Depth from HDR:

Depth Induction or Increased Realism?

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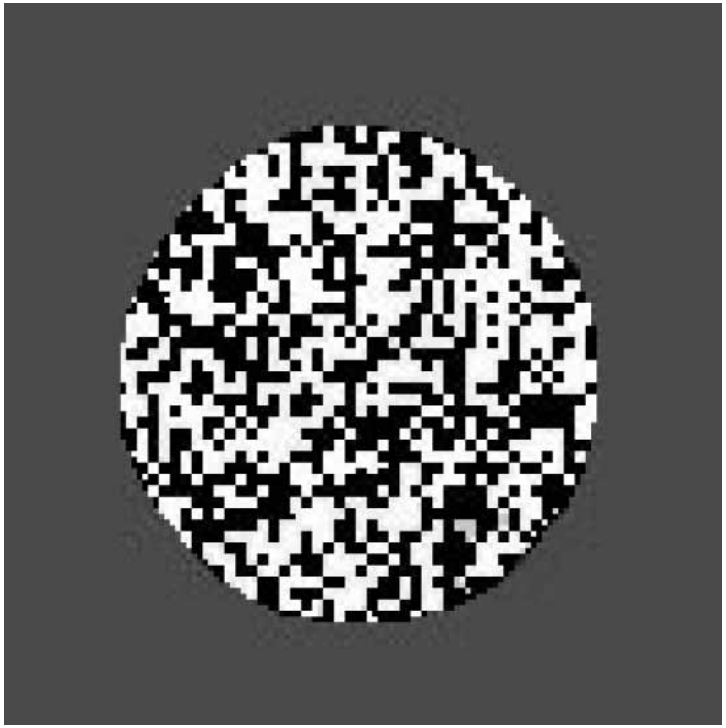
Depth from HDR

- *“like looking through a window”*

- Additional depth cue in stereo HDR display?

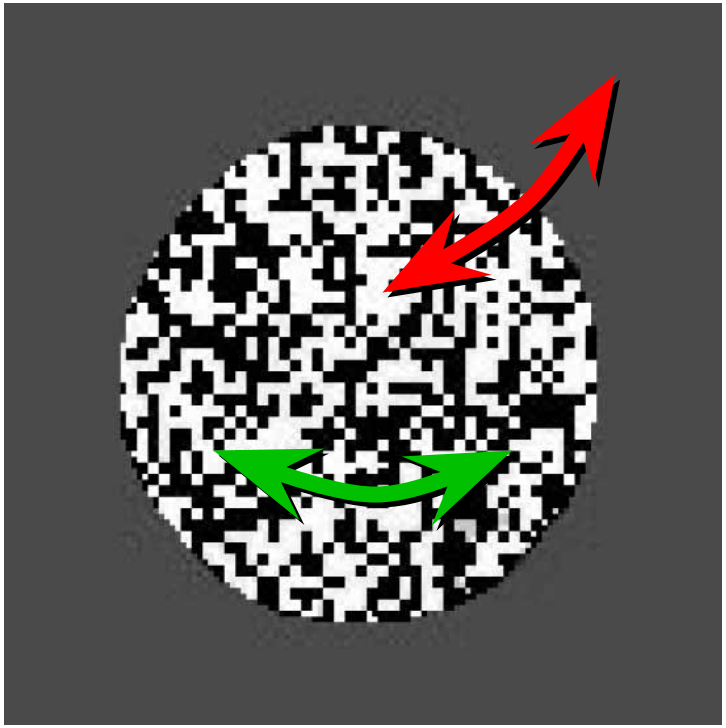
Depth from HDR

- [Ichihara et al., Perception 2007]



Depth from ~~HDR~~ contrast

- [Ichihara et al., Perception 2007]

