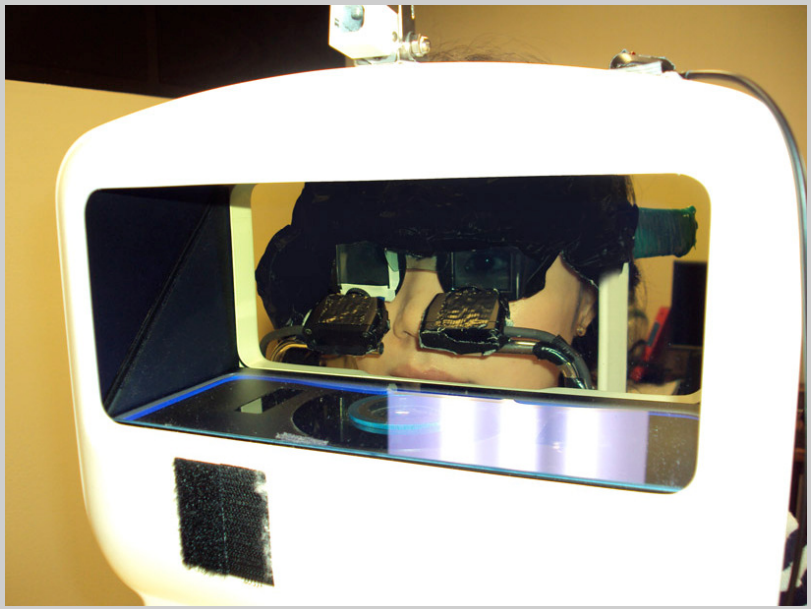
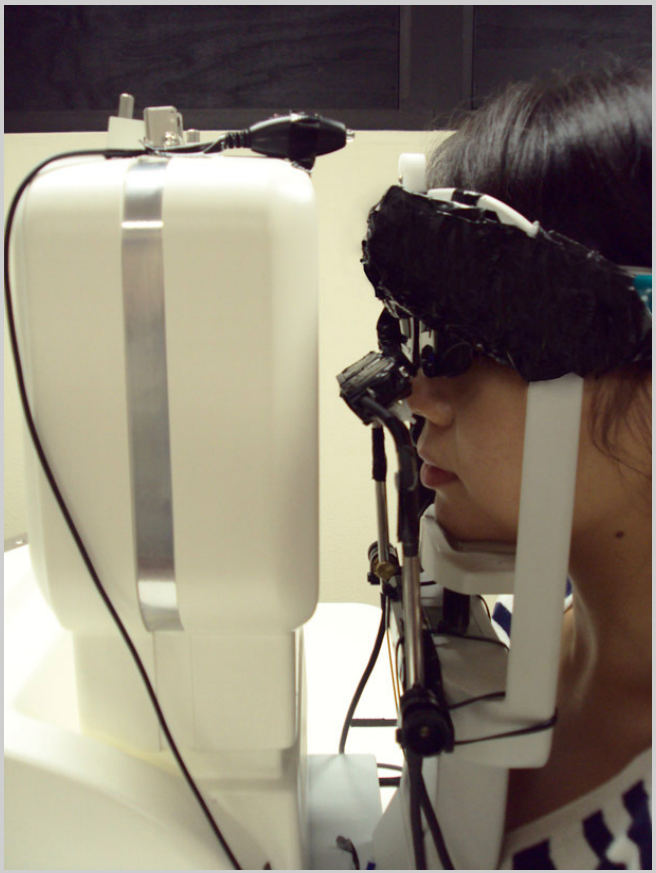
