Human Visual Perception
relevant to
3D-TV

Wa James Tam

Communications Research Centre Canada

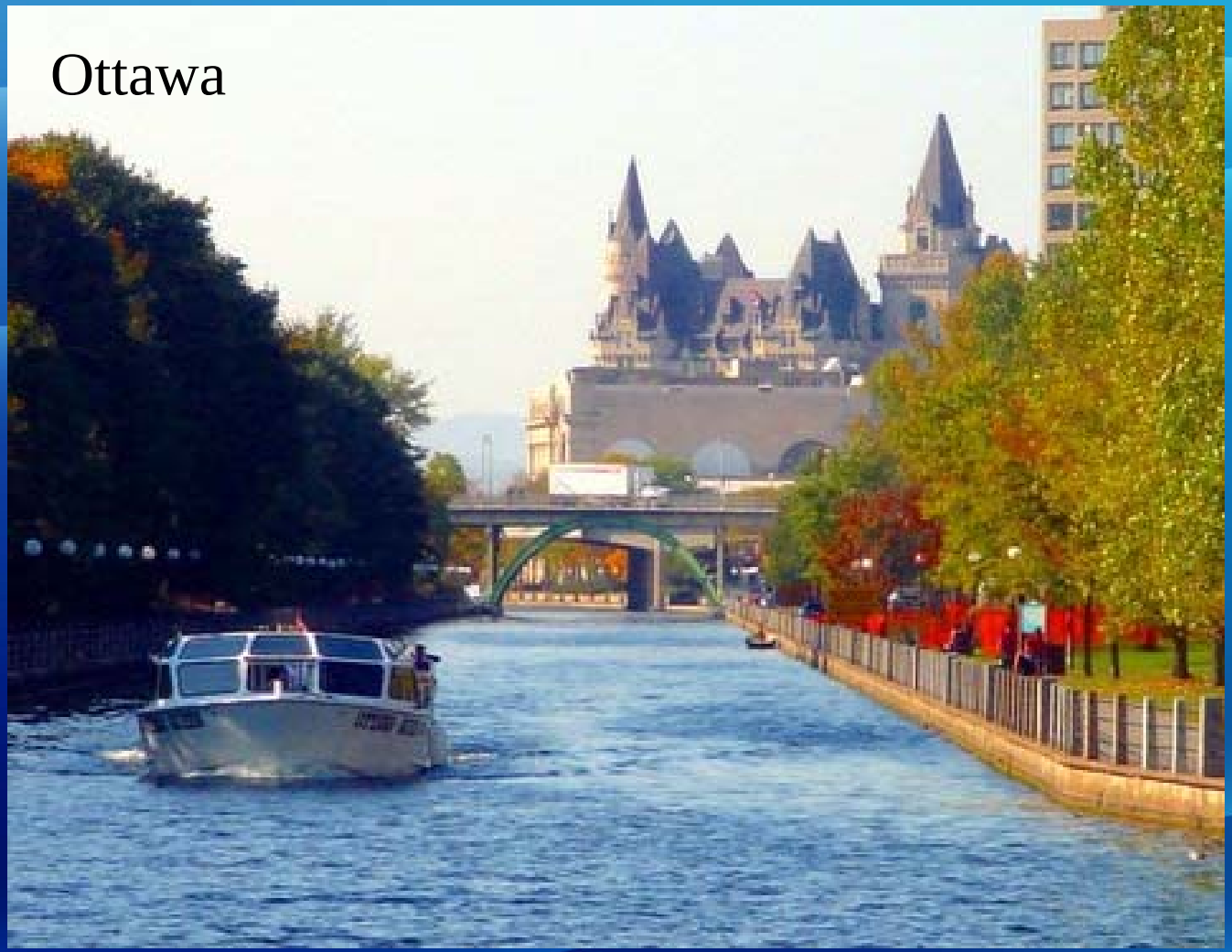
An understanding of

Human Visual Perception

is important

for the development of

3D-TV

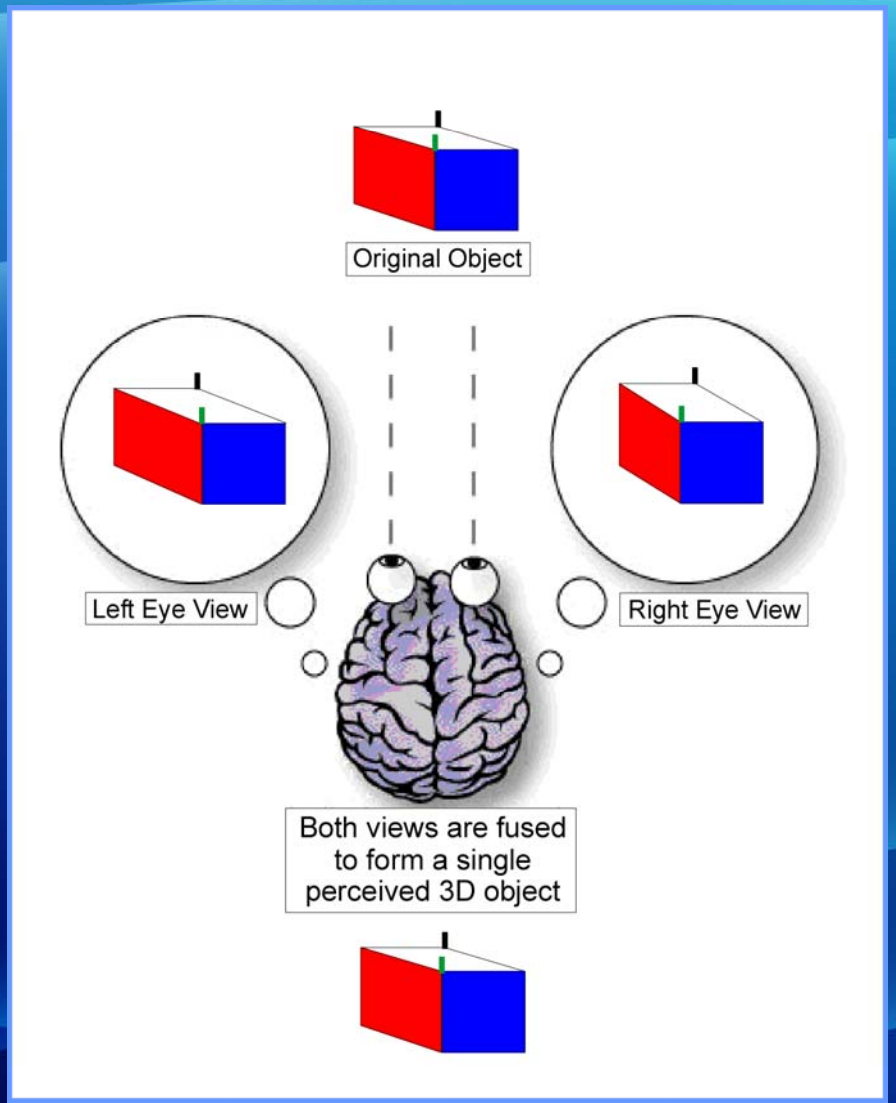


Communications Research Centre Canada (CRC)

is the primary federal laboratory for R&D in advanced telecommunications in Canada.

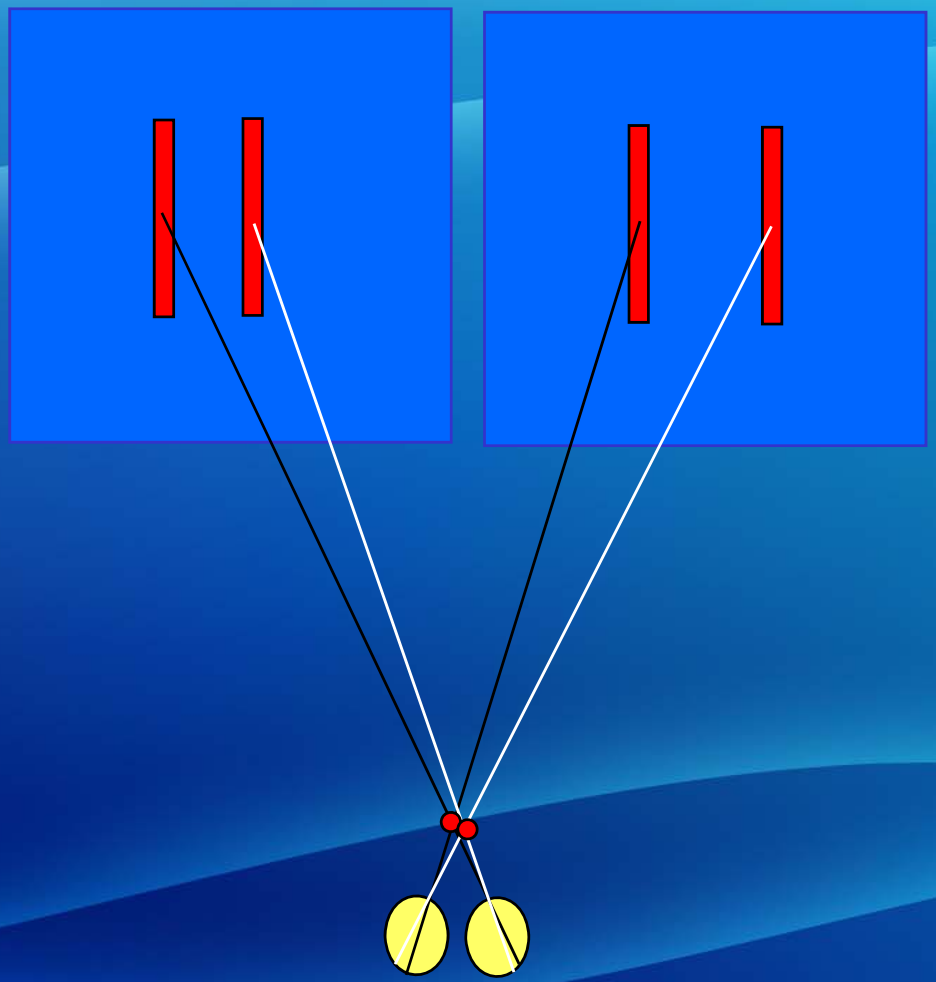
Surrogate Depth Maps

What underlies 3D-TV?

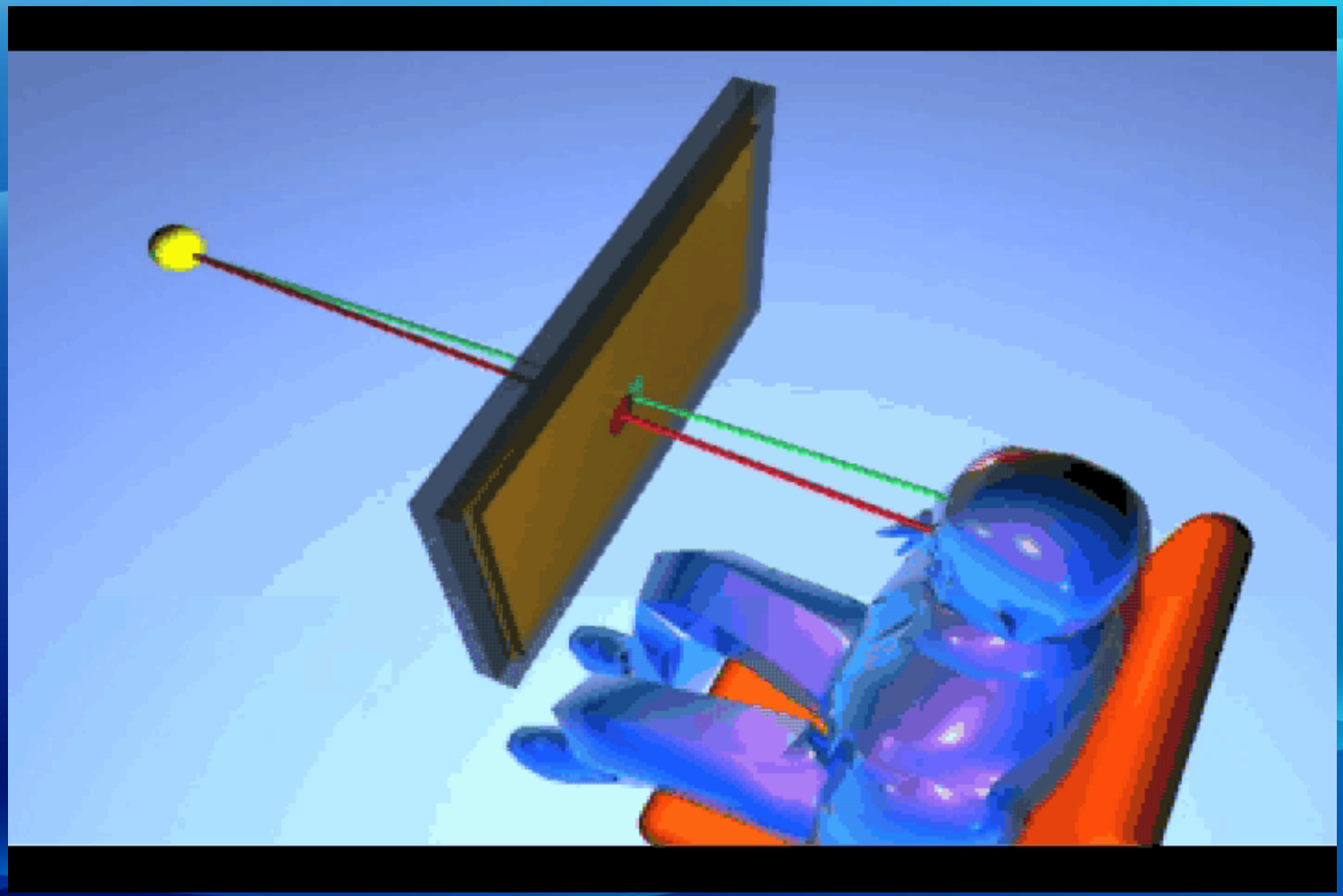


Depth from Disparity Processing by the Human Visual System

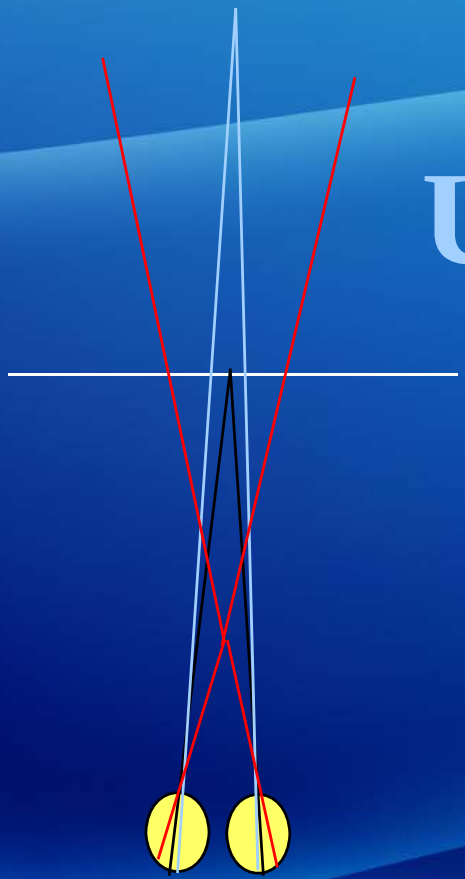
Horizontal Disparity



Changing Horizontal Disparities



Two Types of Disparities



Uncrossed Disparity

Crossed Disparity

Differences/Implications

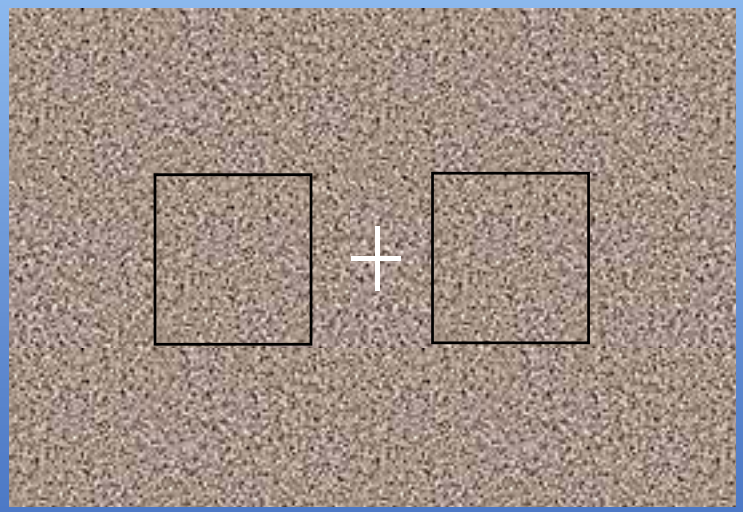
Stereo deficiency

Performance

Visual comfort

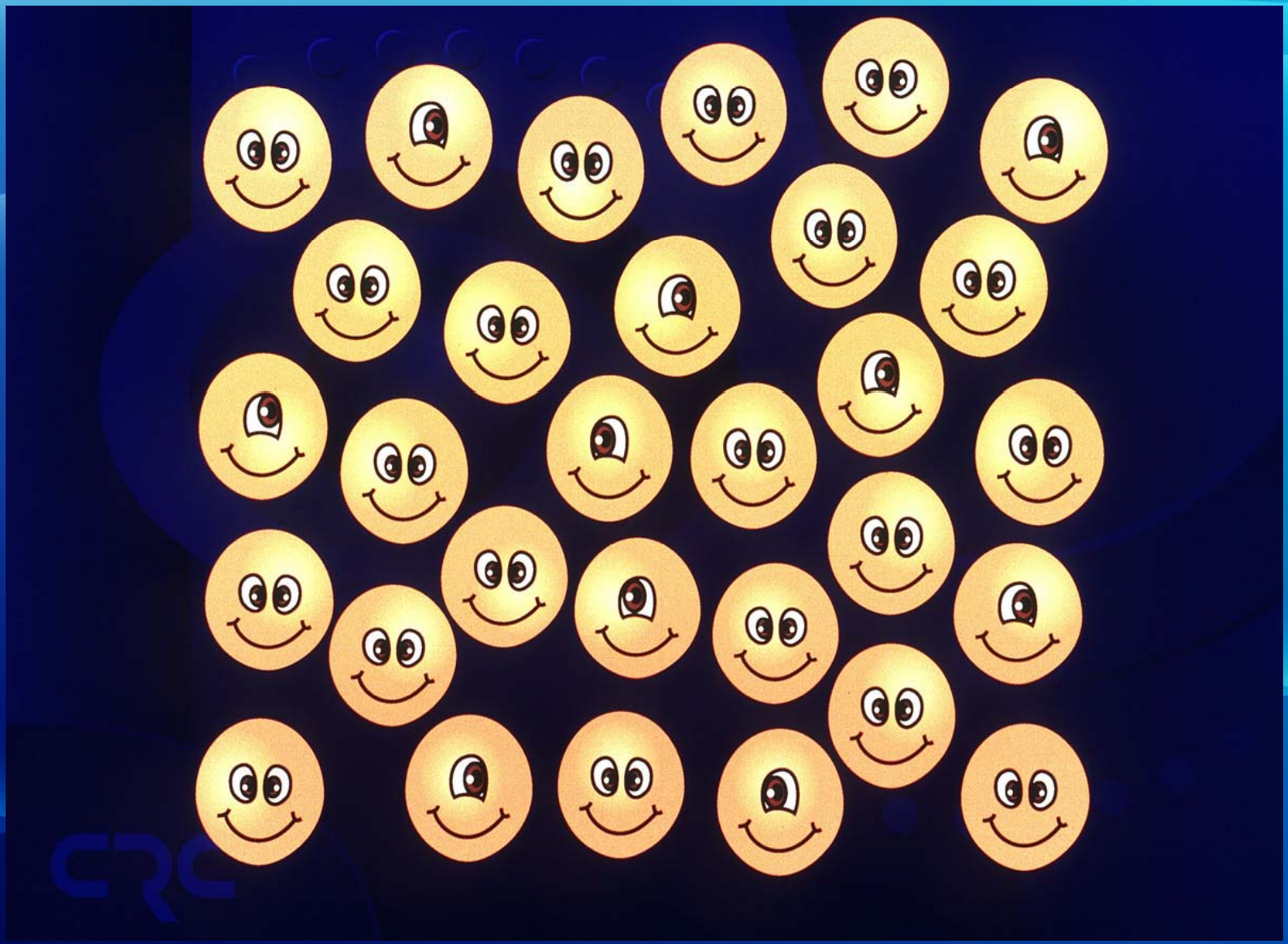
Visual display

Stereo Deficiencies



Who can benefit from 3D TV?