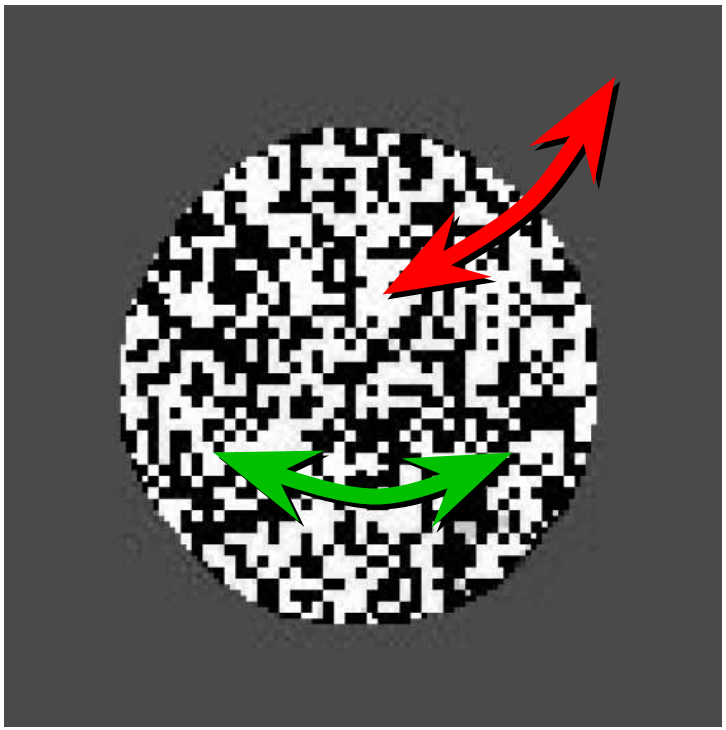


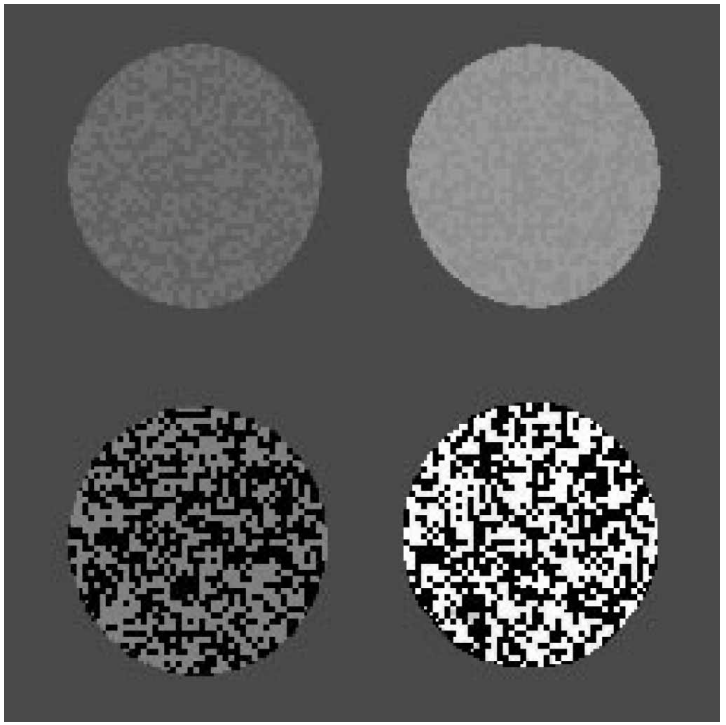
area contrast
object vs. background

texture contrast
within object

Depth from ~~HDR~~ contrast

- [Ichihara et al., Perception 2007]





higher texture contrast

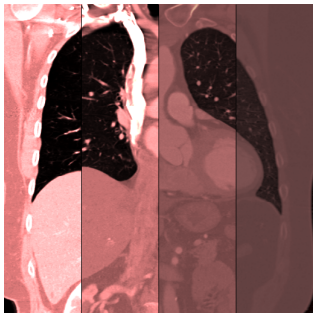
⇩

higher area contrast ⇨ appears closer

Depth from HDR

- [Rempel et al., APGV poster 2011] confirmed for HDR contrast levels hypothesis for depth from HDR

- [Easa et al., TAP 2013] confirmed effective depth cues for medical visualizations



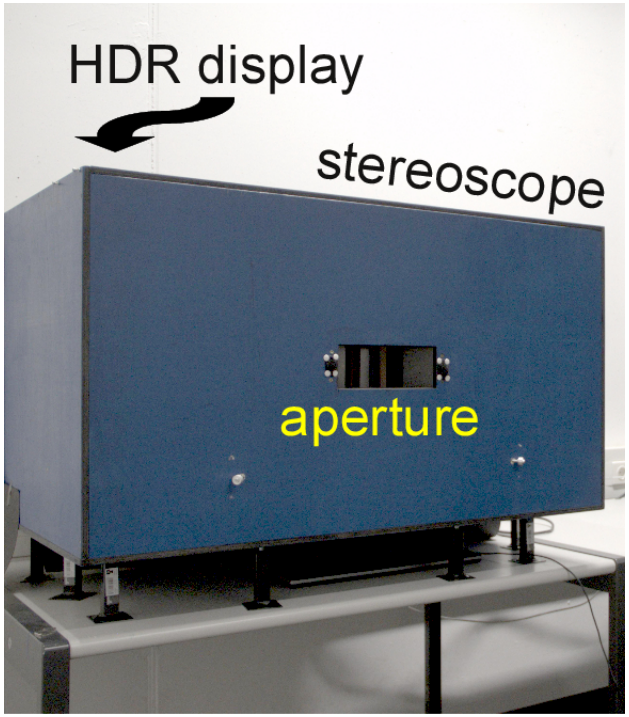
Motivation

- How much depth is conveyed by contrasts?
  - Compared to binocular depth cues

- Verify explanations of depth from HDR
  - Contrasts?
  - Fidelity of contrast reproduction?