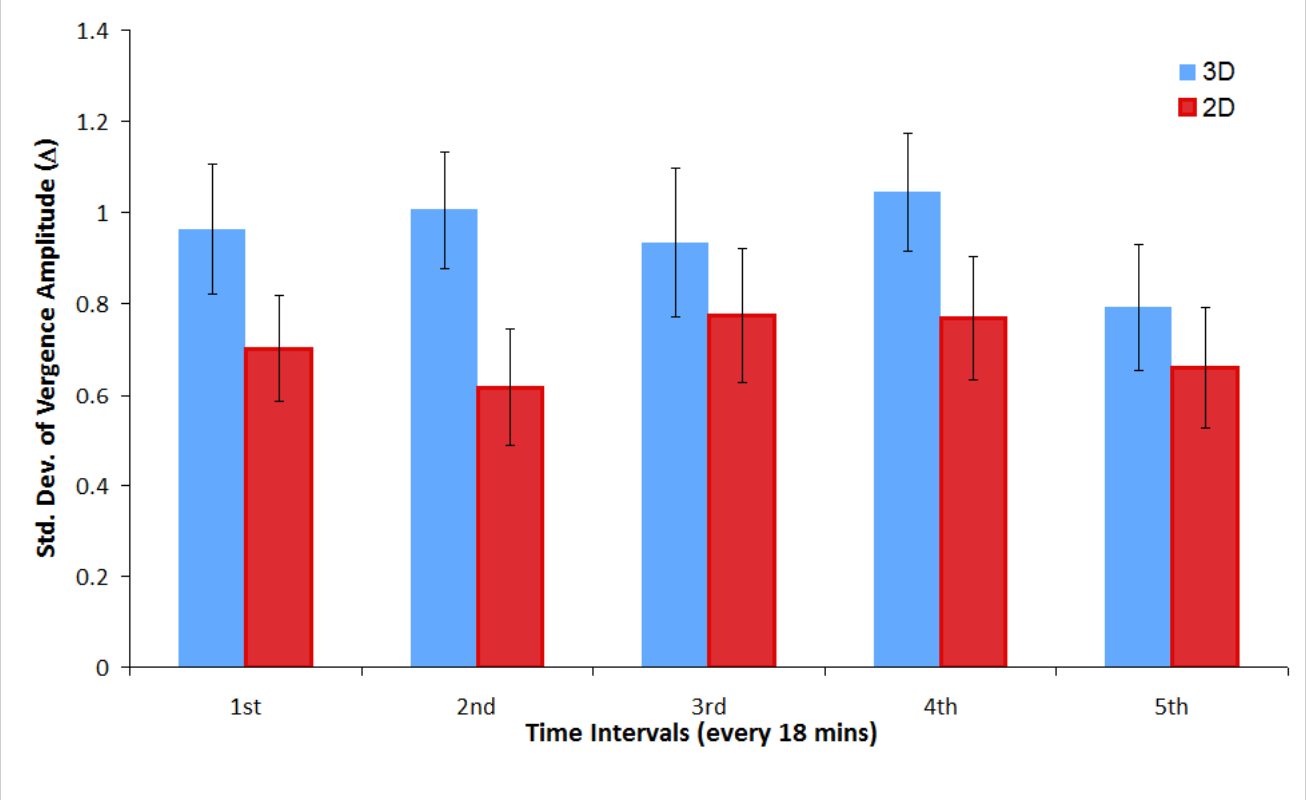
Testing Setup