6% vs. 30%

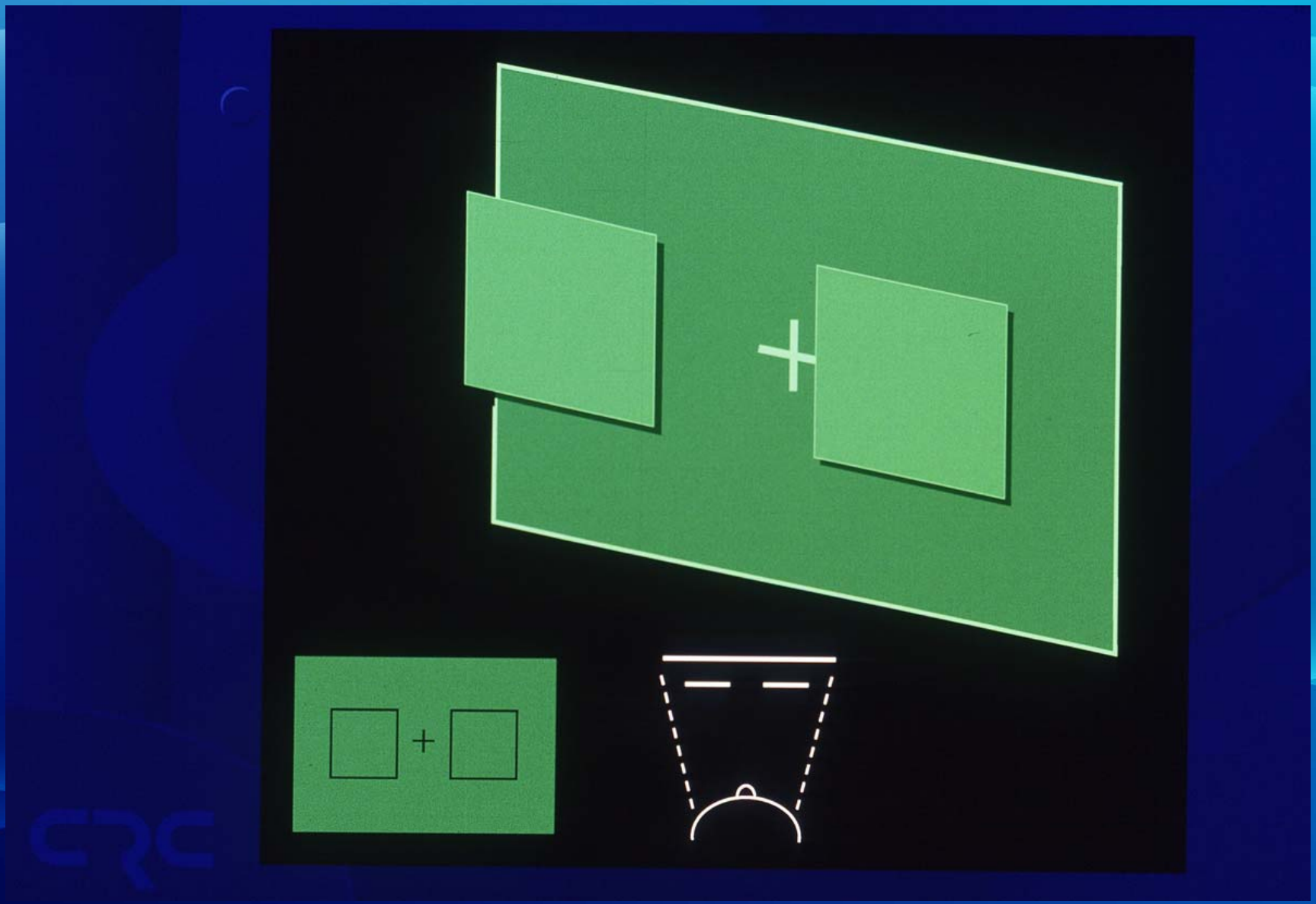


Display Duration and Depth Discrimination

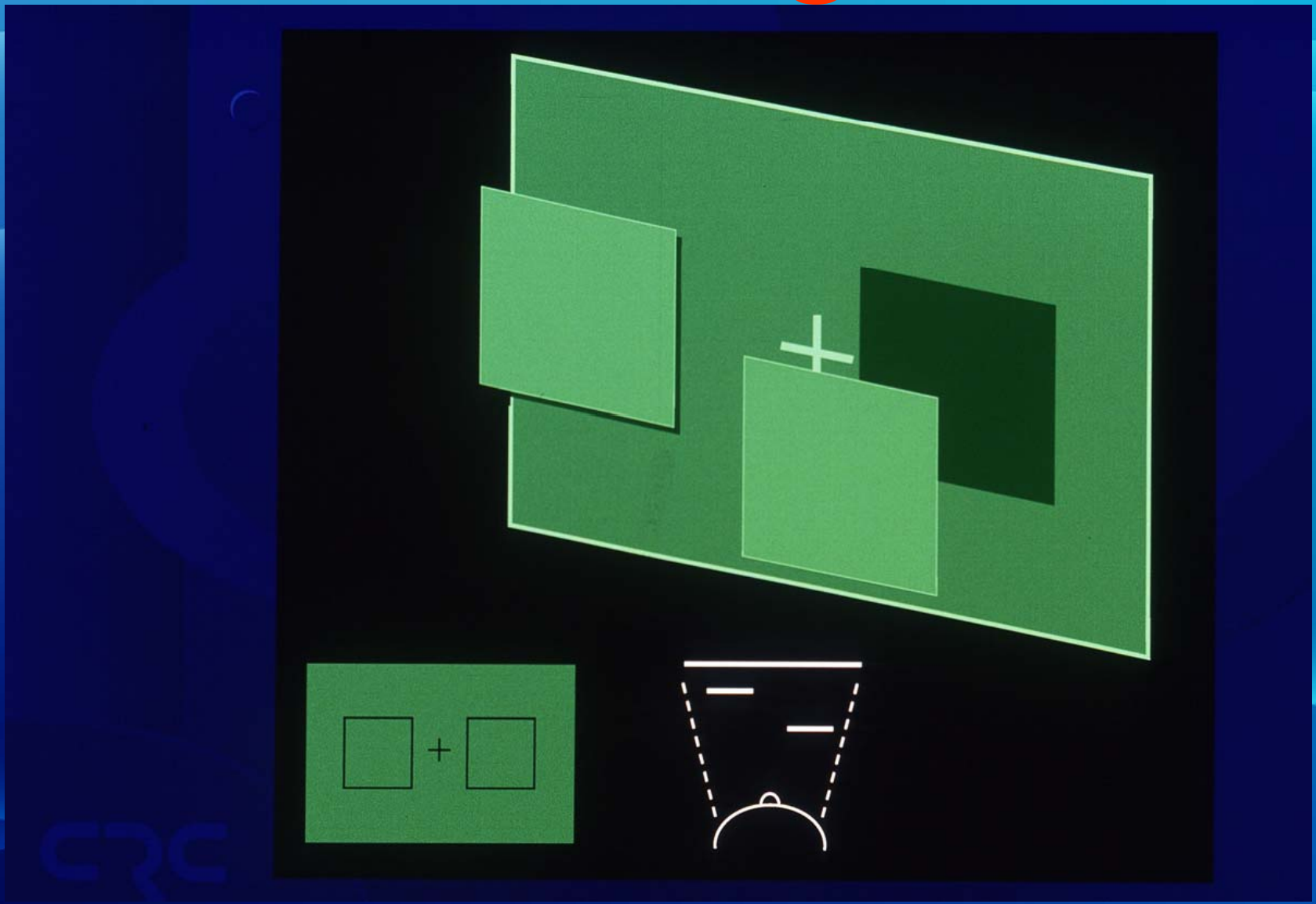
Apparatus

Test Set-up

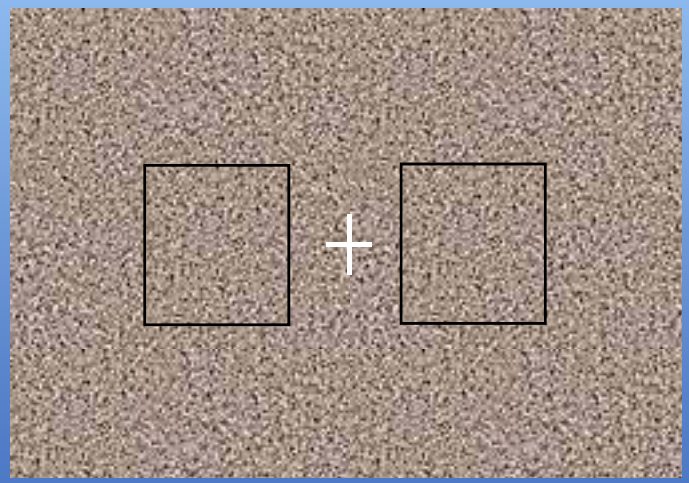
Front or Back?



Left or Right?



Depth Discrimination



4.7 deg

10.6 deg

Front/back?
Left/Right closer?

0.25 deg &
0.125/0.375 deg

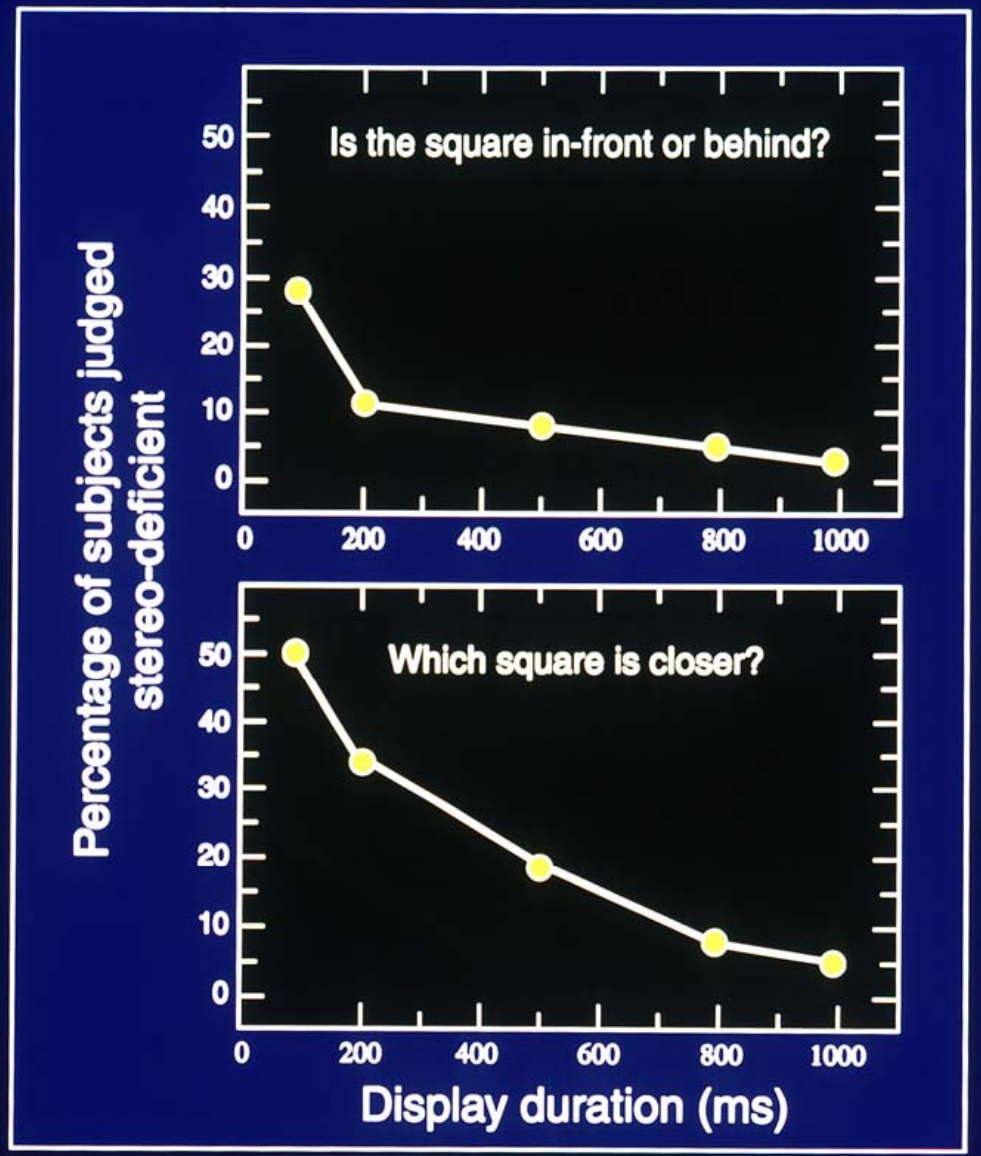
Dynamic tracking
(PEST)