HDR Stereoscope

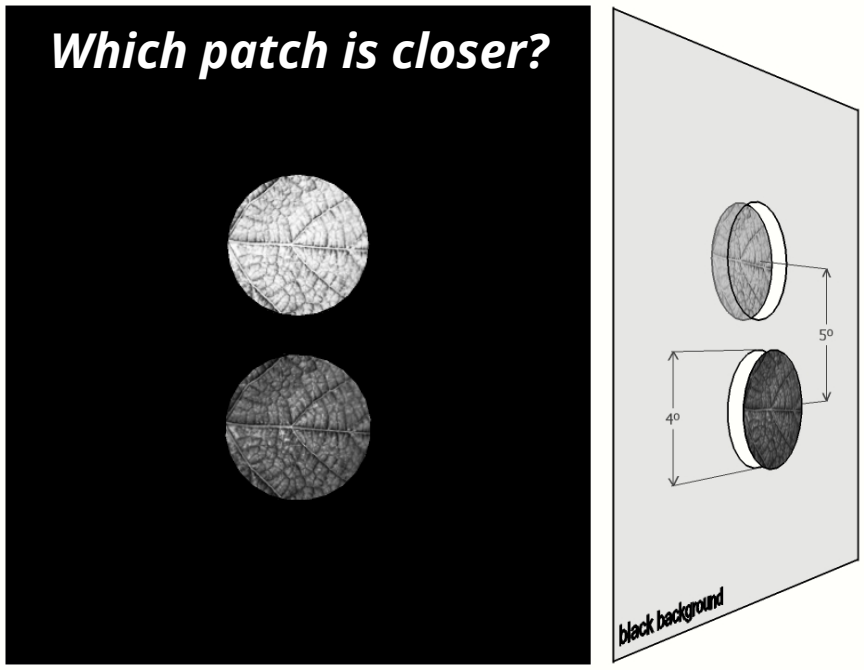
- See previous presentation :-)



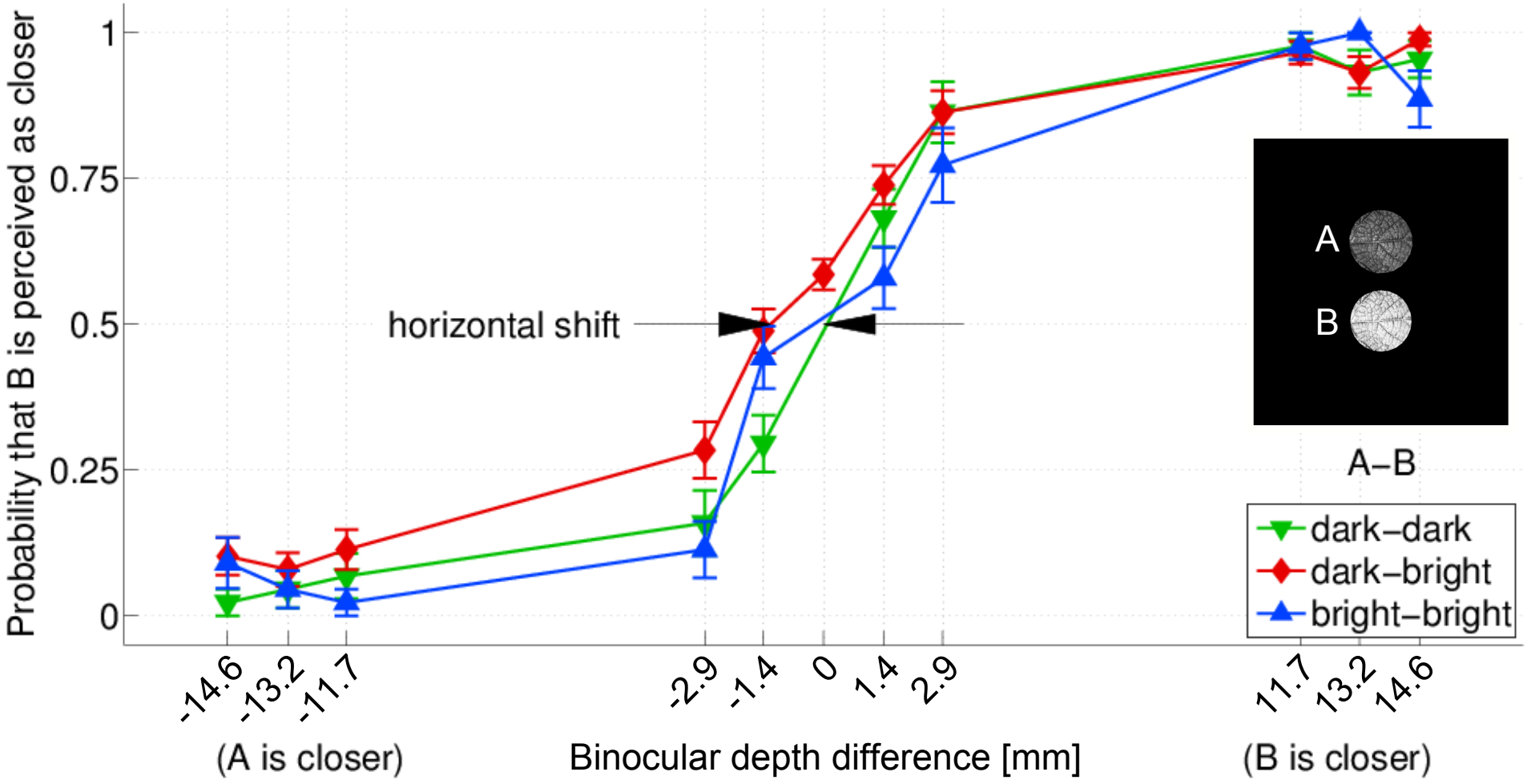
- HDR display
- Custom stereoscope
- Photopic conditions
  - no ND filters