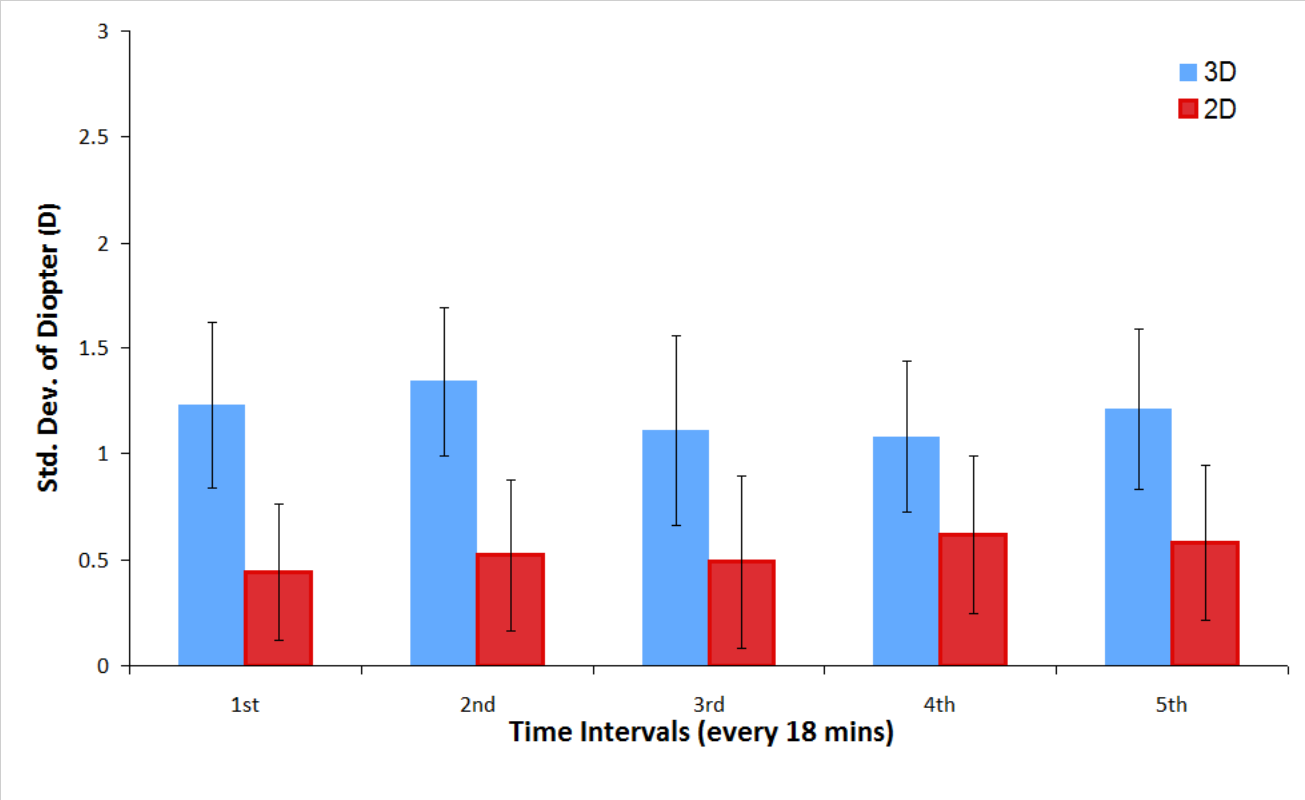




Variance in Vergent Response



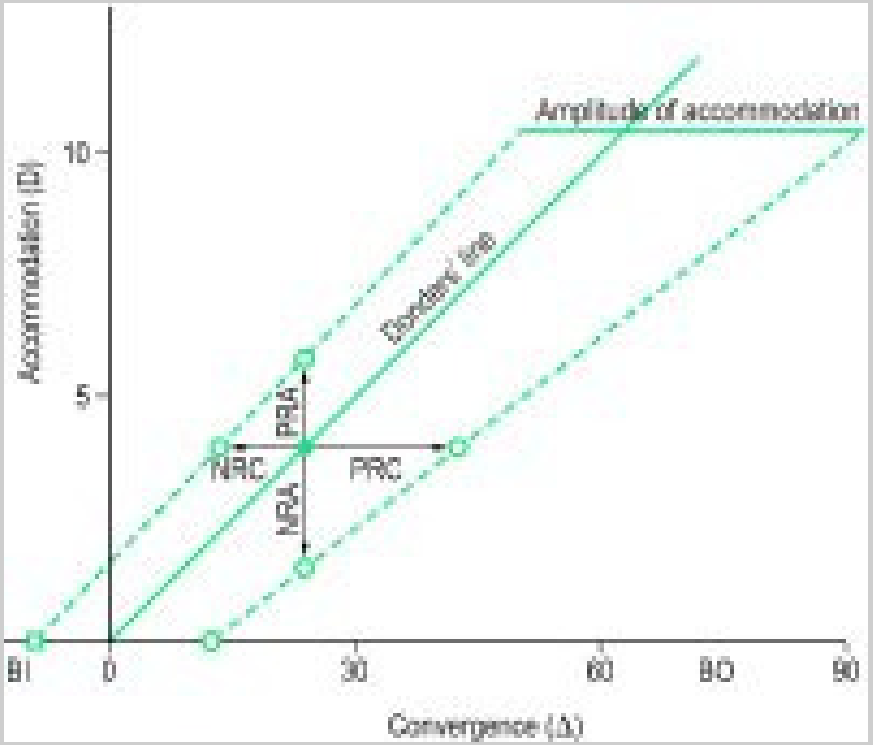
Variance in Accommodative Response



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 acommodation**
- **NRA and PRA are changesd 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.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http://en.ipsled.com查询