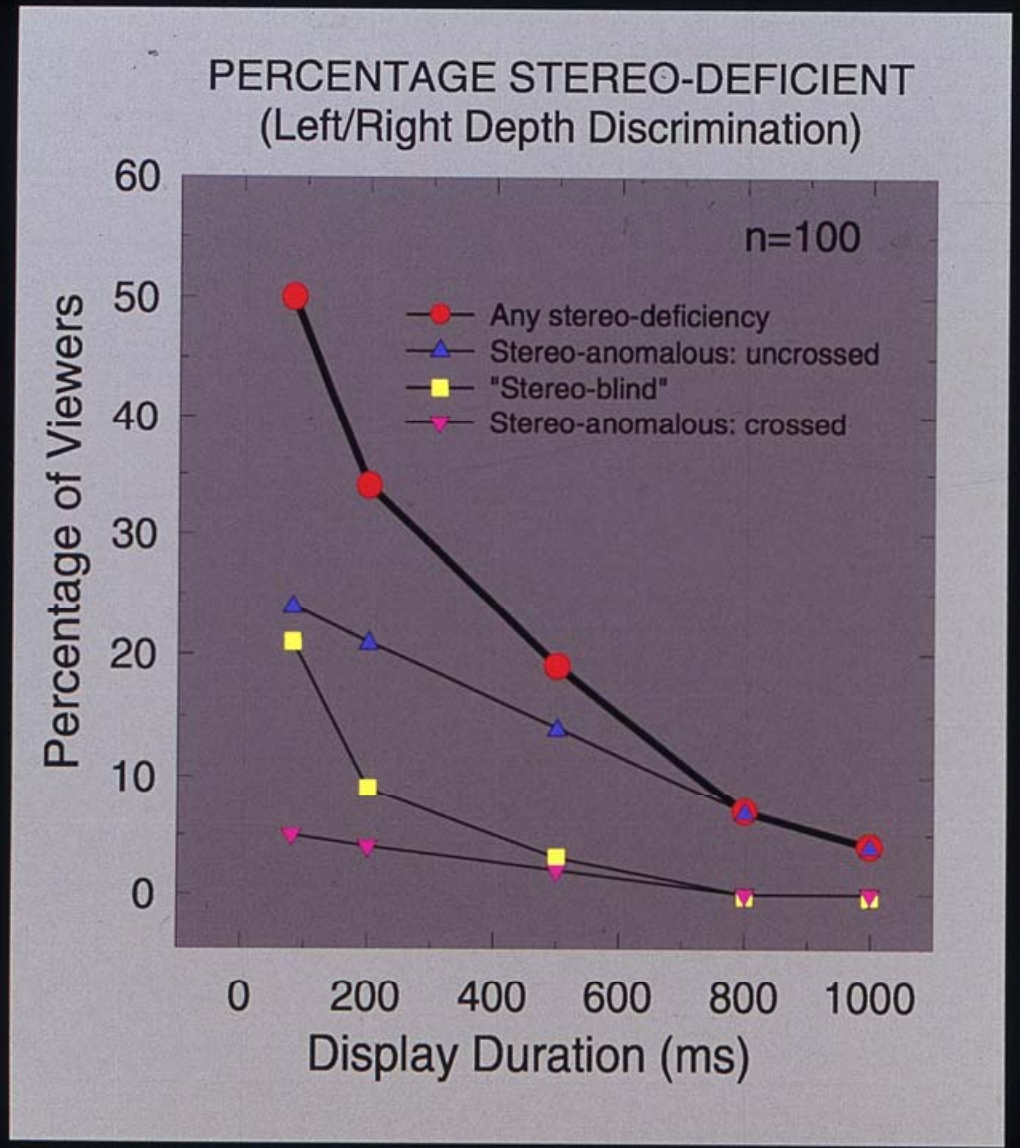
Duration varied
20 – 1000 msec

100 viewers
8 Estimates each

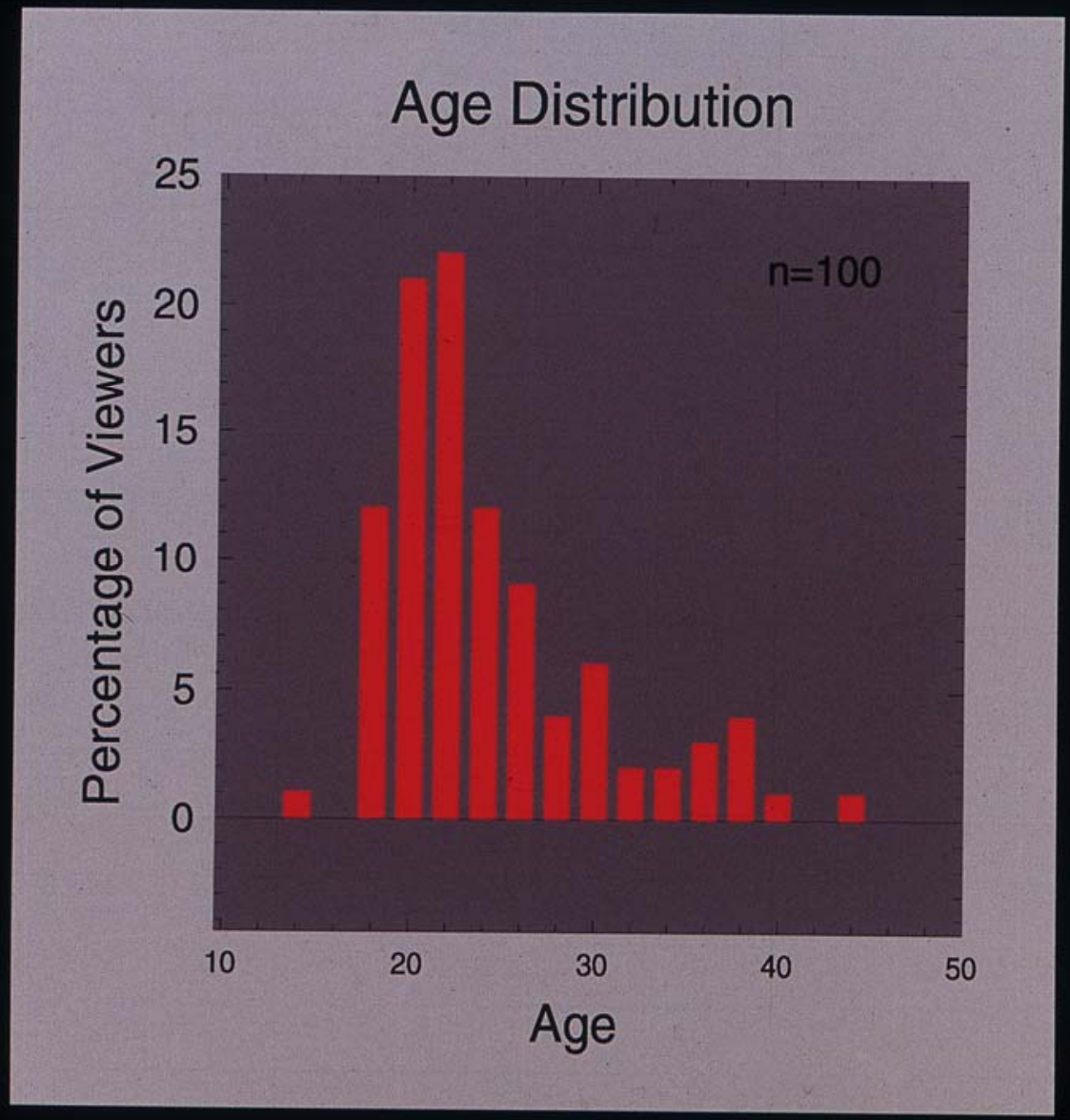
Results

Prevalence of stereo-deficiency assessed using two different tasks

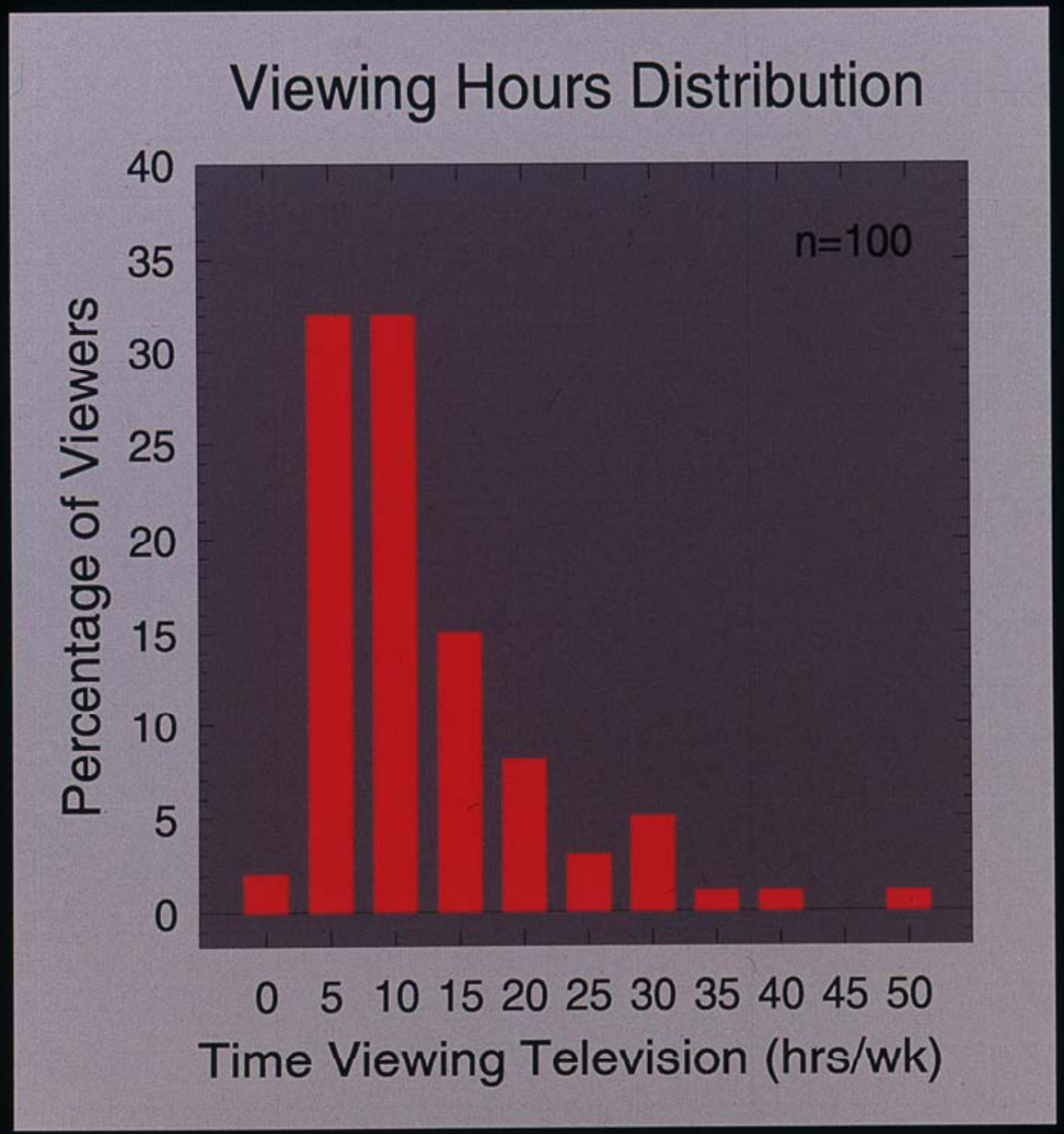




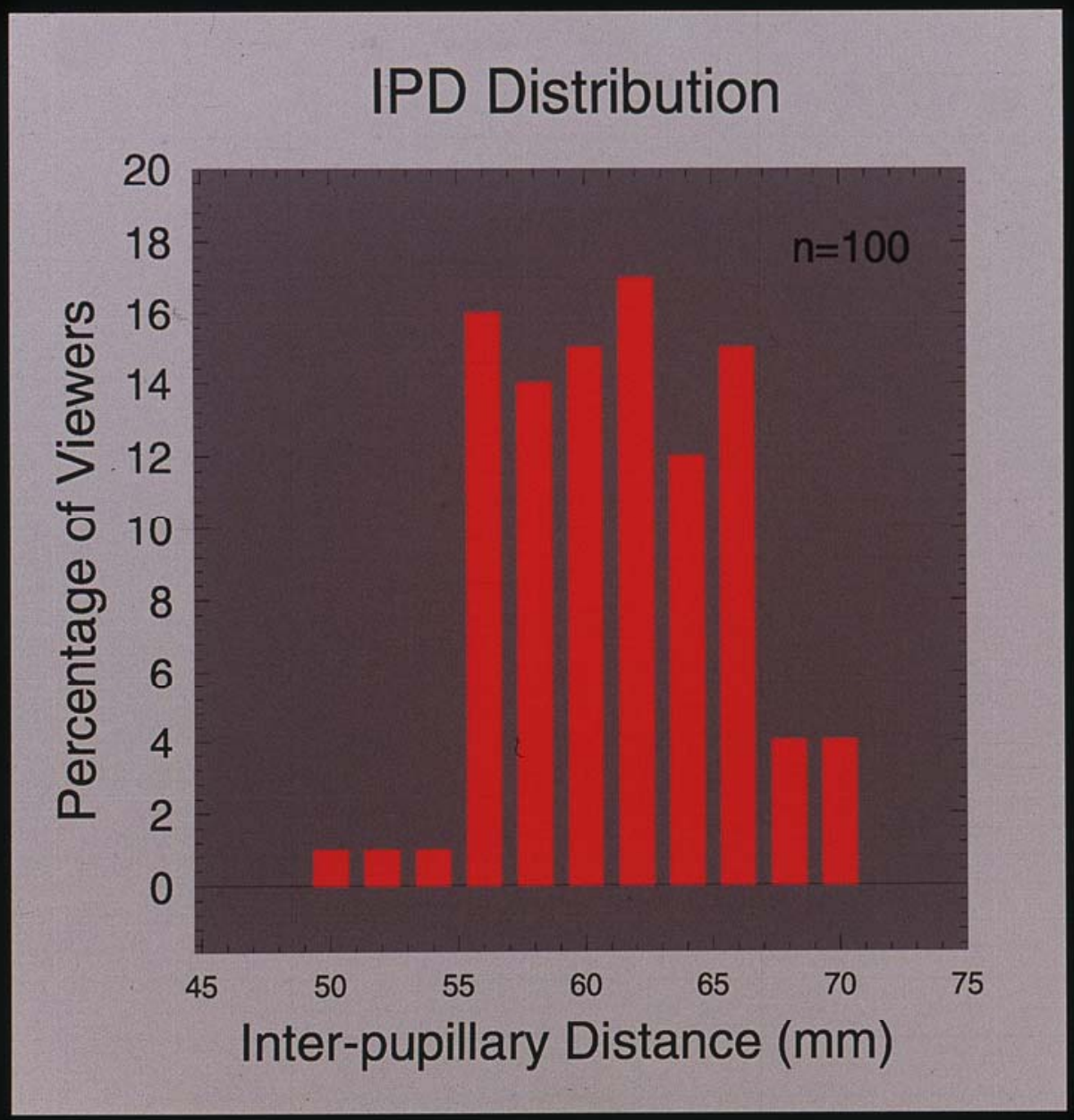
Results breakdown


Age Distribution
n=100
Percentage of Viewers
25
20
15
10
5
0
10
20
30
40
50
Age

Age



Hours watching TV

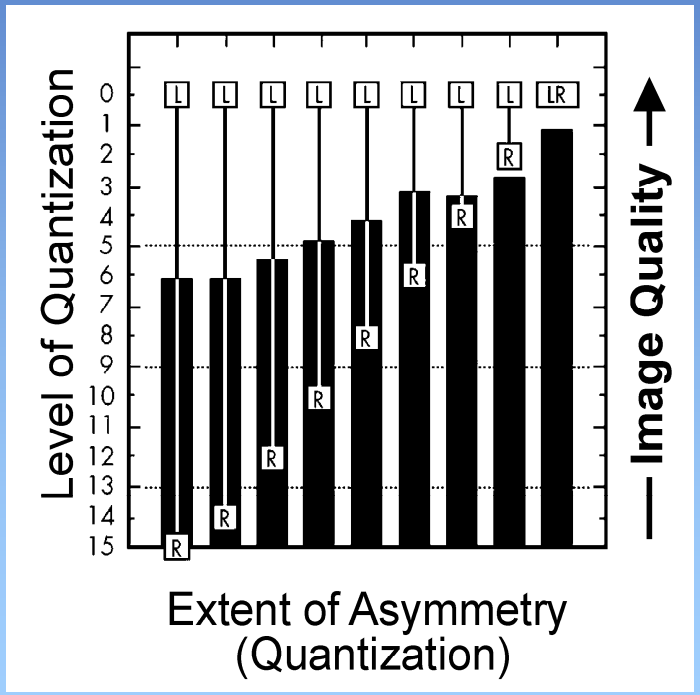


Inter-pupillary separation

Conclusion

Individuals vary along a continuum in their ability to process stereoscopic depth information

Inter-ocular Averaging

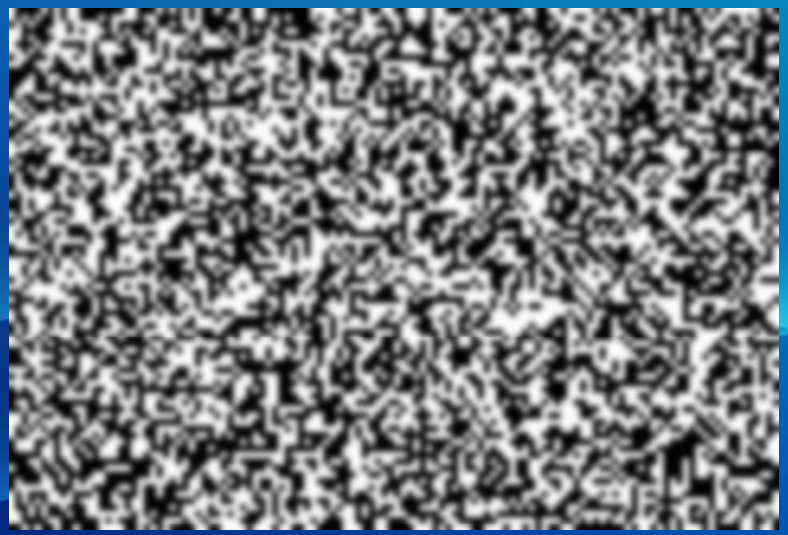


How can bandwidth be reduced?

3D-TV

Interocular masking of blur in one eye

Julesz ’71



3D-TV

Asymmetrical Quality

Subjective evaluation of Image Quality

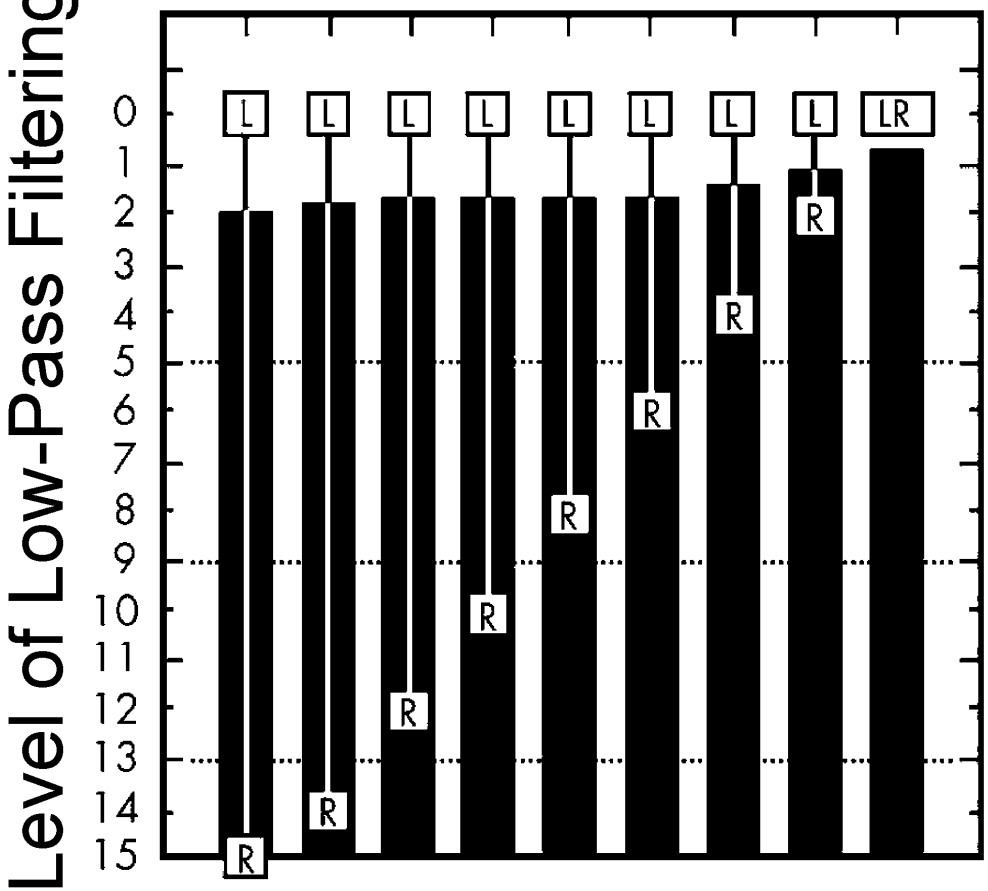
For different extents of asymmetry in image quality