Near-threshold Depth Induction

- Quantitatively measure depth-from-HDR
  - simultaneous comparison to binocular depth cues
    - vergence
    - disparity
  - depth range
    15 mm
  - luminance
    50 or 1000 cd/m^2



Near-threshold Depth Induction



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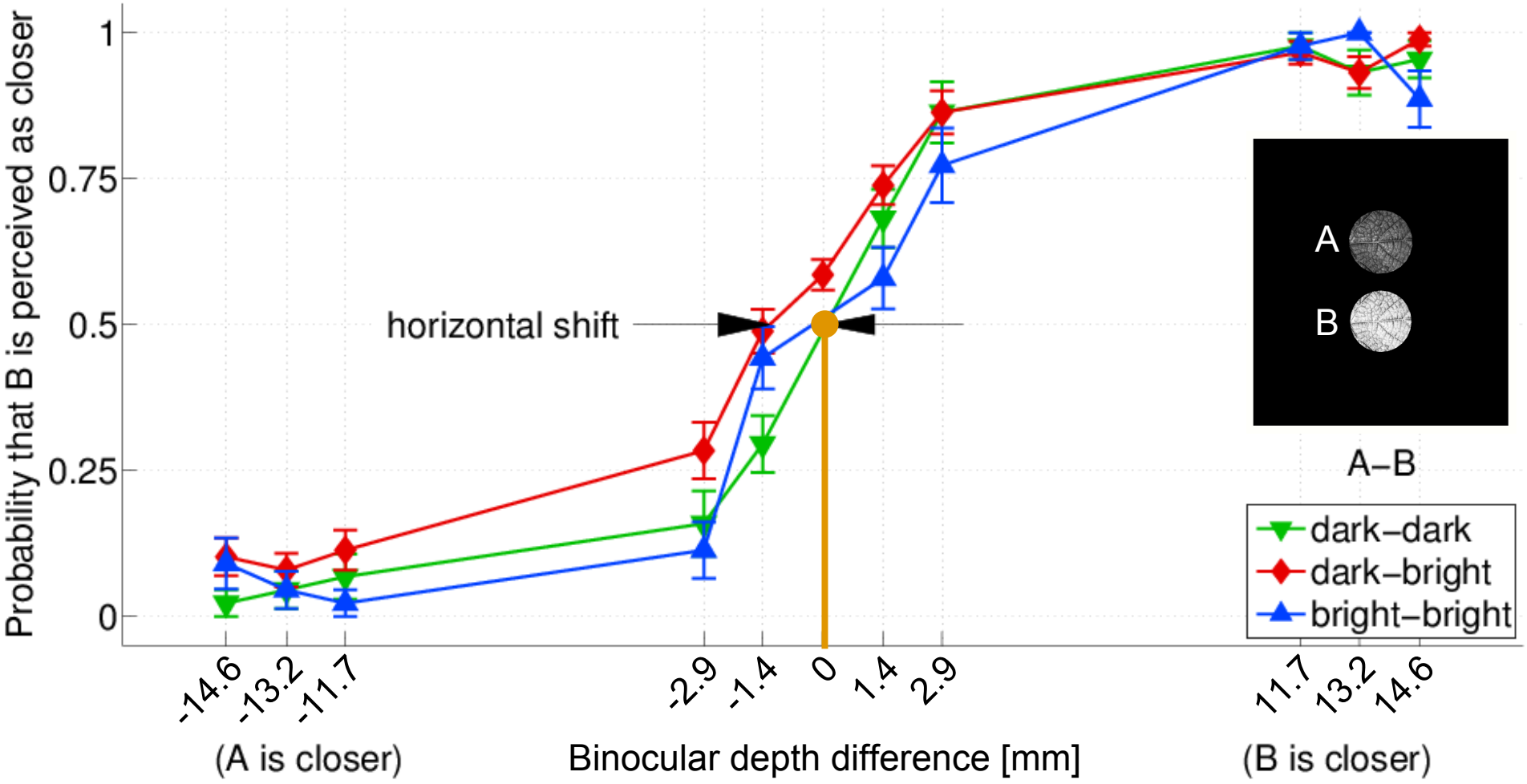