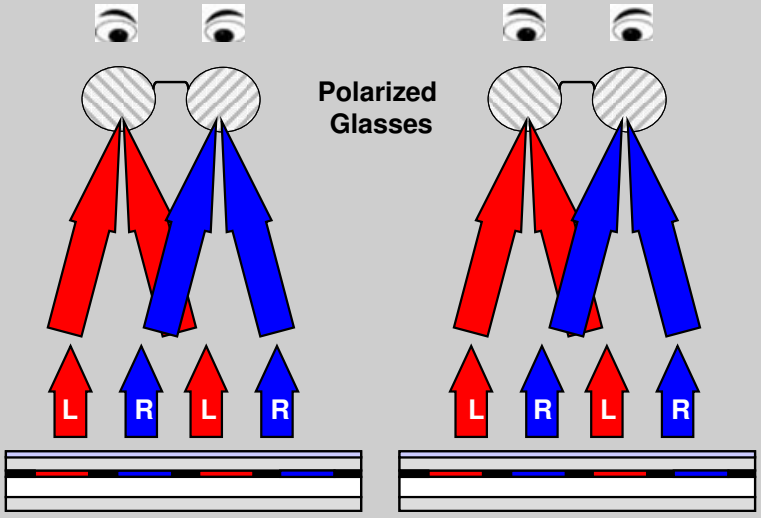
Glasses and the image separation method can add further stress to 3D viewing

- **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

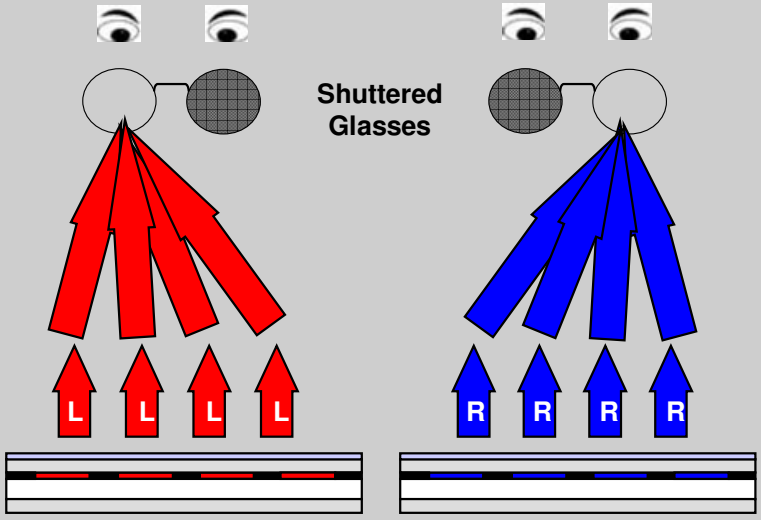
Film Patterned Retarder

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



Shutter Glasses

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

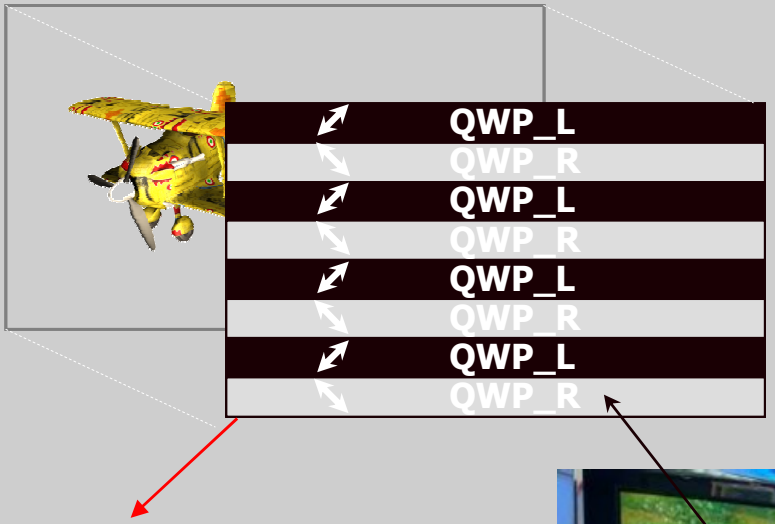


Shutter glasses (SG)