Continuous Quality Scale

Subjective Assessment

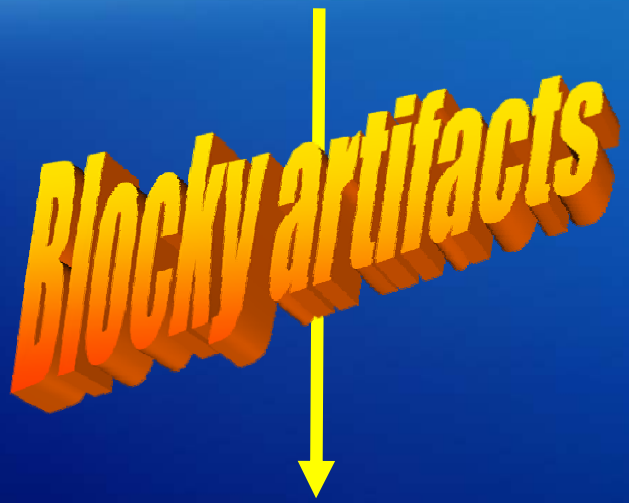
Original

Severe

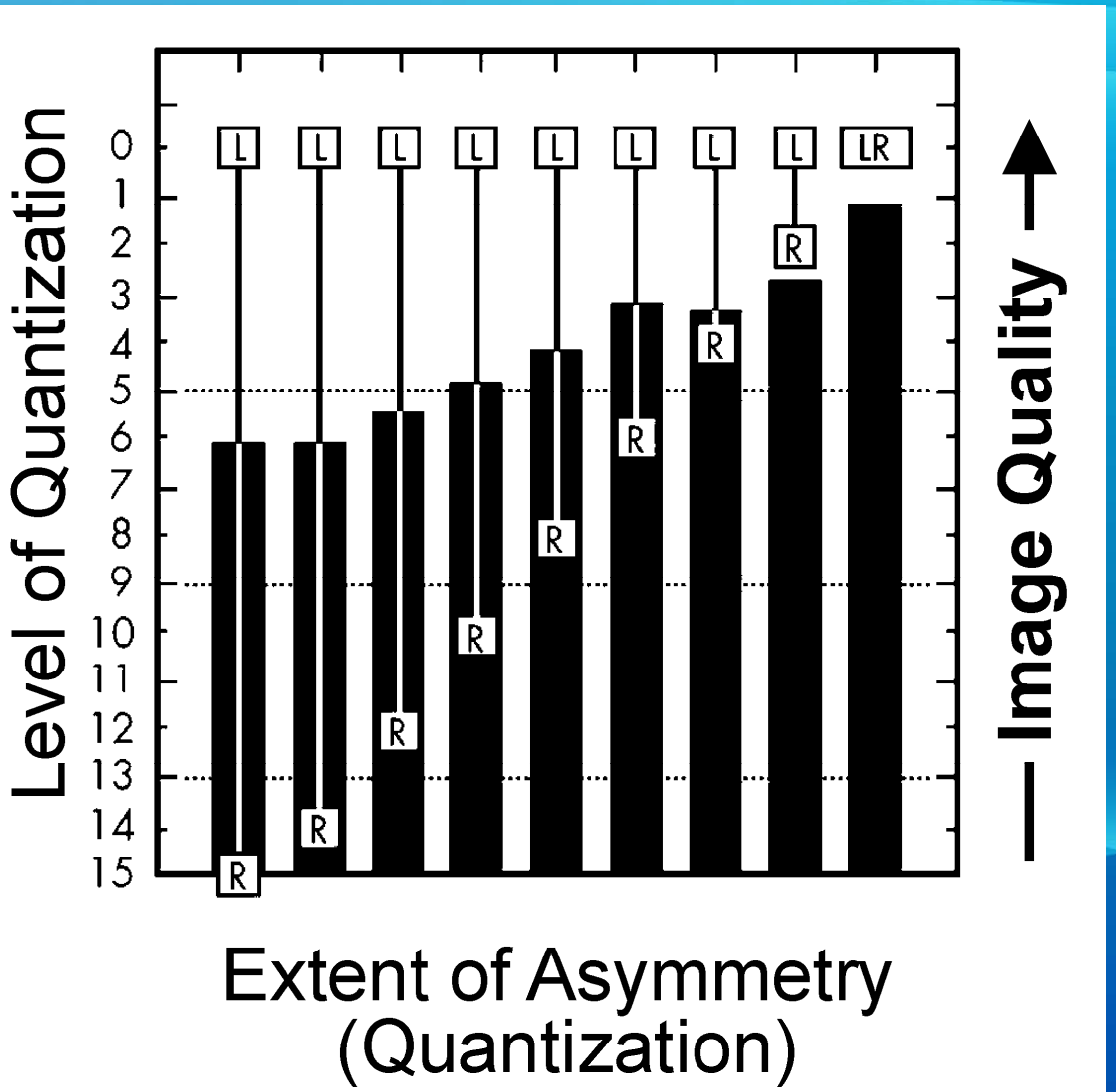


Subjective Assessment

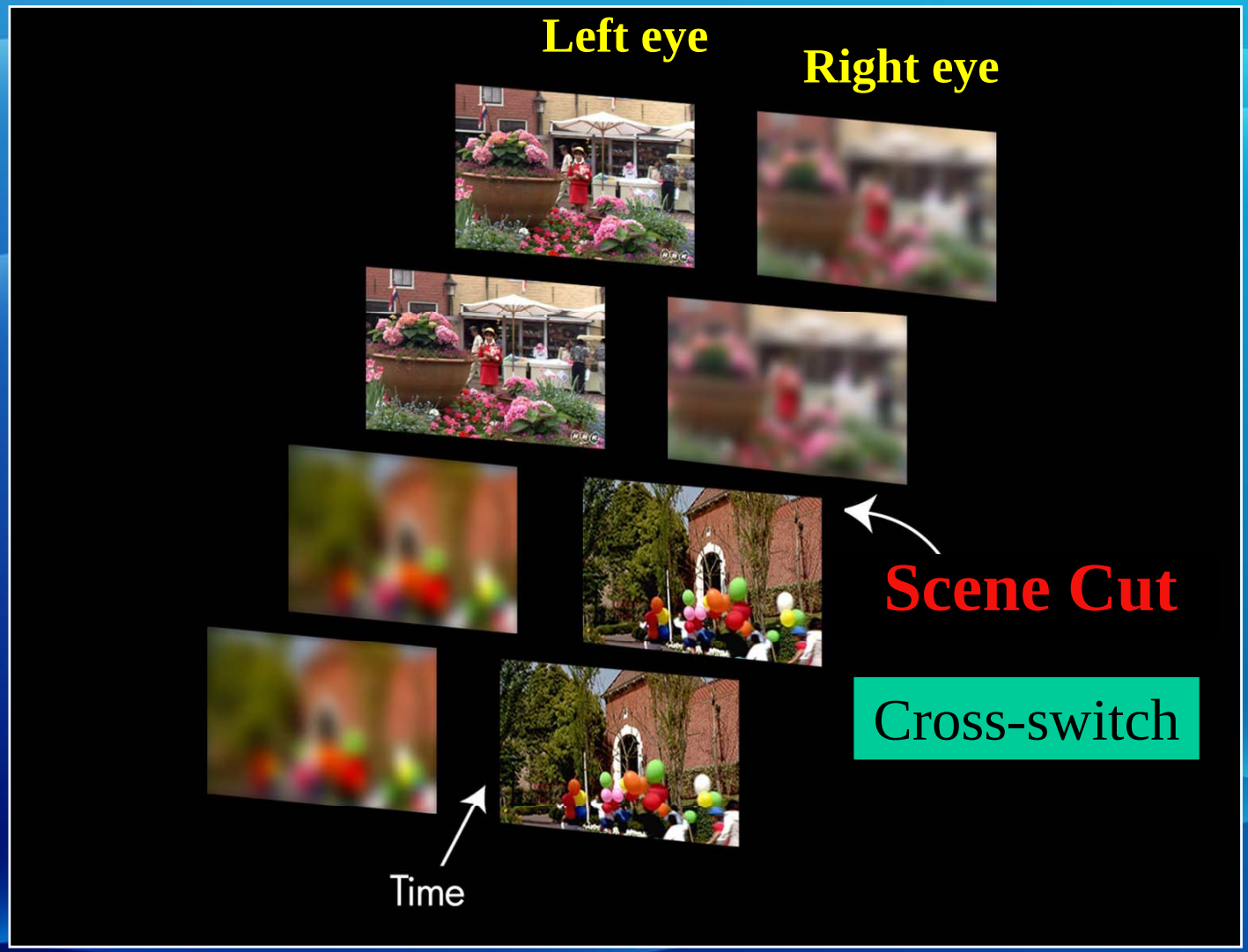
Original



Coarse



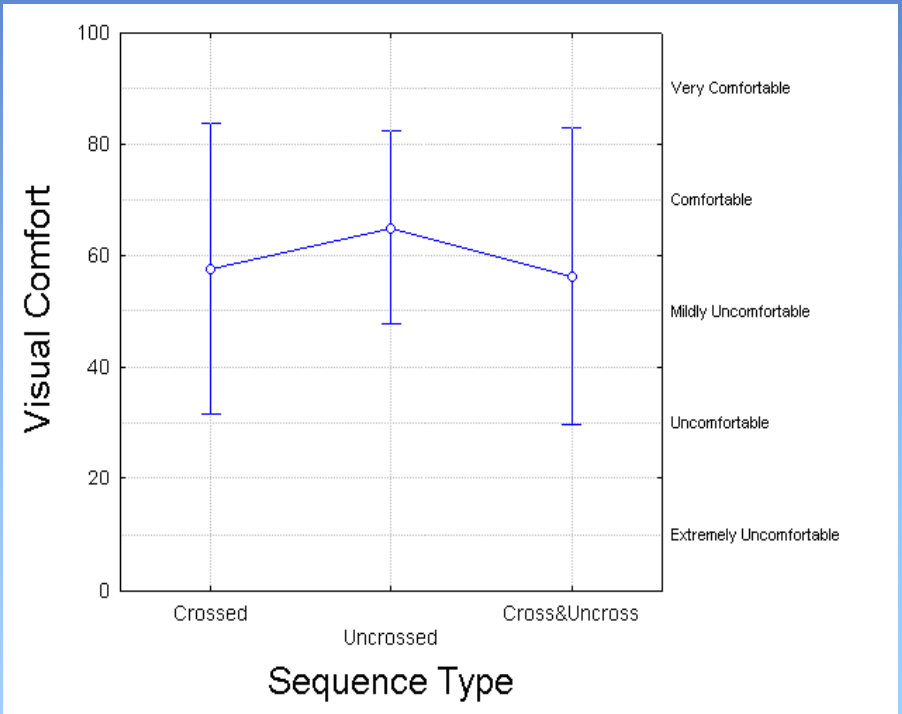
3D-TV


Left eye
Right eye
Scene Cut
Cross-switch
Time

Conclusion

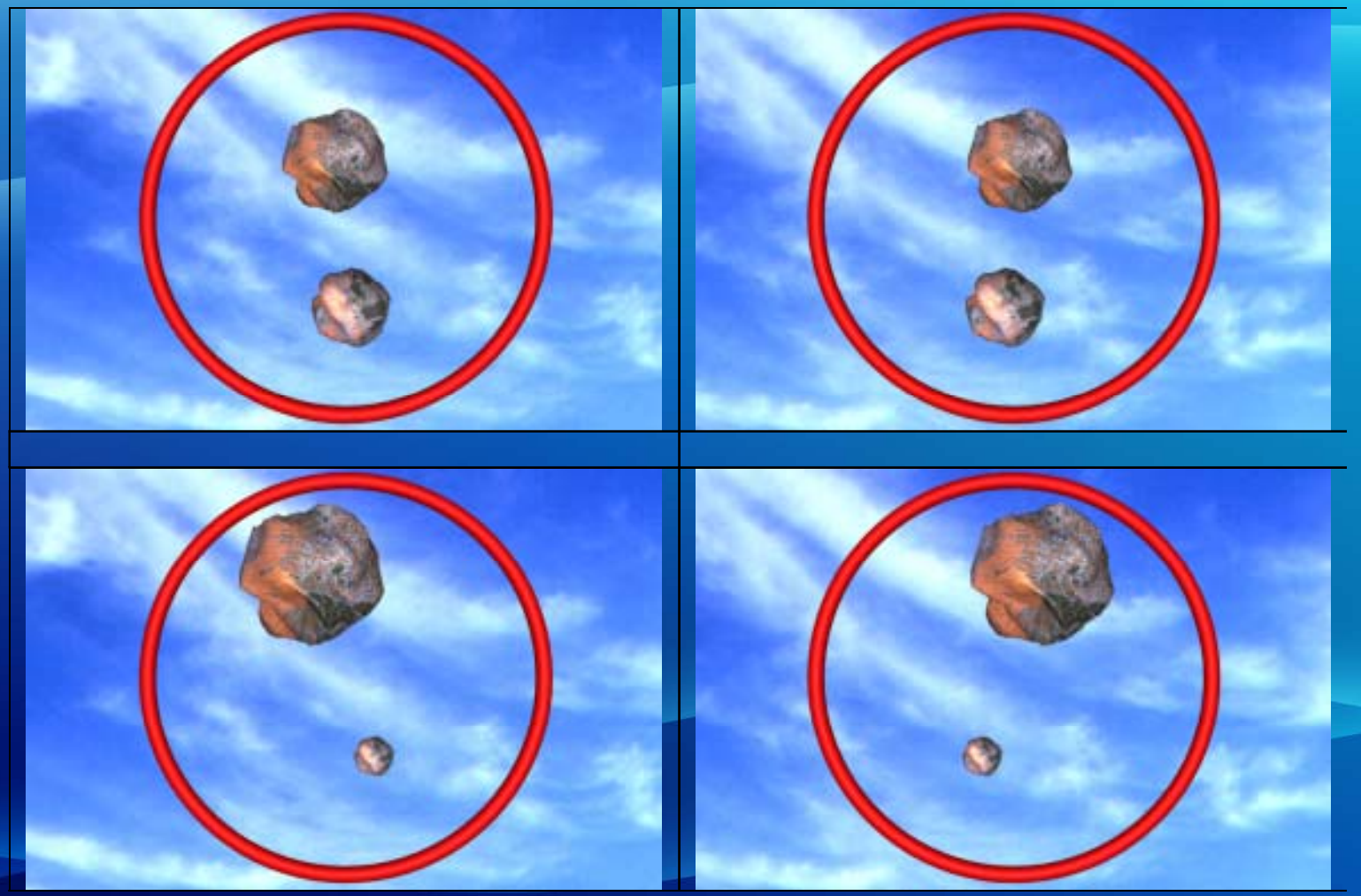
Asymmetrical coding with cross-switching at scene cuts is a viable method for bandwidth savings

Motion & Visual Comfort

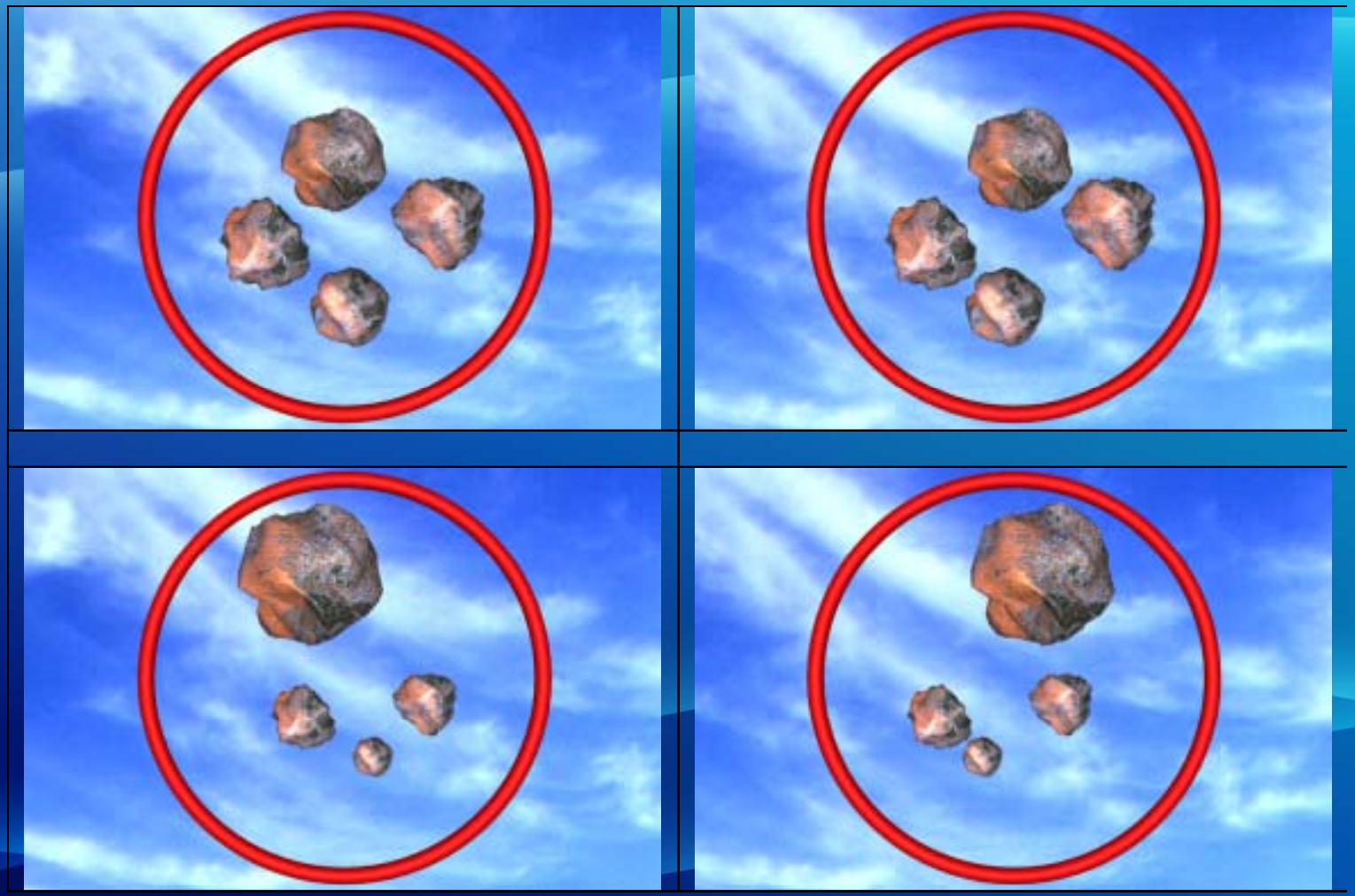


How might visual comfort be affected by stereoscopic objects in motion?