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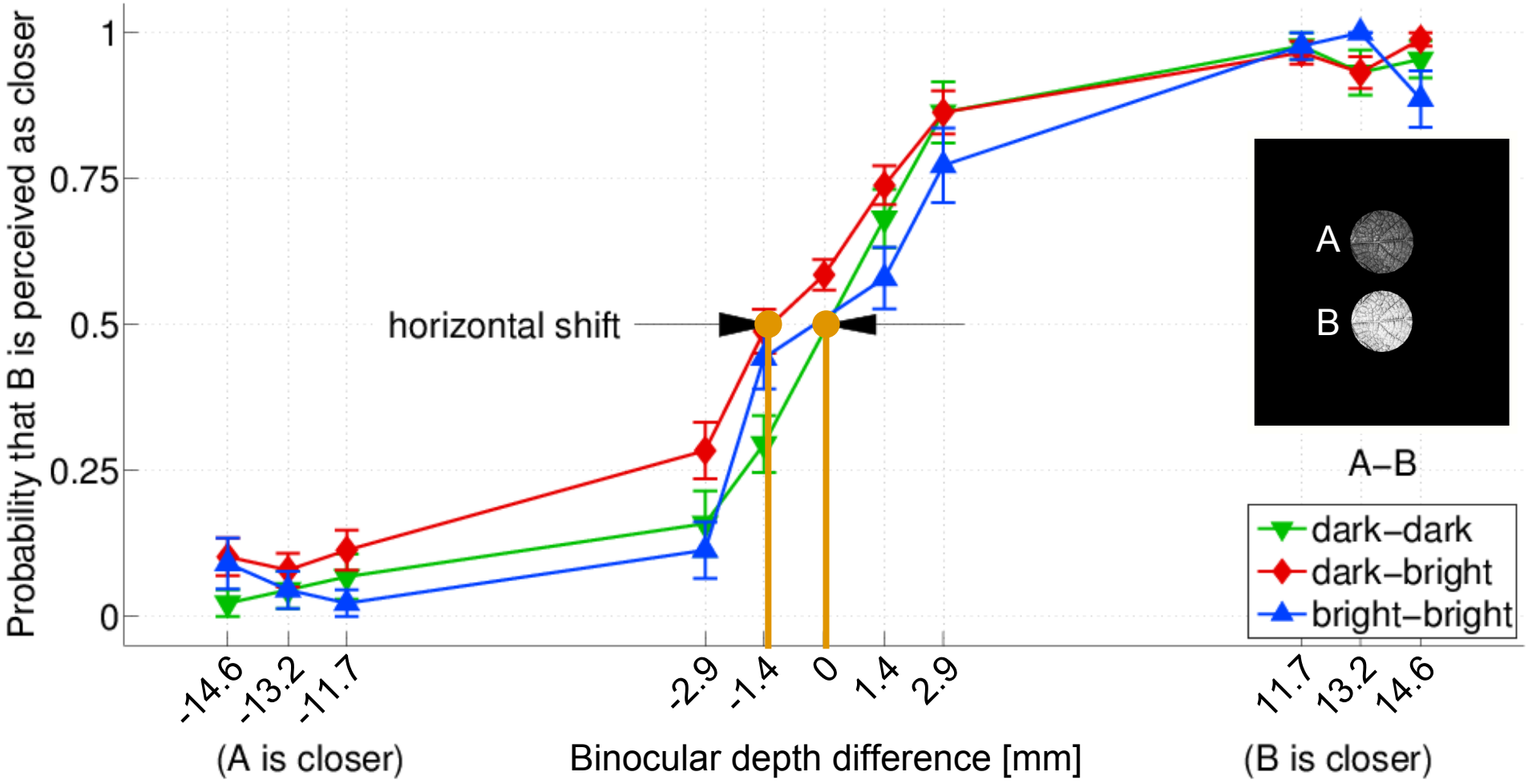
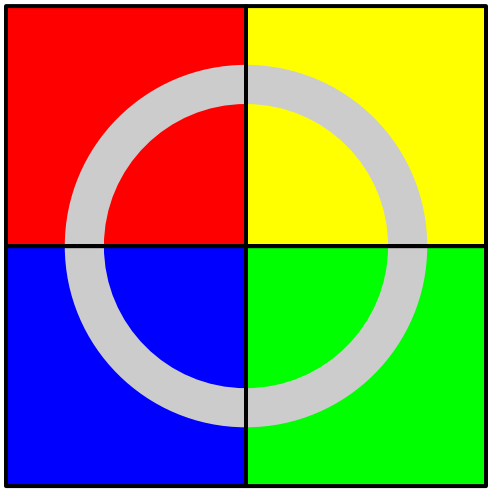


Near-threshold Depth Induction

- Conclusion
  - Confirmed that depth-from-HDR exists
  - Depth induction is very weak compared to near-threshold binocular depth cues
  - Similar to other illusions like color induction