- DLP technology
- Flicker
- Complex timing
  - "Cross-talk"

FPR 3D glasses

- Polarized Glasses



Film Patterned Retarder

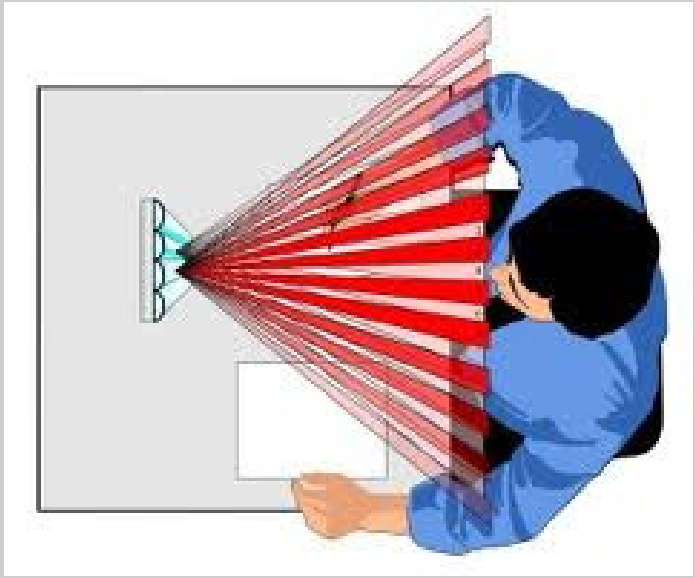
QWP QWP Polarizer

- QWP : Quarter
- Wave Polarizer

Polarized glasses vs shutter glasses

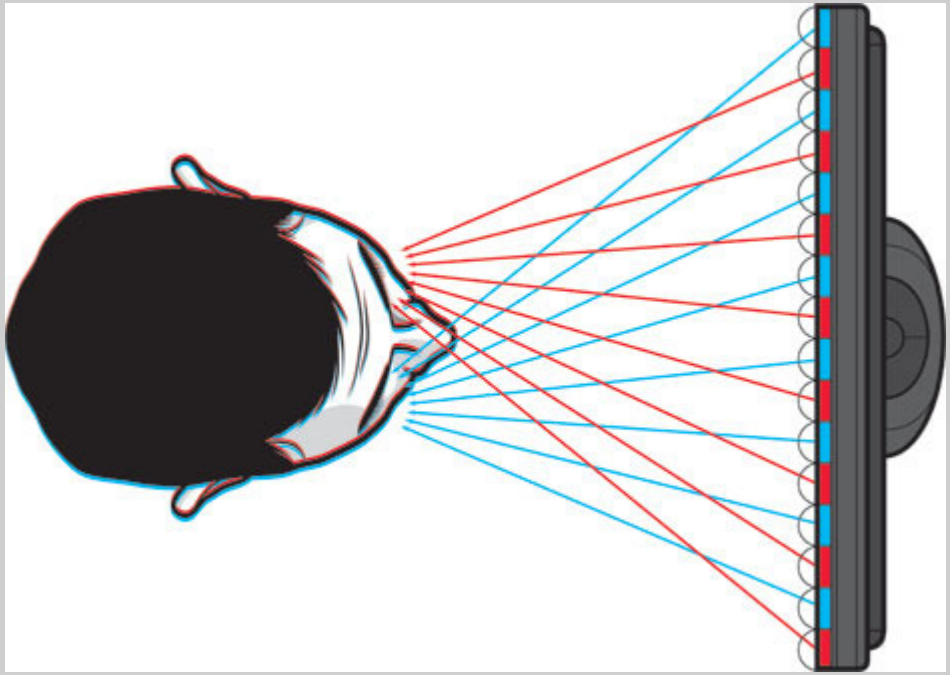
- Less flicker
- Lighter & more comfortable
- No battery & driving circuit.
- Less cross talk
- Higher Brightness
- Curved lenses

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

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5th Annual Research Conference

June 1-3, 2011

Pacific University Campus
Forest Grove, Oregon