Motion in Depth

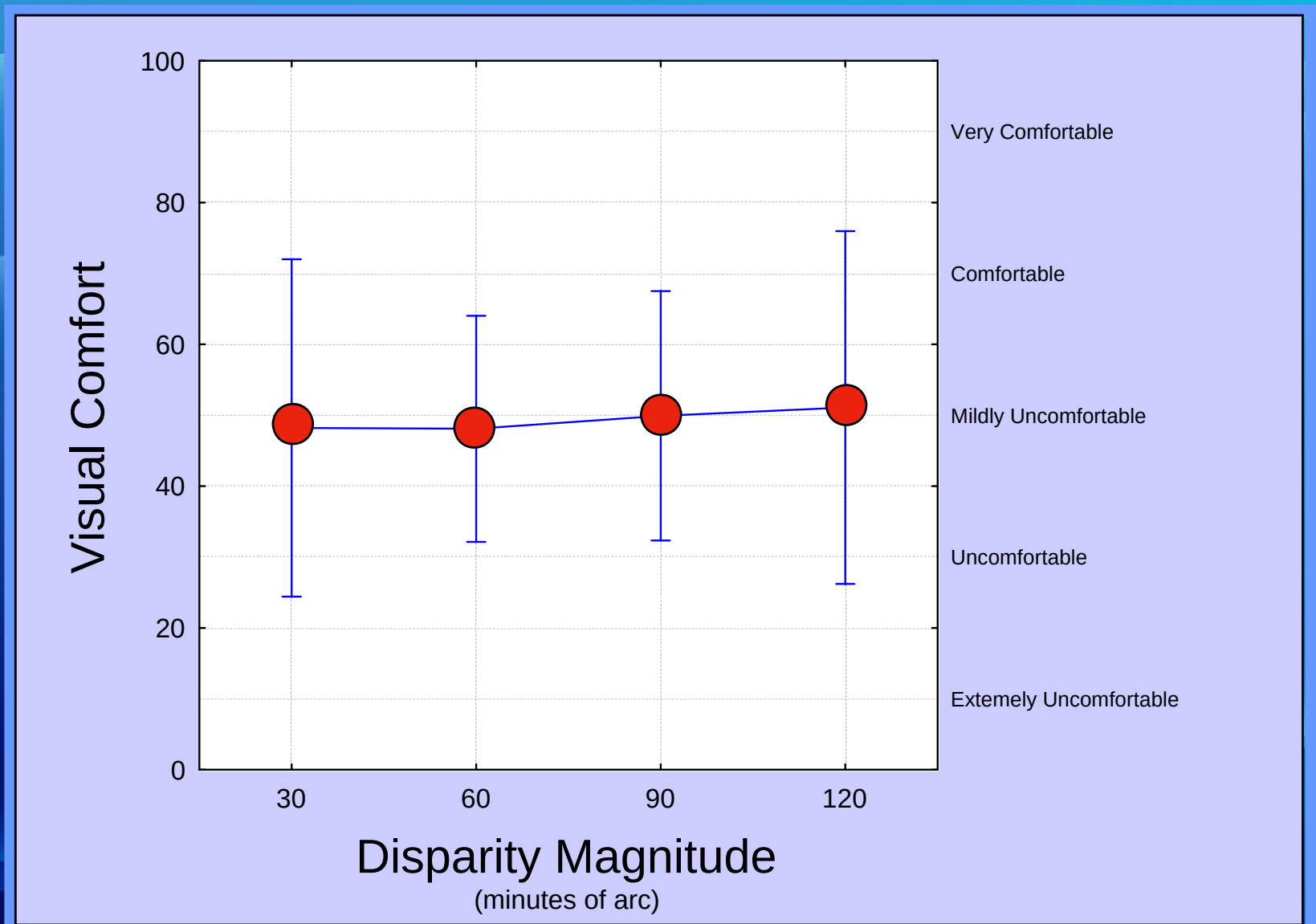


Display



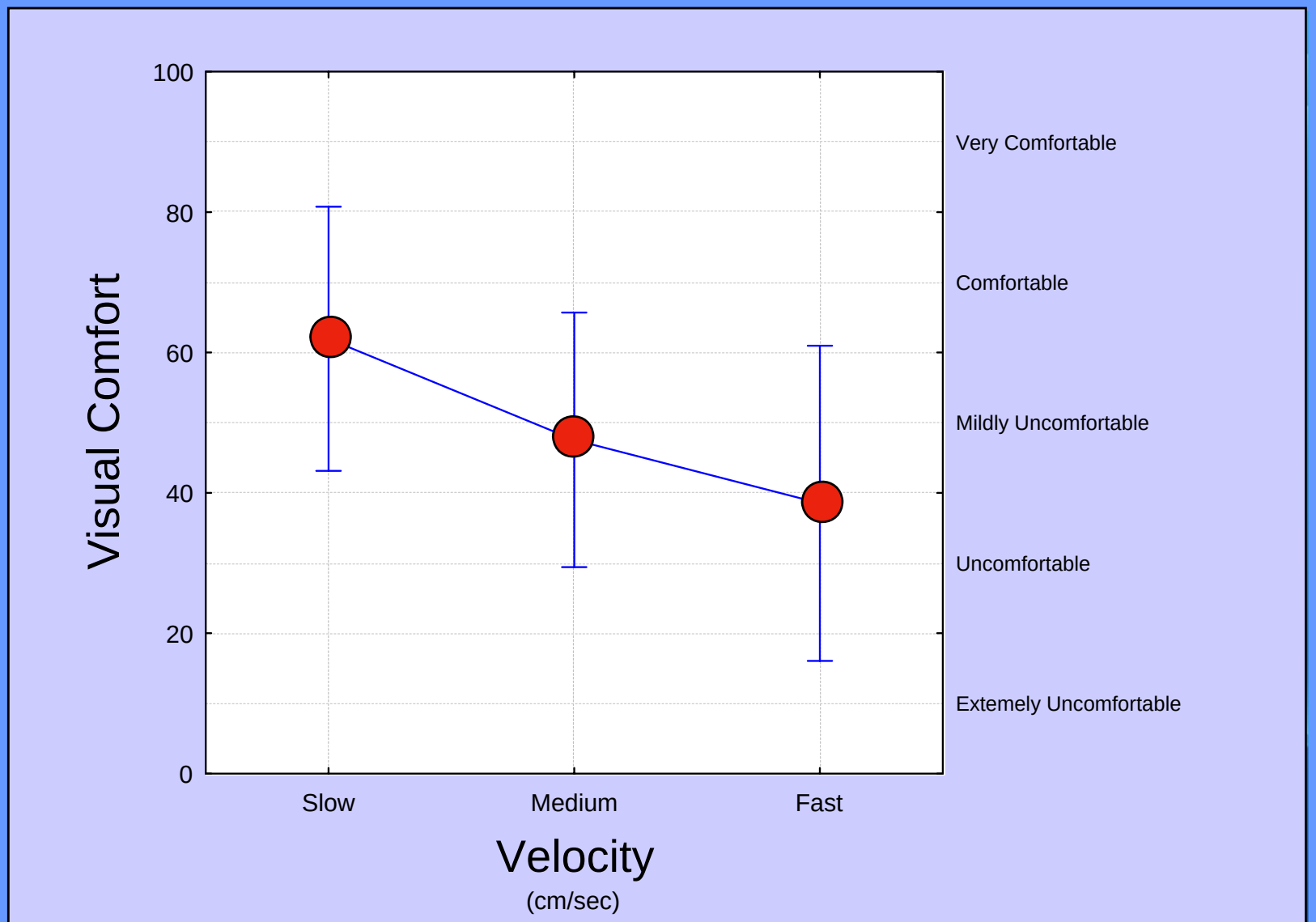
Visual Comfort

21 Viewers

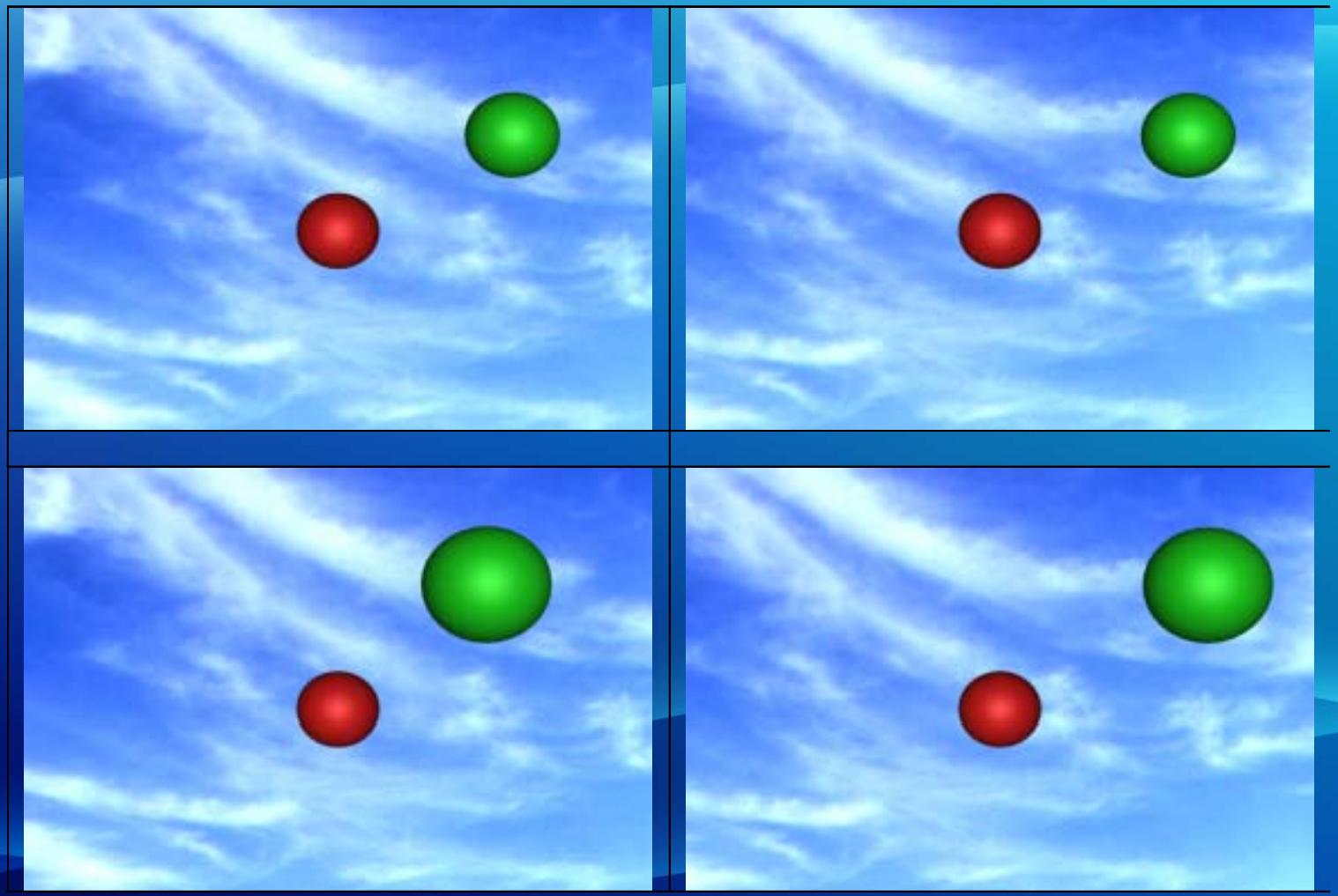


Visual Comfort

21 Viewers

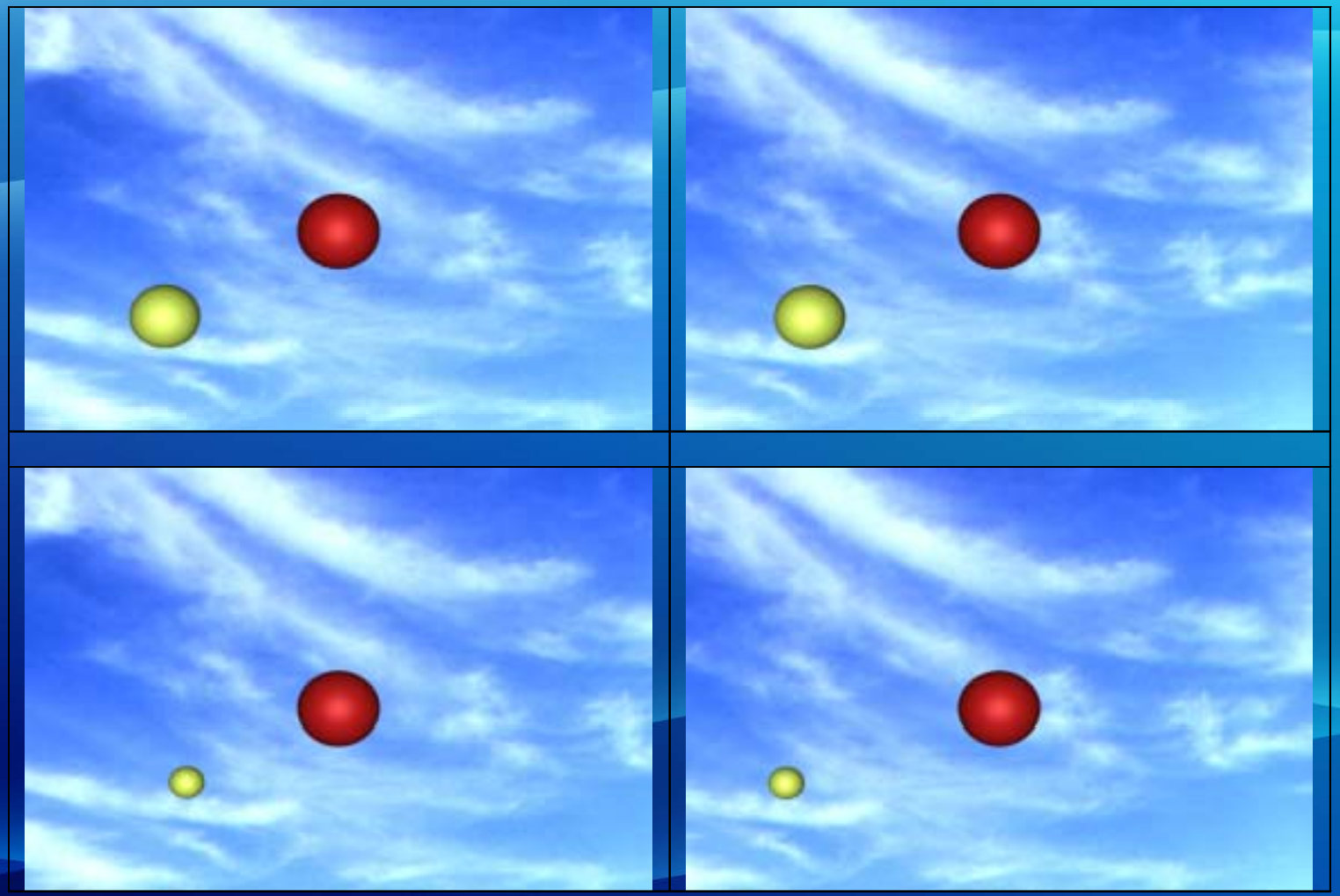


Horizontal Motion



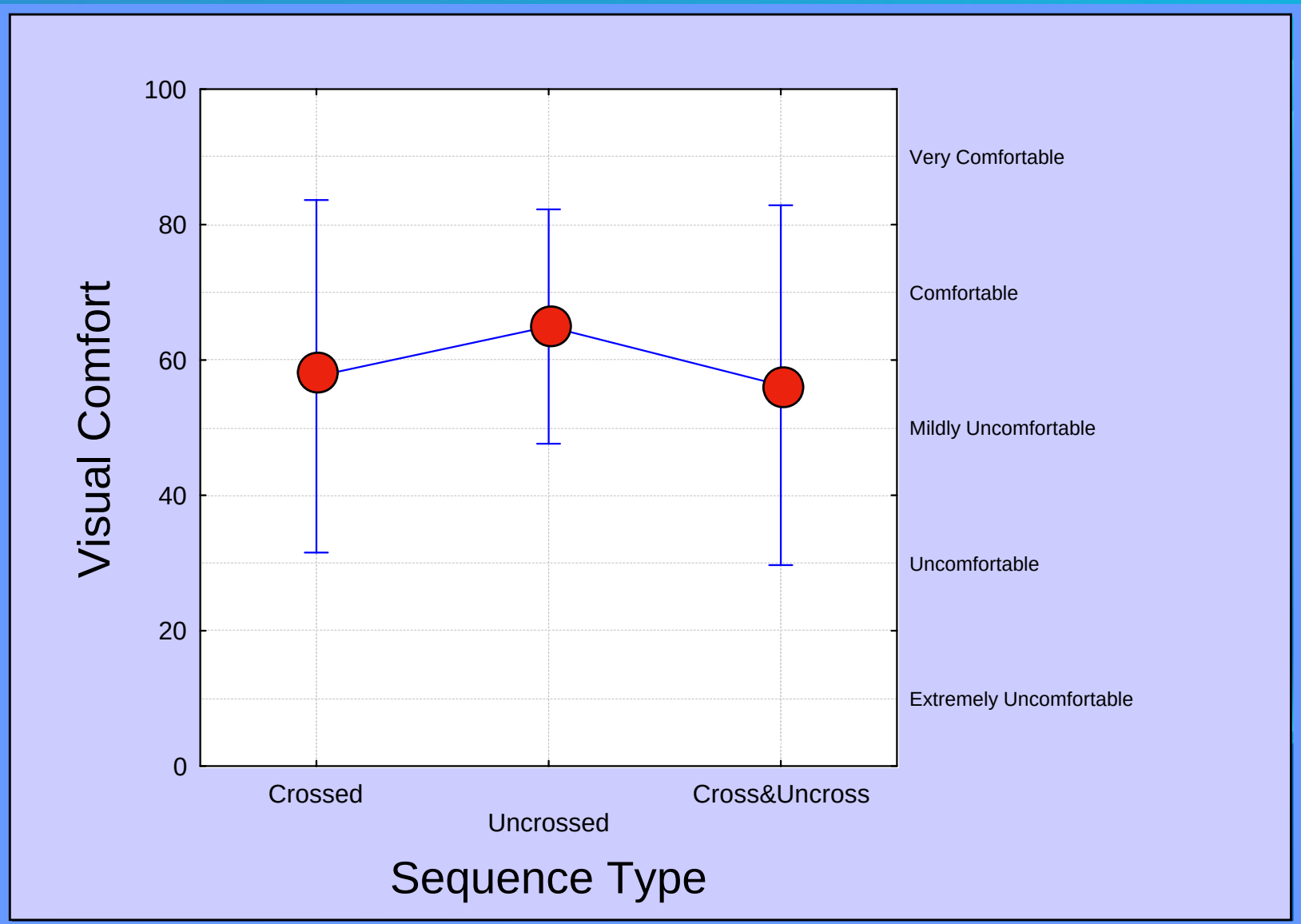
Crossed Disparity

Display



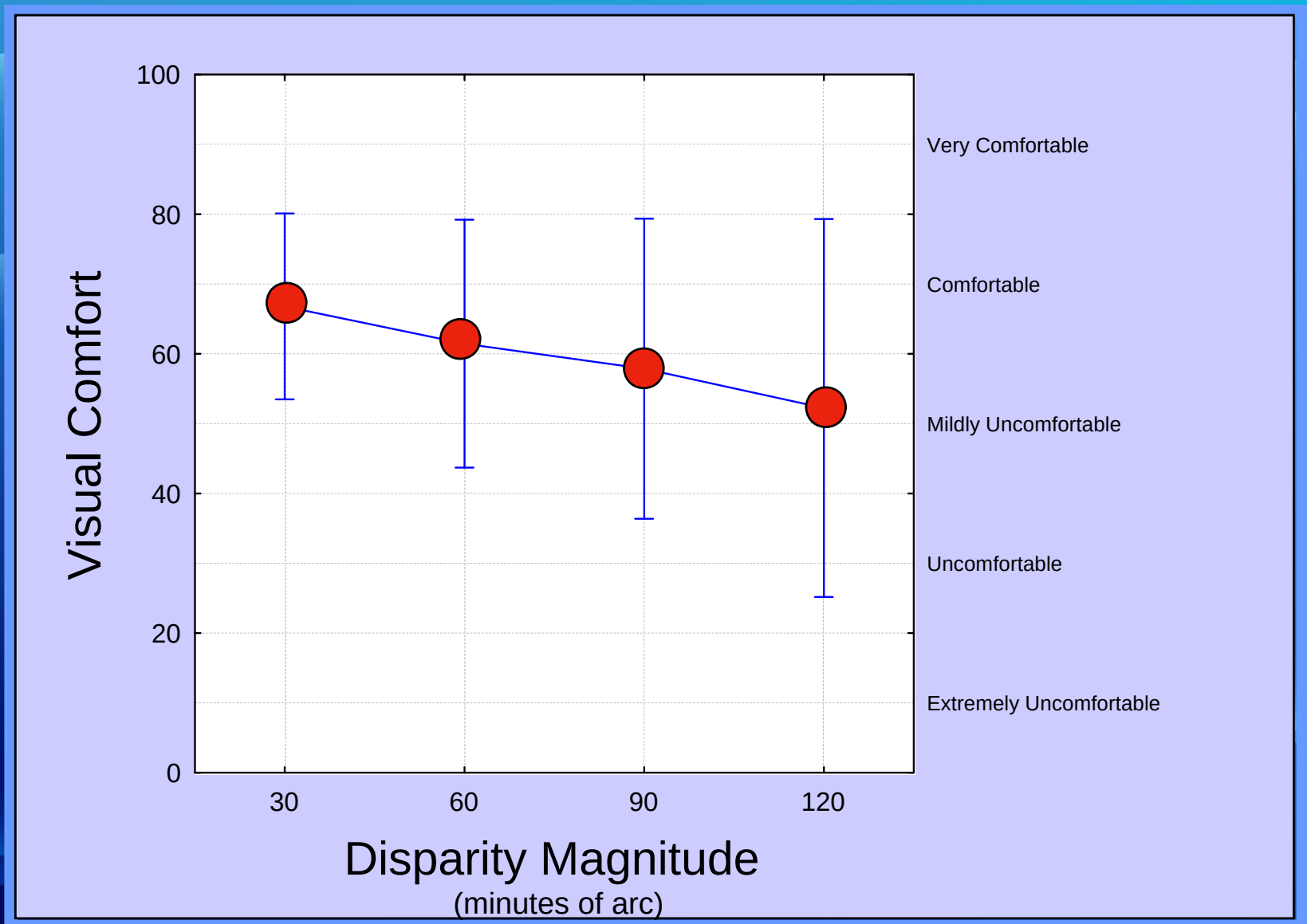
Uncrossed Disparity

Visual Comfort



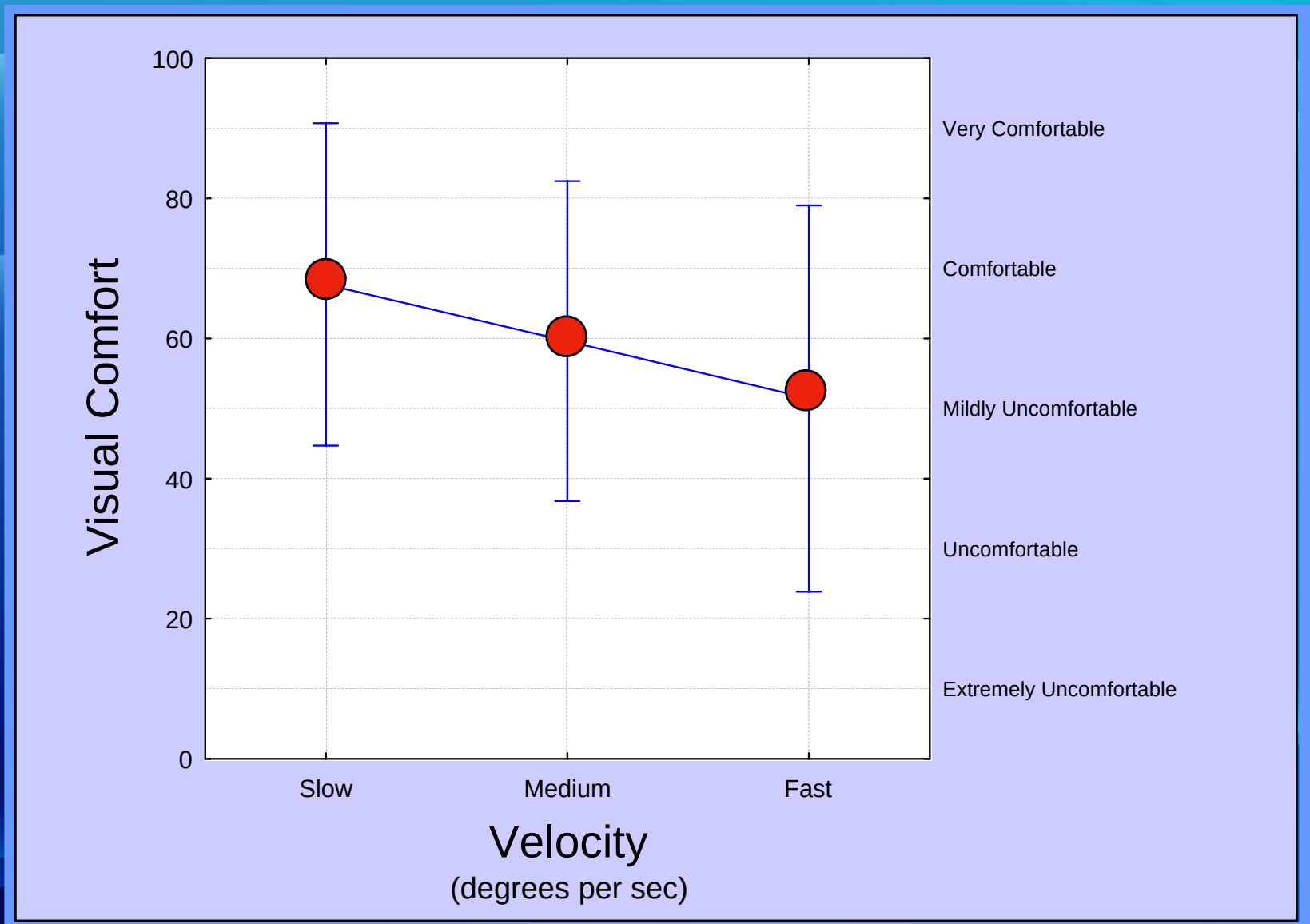
21 Viewers

Visual Comfort



21 Viewers

Visual Comfort



21 Viewers

Conclusion

Aside from disparity, object motion can significantly influence visual discomfort

Surrogate Depth Maps

How to create 3D contents from 2D?