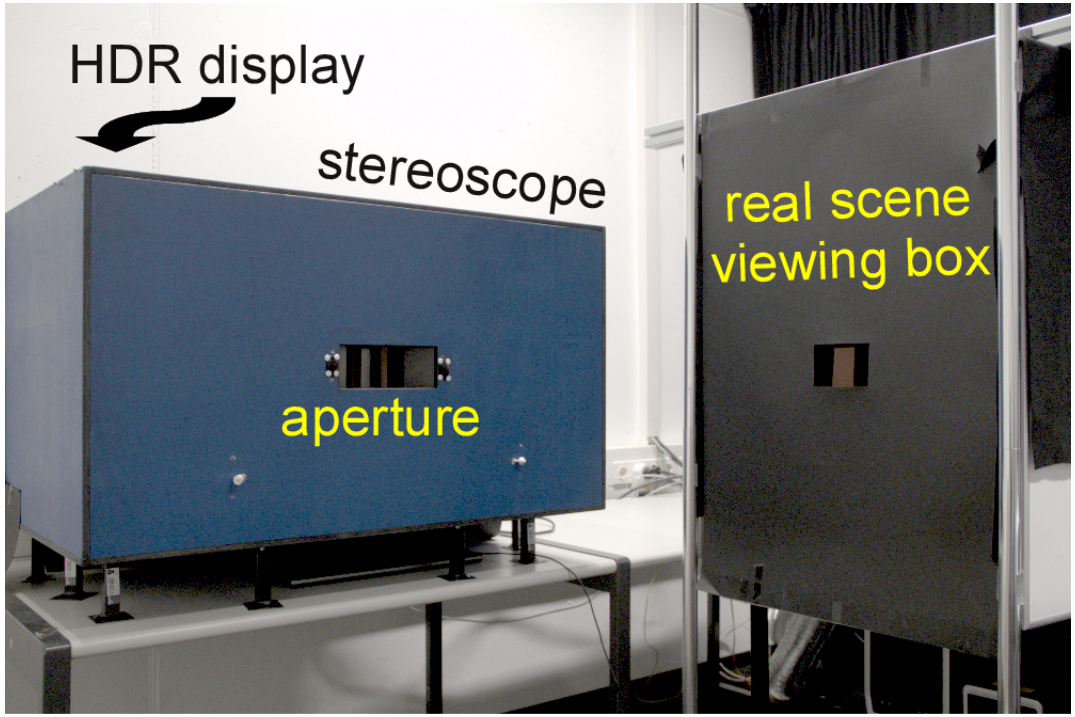


Near-threshold Depth Induction

- Practical implications
  - Depth induction effect overpowered by supra-threshold binocular depth cues
  - Not effective for depth enhancement in stereo 3D

Increased Realism

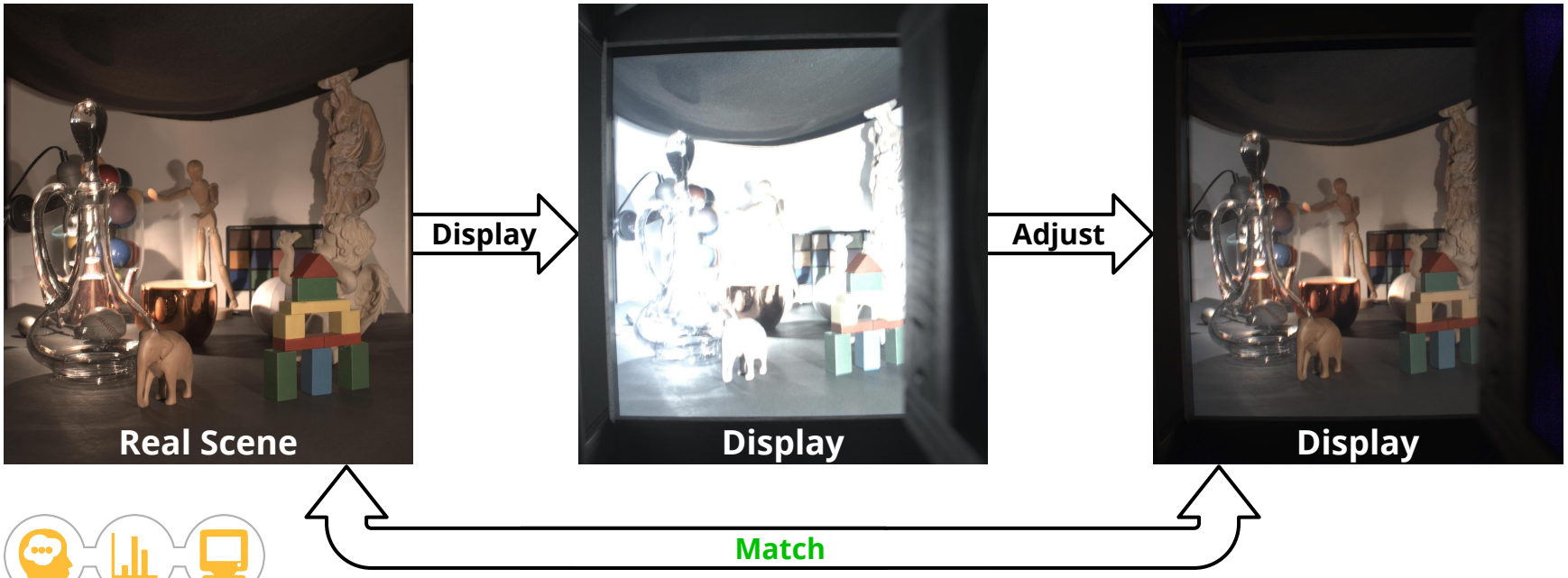
- Display an HDR stereo image of a real scene