2D-to-3D

Conversion Technique

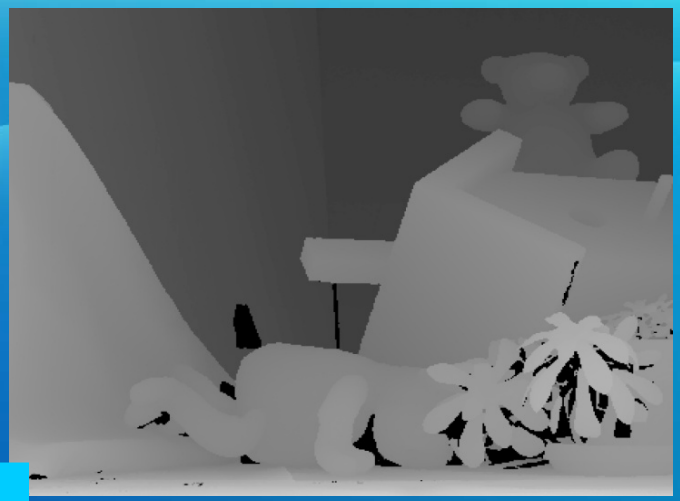
Object segmentation and horizontal shifting

2D-to-3D

Another Approach

Depth Maps

2D + Depth



Multiple views for autostereoscopic displays

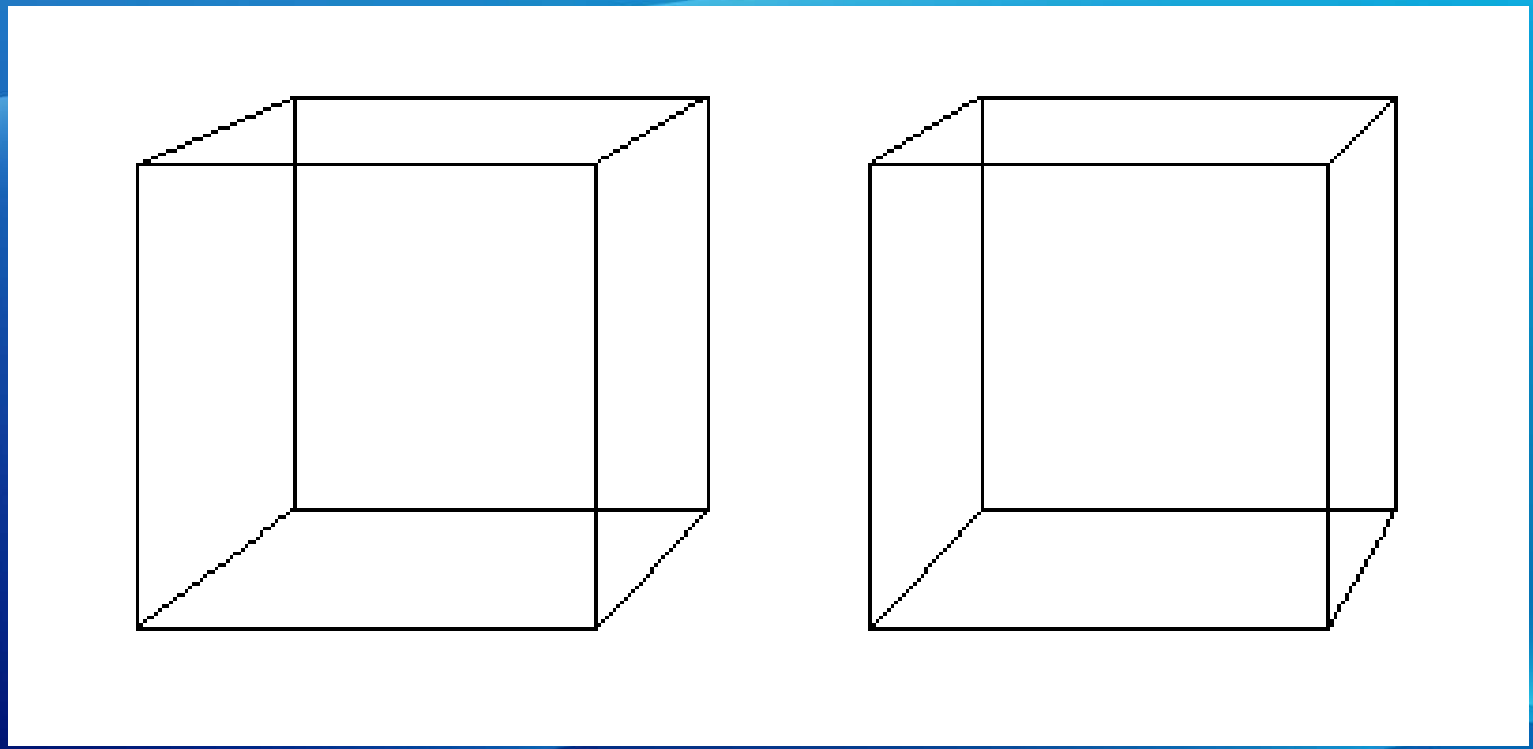
Advantages

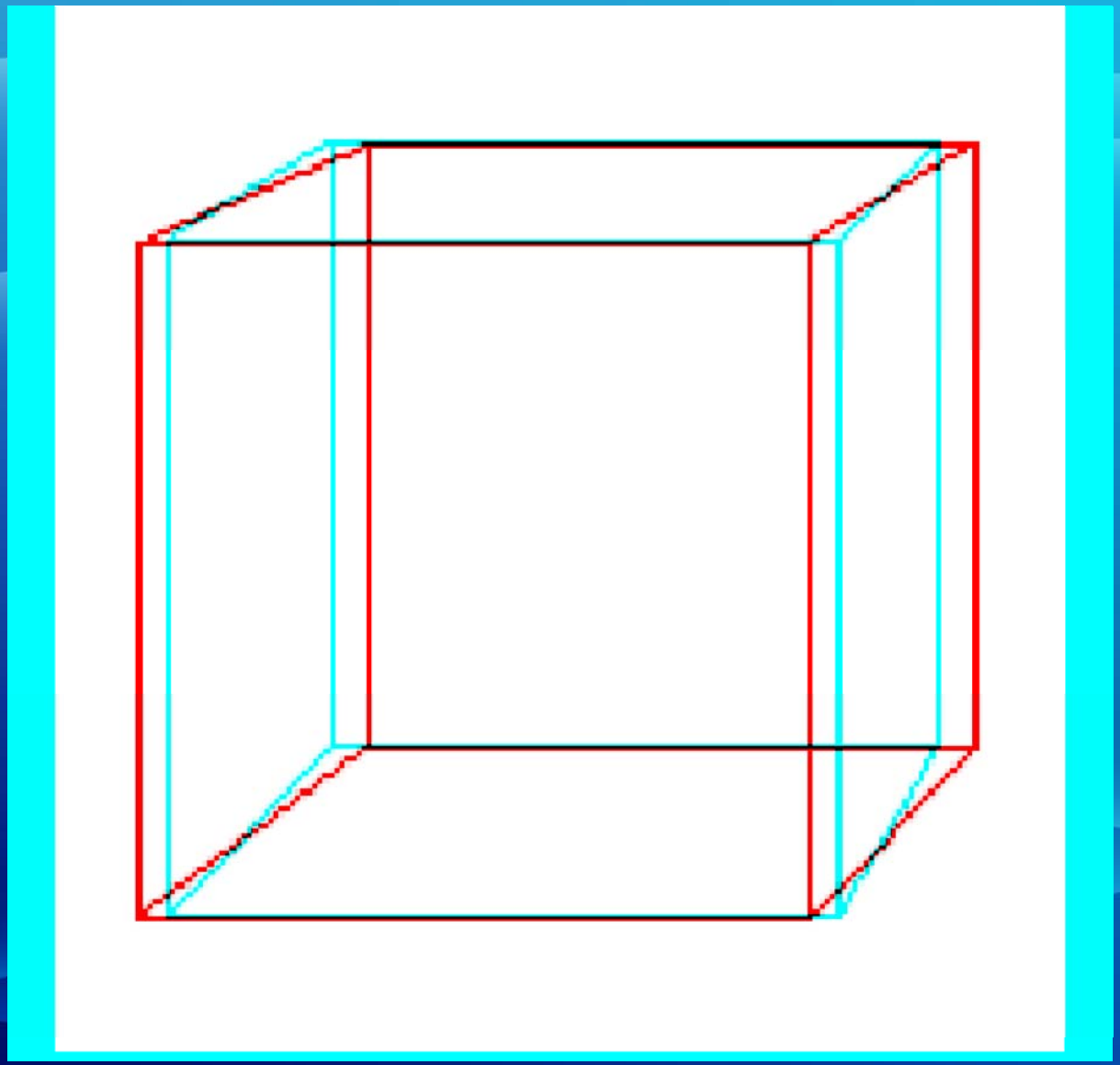
bandwidth-efficient, multiple images & viewpoints

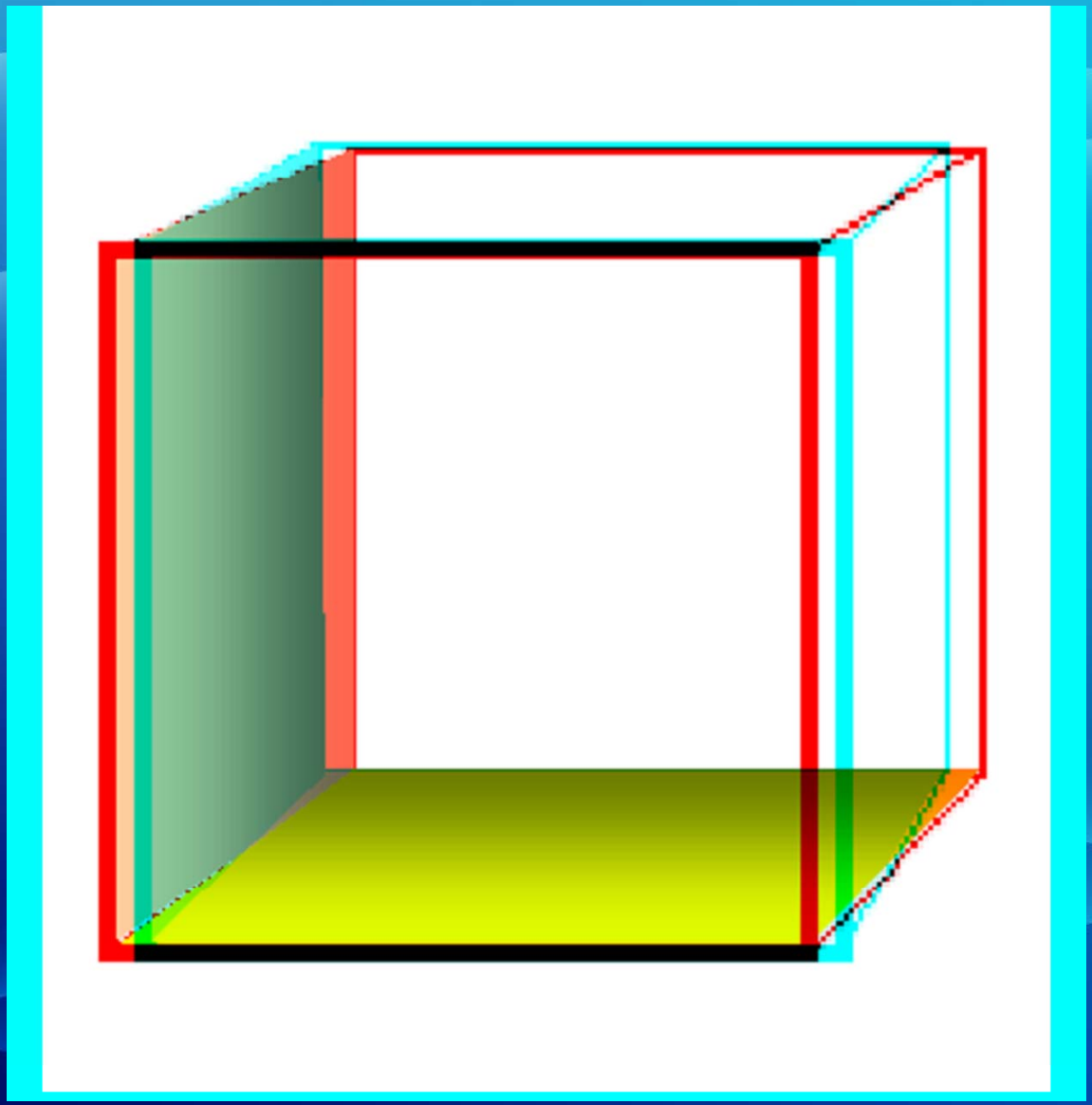
Create Depth Maps using information from 2D source images

Make use of human visual perception for 2D-to-3D conversion

Depth Filling/Interpolation







Depth Surface Perception

The region surrounded by a disparate boundary tends to take up the same depth as its boundary

First Study

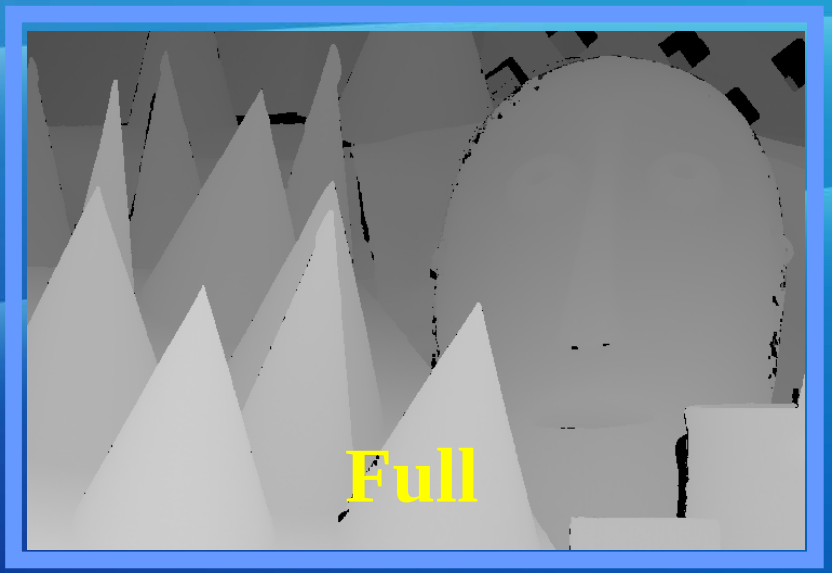
Sparse Depth Maps

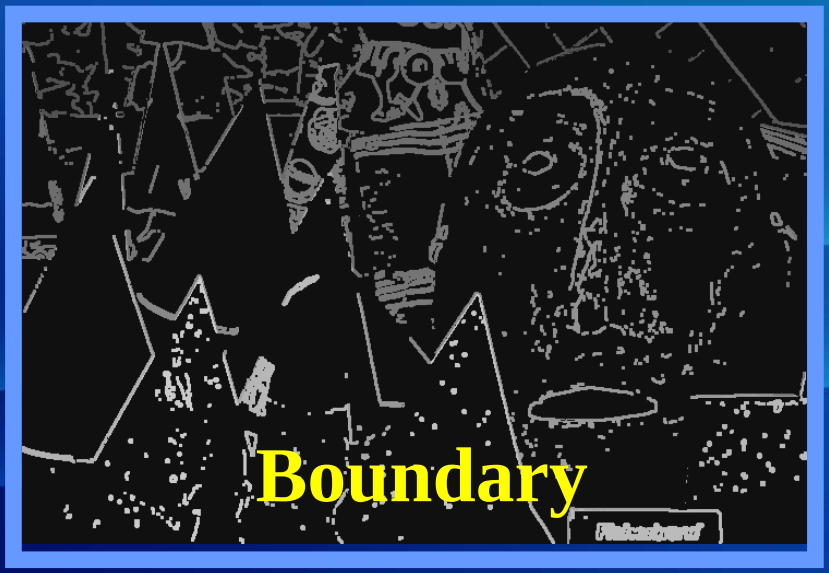
Communications Research Centre Canada

Cones

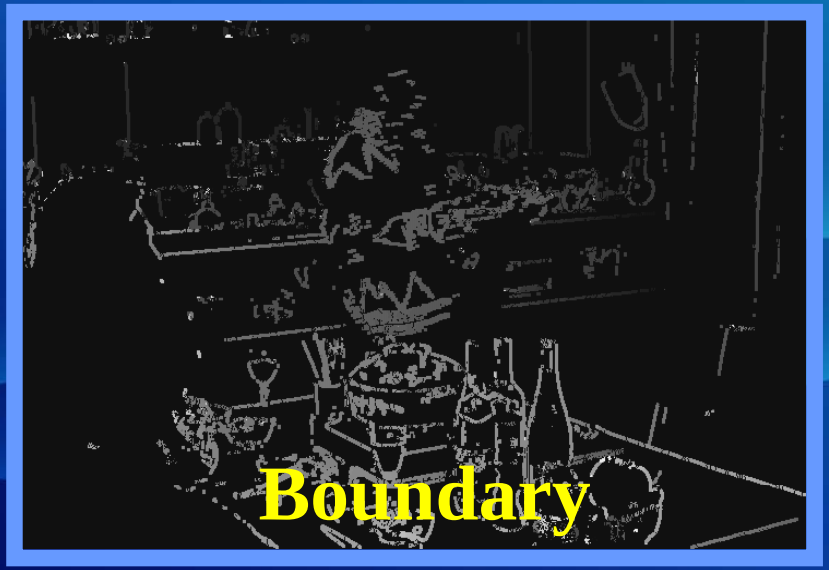
Meal

Cones





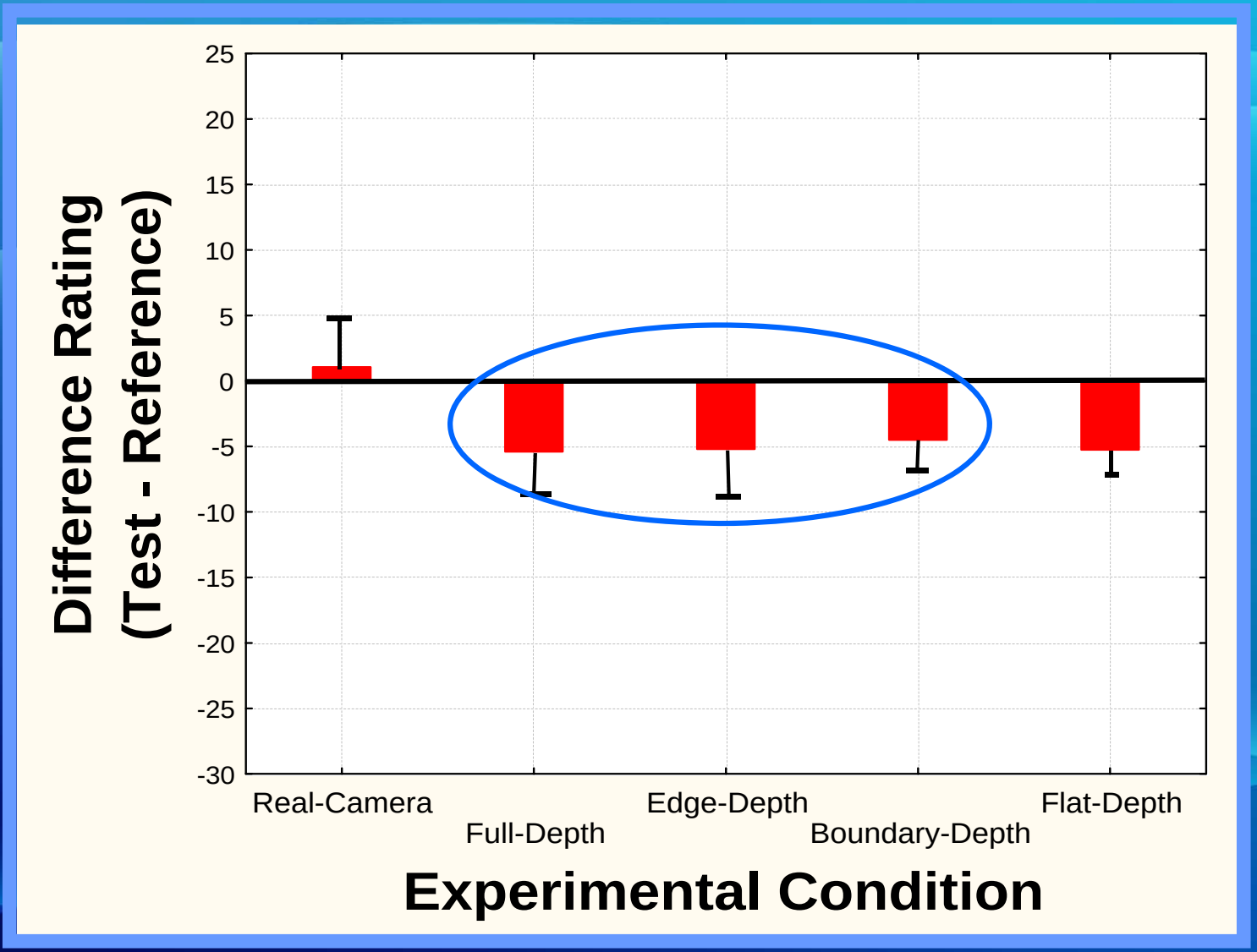
Meal



Double-stimulus Continuous Quality Scale

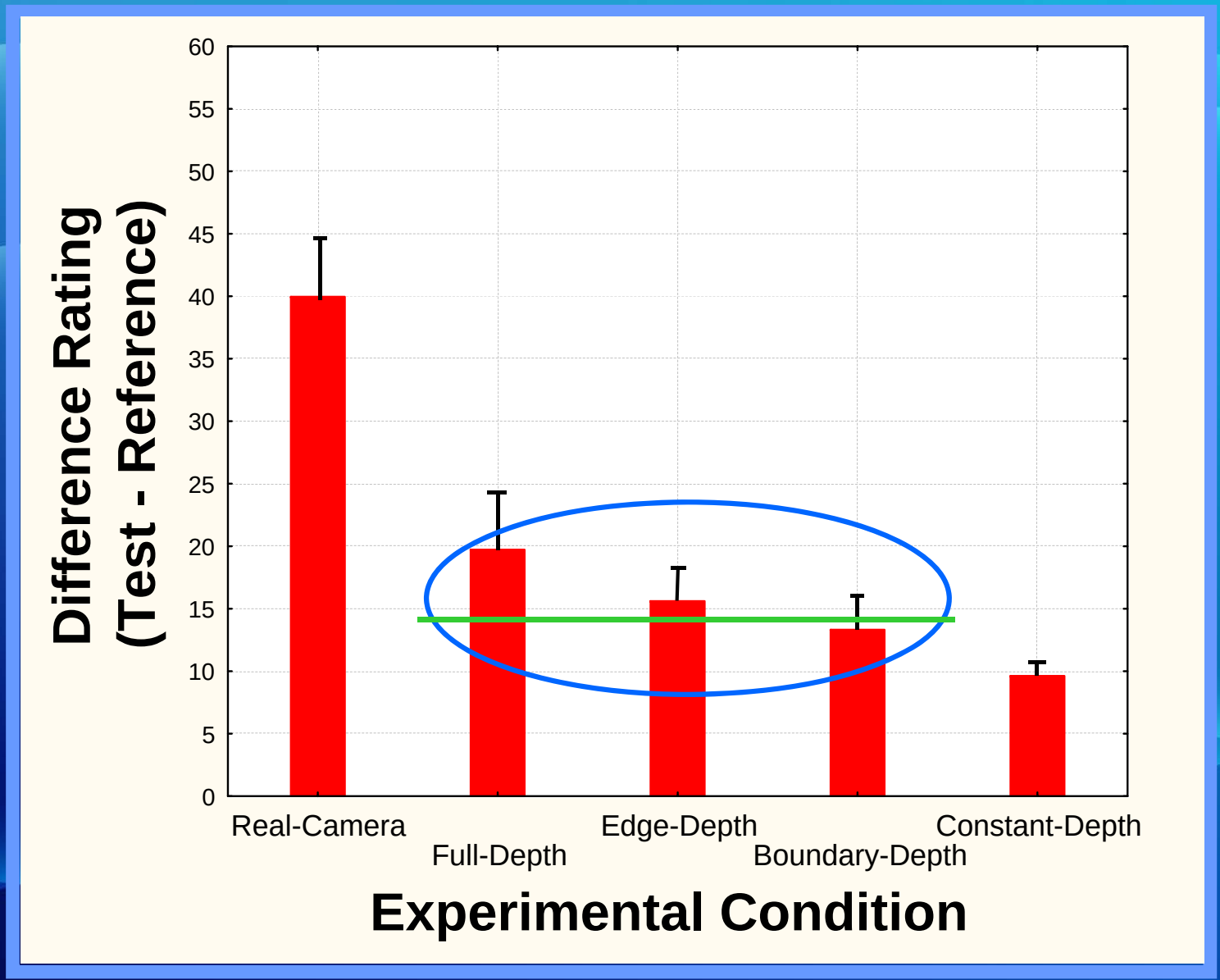
Image Quality

17 Viewers



Depth Quality

17 Viewers



Better

Surrogate Depth Maps

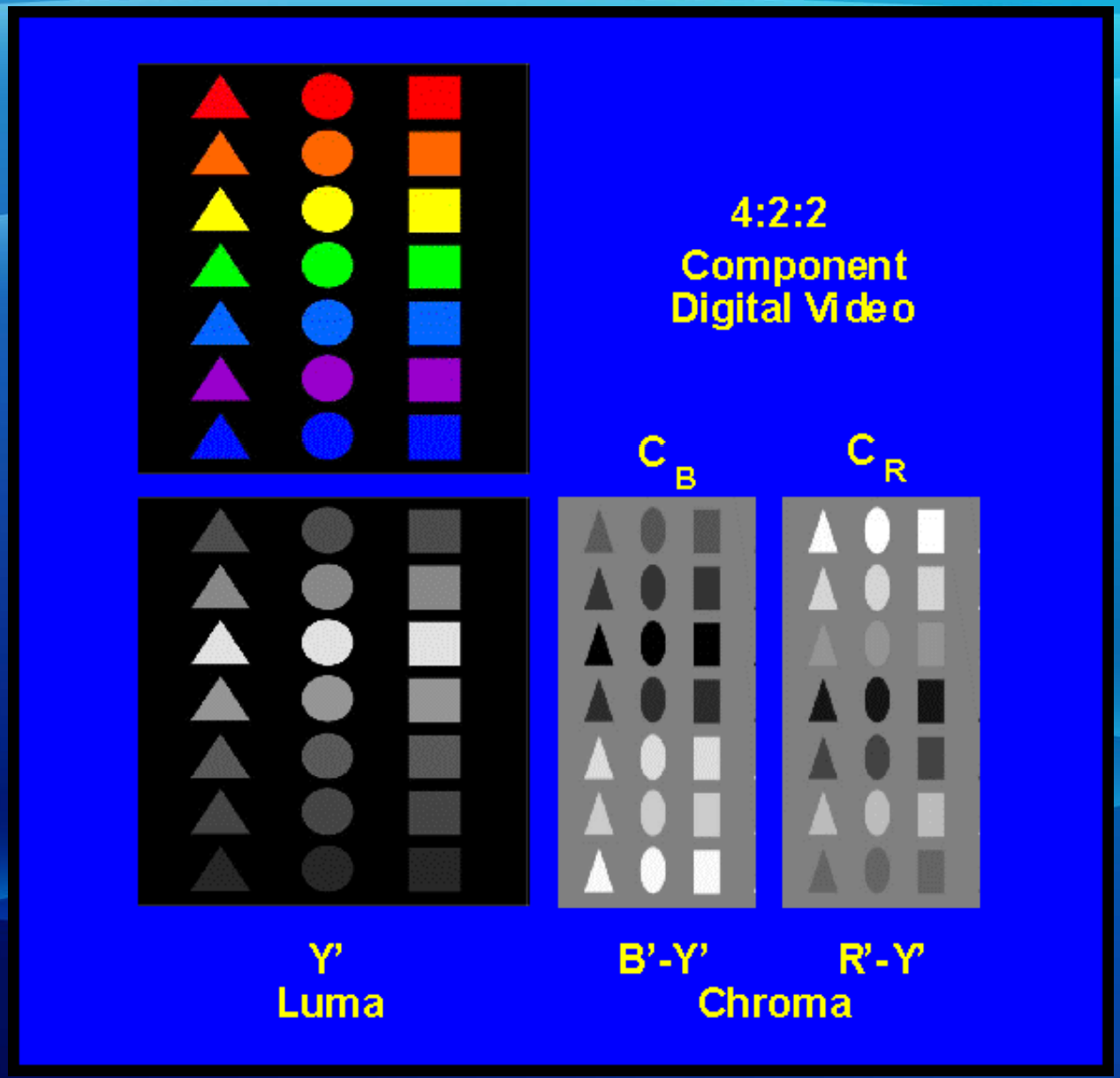
Clearly different but functionally equivalent in a critical way

Communications Research Centre Canada

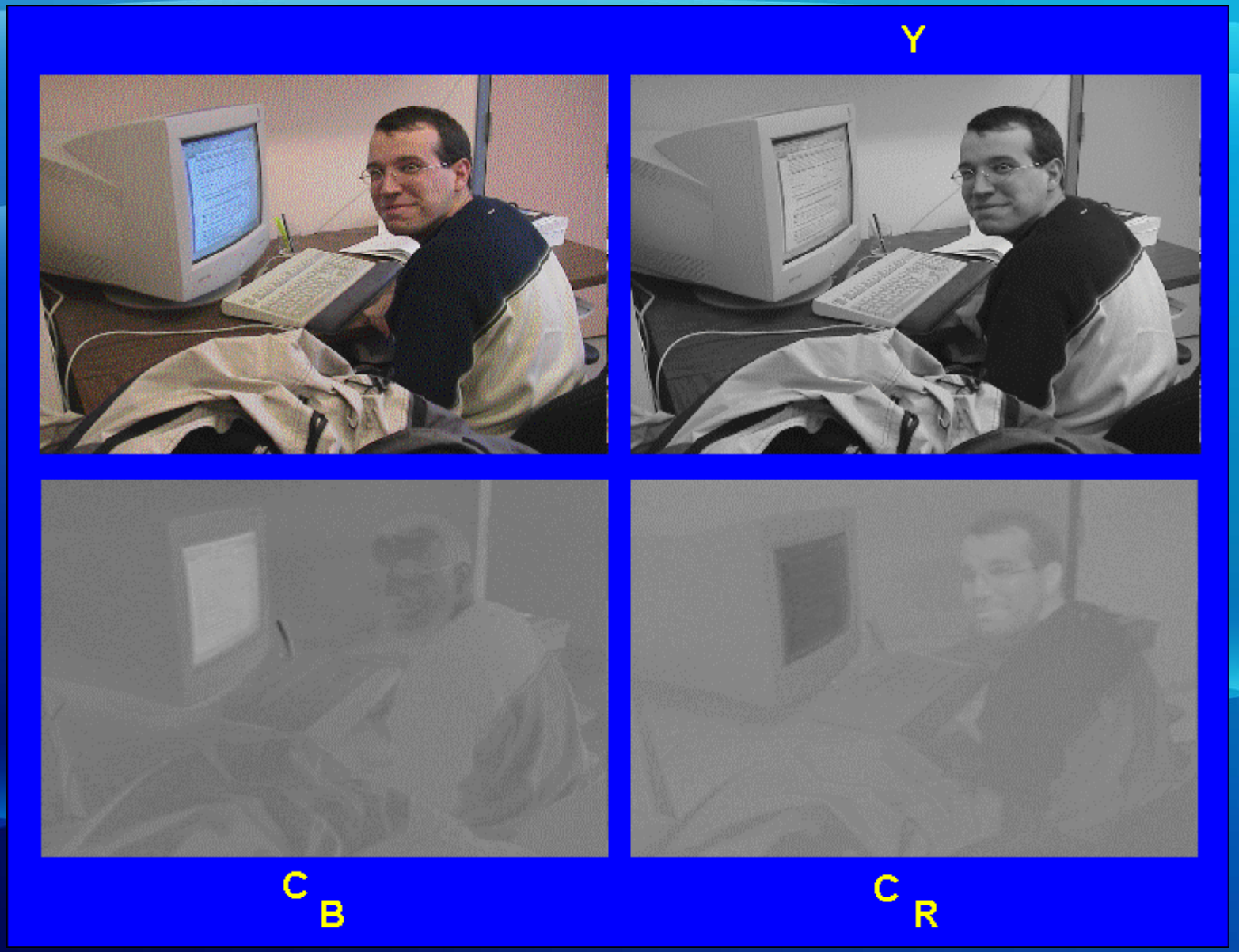
New Method

based on the gray level intensities of a colour component

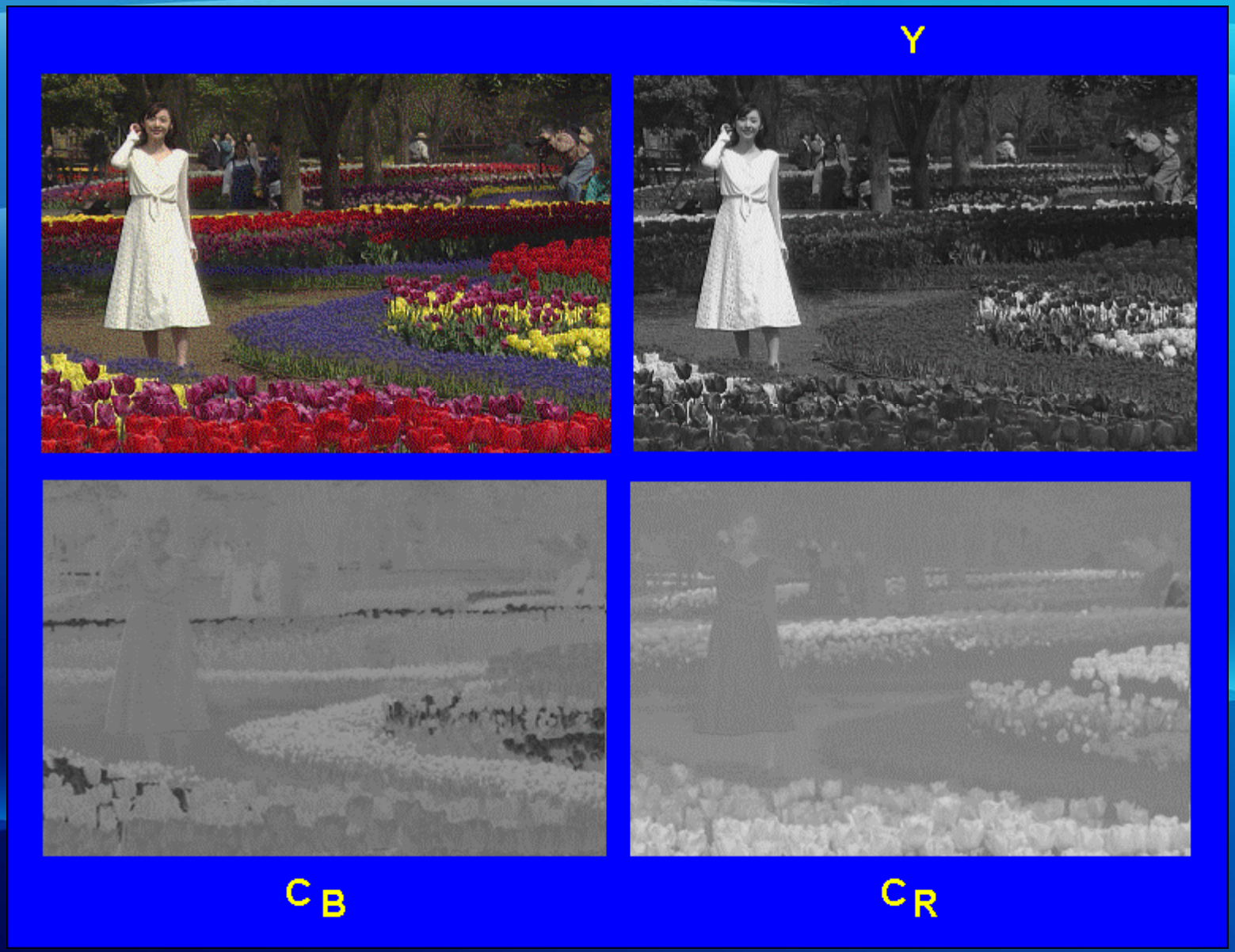
Components of Colour Image



Components of Colour Image



Components of Colour Image



Experimental Study

Surrogate Depth Maps

based on colour component

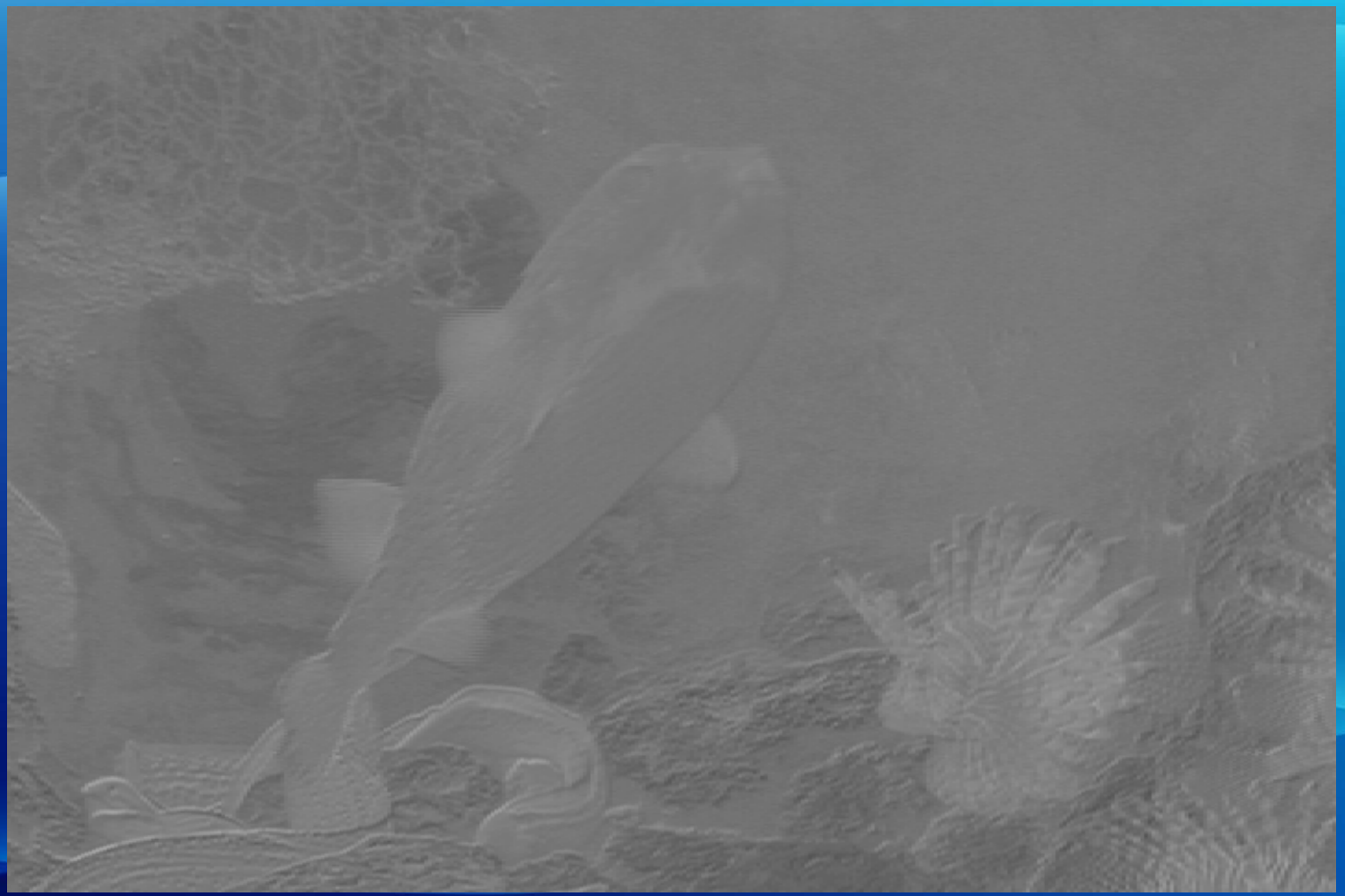
Communications Research Centre Canada

Test sequences

Ten eight-second video clips

ITU-601 format (720x480, 30fps)