- Orthostereo
  - no toe-in
- Field of view
- 1:1 matching view geometry

Increased Realism

- Image-specific color calibration
  1. Point a camera at real scene and displayed image
  2. Adjust the displayed image until the camera can't tell the difference to the real scene



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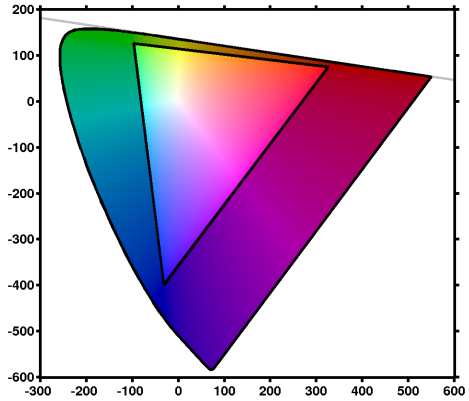
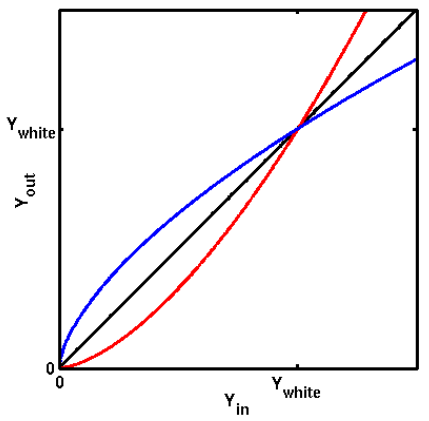
- Evaluation
  - Gamut: sRGB ≪ real world
  - Specific image reproduced better than with generic color calibration
    - well enough to fool some people



Increased Realism

- Toggle between two images of the real scene
  - camera interaxial distance
    - 0.00 cm no stereo
    - 3.25 cm reduced stereo
    - 6.50 cm correct stereo (avg. interocular)
    - 9.75 cm exaggerated stereo
  - contrast level γ
    - 0.63 reduced contrast
    - 0.79
    - 1.00 correct contrast
    - 1.26
    - 1.59 exaggerated contrast

$$Y_{out} = (Y_{in} / Y_{white})^{\gamma} \cdot Y_{white}$$



Increased Realism

- Toggle between two images of the real scene
  - camera interaxial distance
  - contrast level γ
- *Which image looks more realistic?*

or

- *No reference*

Increased Realism

- Observer clusters
  - Most realistic *stereo*
    - reduced (6)
    - moderate (6)
    - exaggerated (8)
    - indifferent (8)
  - Most realistic *contrast*
    - reduced (3)
    - moderate (14)
    - exaggerated (11)
    - indifferent (0)

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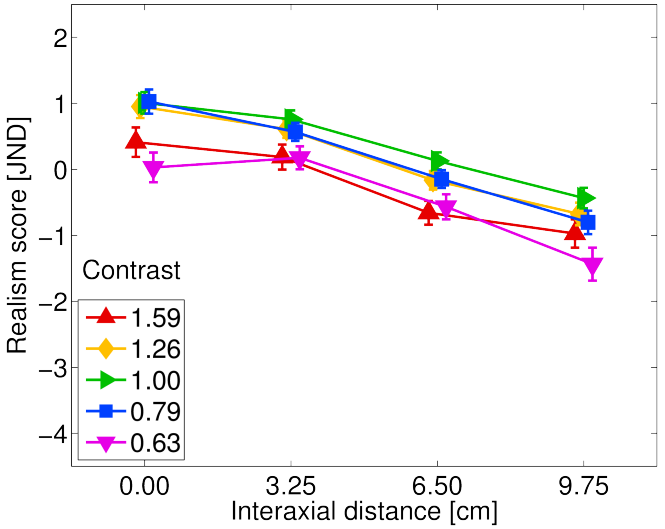

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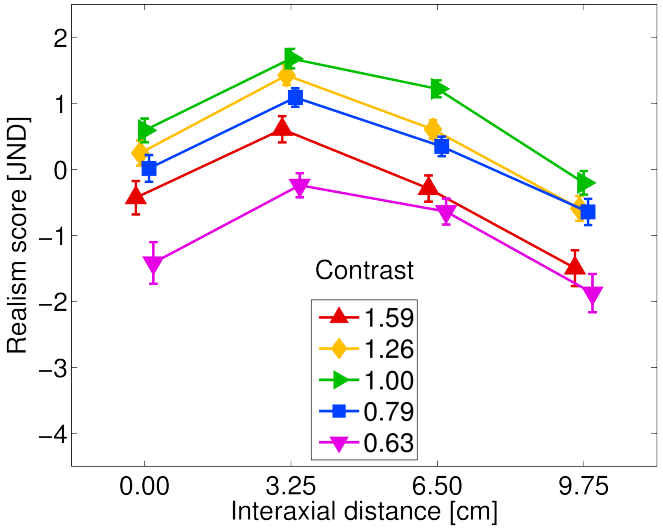