Aquarium



Camera Test

Confetti

Crowd

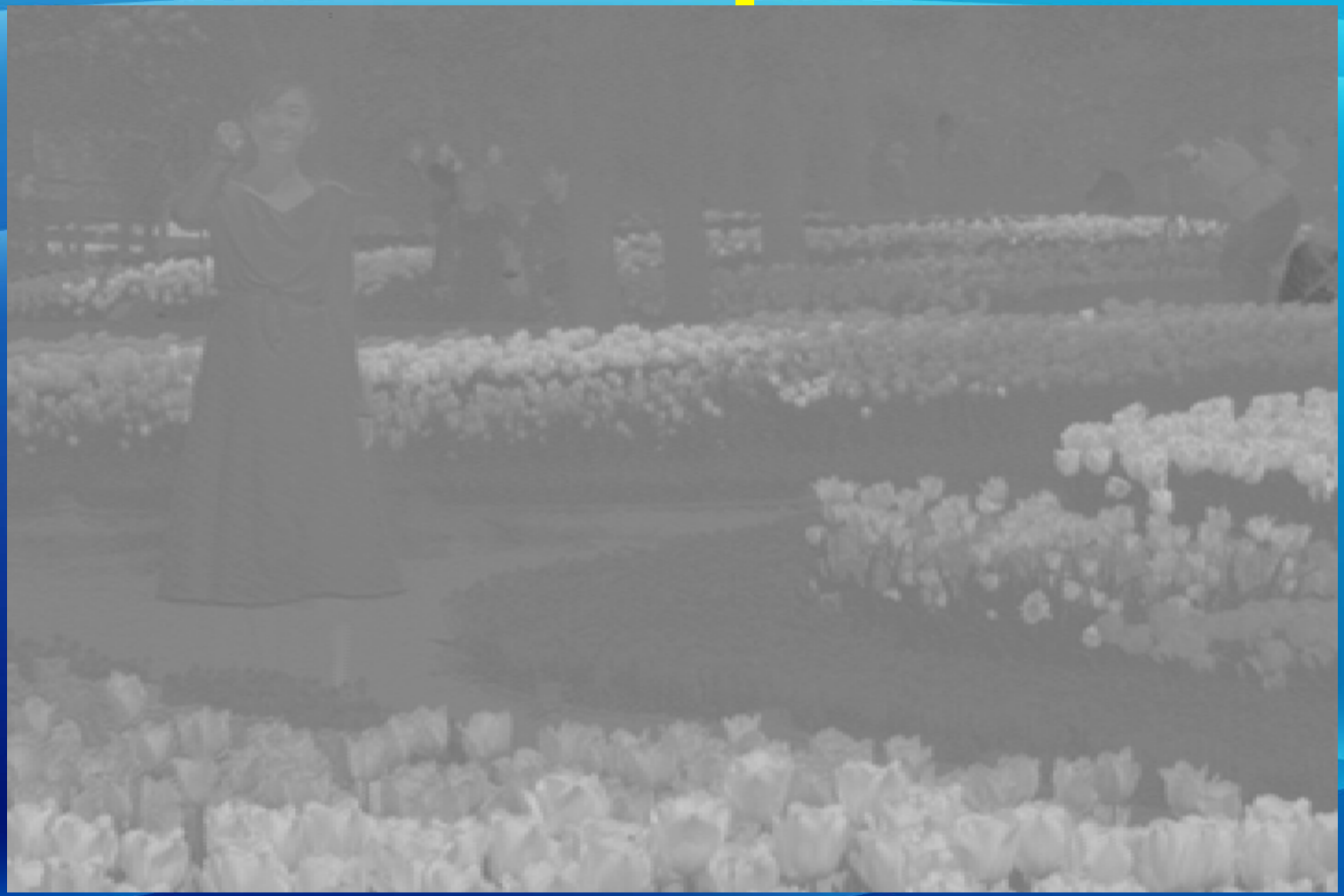
Flowerpot

Red Leaves

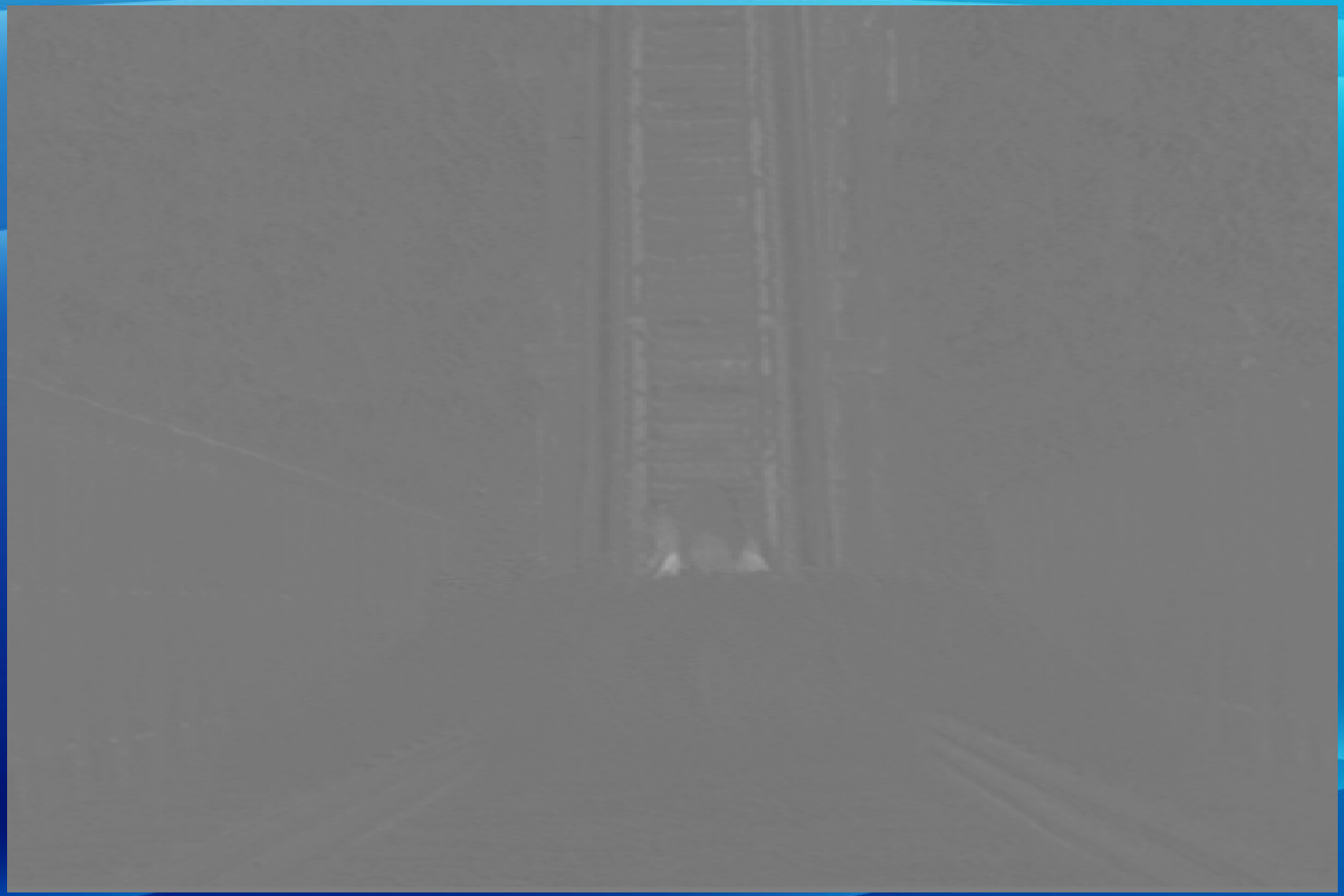
Street Organ

Trapeze

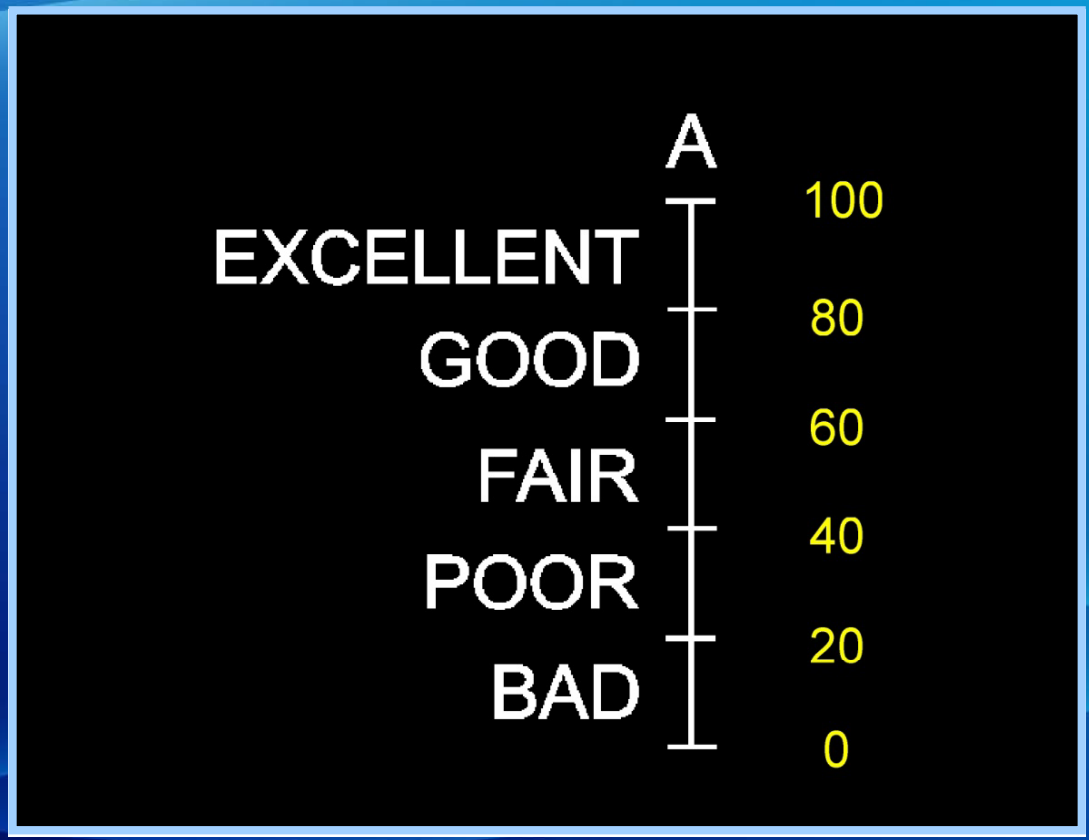
Tulips



Waterslide



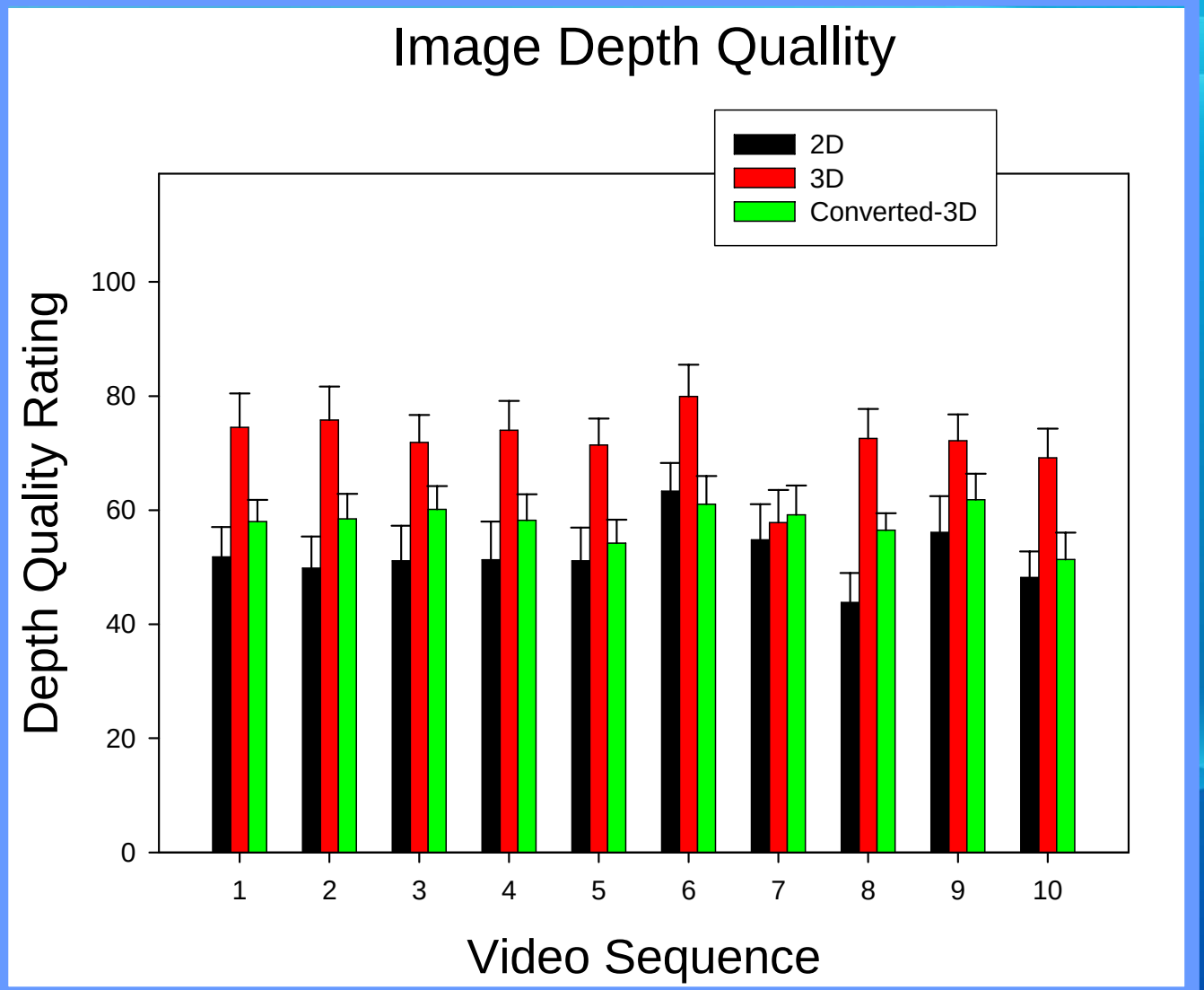
Single-stimulus Continuous Quality Scale



Single-stimulus Continuous Quality Scale

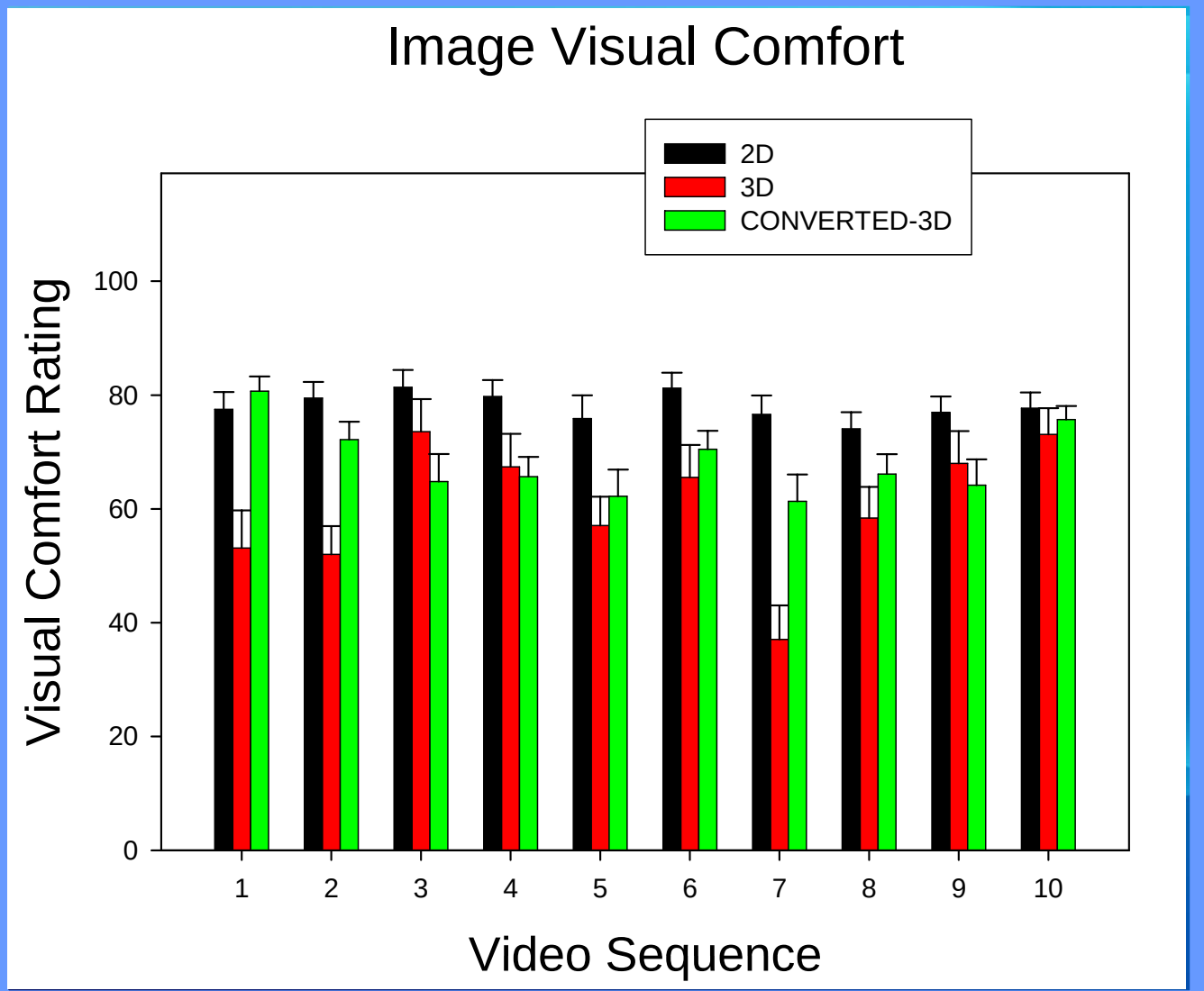
Depth Results

1. Aquarium
2. Camera Test
3. Confetti
4. Crowd
5. Flower Pot
6. Red Leaves
7. Street Organ
8. Trapeze
9. Tulips
10. Waterslide



Visual Comfort Results

1. Aquarium
2. Camera Test
3. Confetti
4. Crowd
5. Flower Pot
6. Red Leaves
7. Street Organ
8. Trapeze
9. Tulips
10. Waterslide



How can it possibly “work”?

- Natural Images
- Foreground-background separation
- Shading within objects
- Visual experience

Depth reversal
Familiarity information

http://www.kyb.mpg.de/bu/demo/index.html

Surrogate Depth Maps

can be useful for

2D-to-3D conversion

Summary

1. **Stereopsis** (& disparity type)
2. **Stereoscopic deficiencies** (& display duration)
3. **Inter-ocular averaging** (& bandwidth reduction)
4. **Object motion** (& visual comfort)
5. **Surrogate depth maps** (& 2D-to-3D conversion)

Take Home Message

Human Visual Perception

can be exploited for 3D-TV

Human Visual Perception is an active process

Thanks!

Half Colour

Half Colour

Sony GDM-F500
21” CRT monitors
4H viewing distance
Field-sequential Stereo

Subjective Assessment

- Depth Quality
- Visual Comfort

21 Viewers