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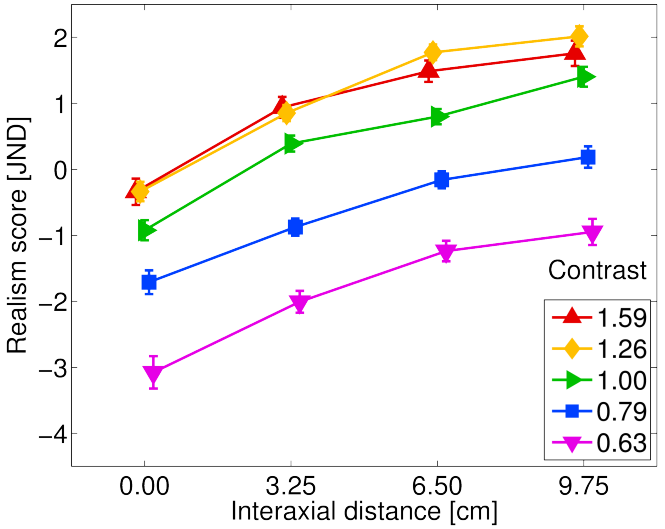

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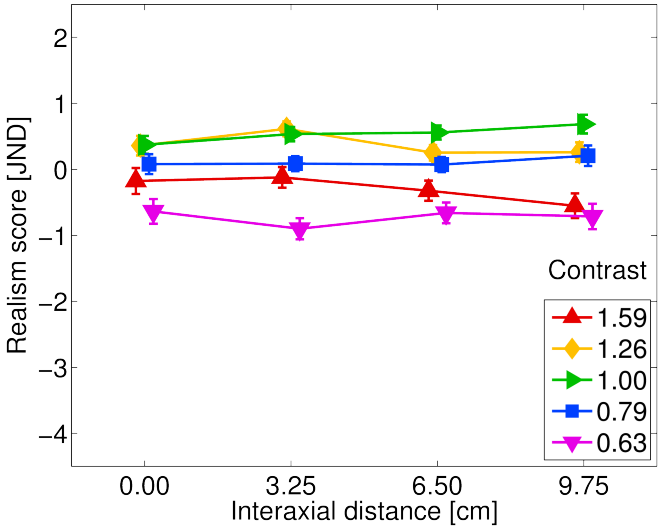

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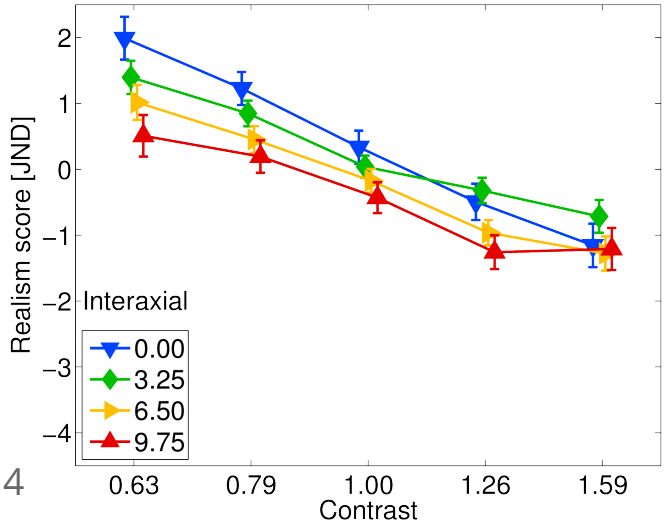

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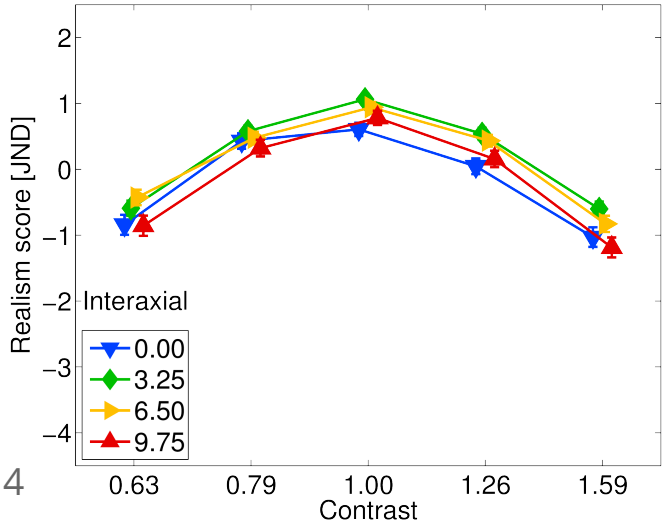

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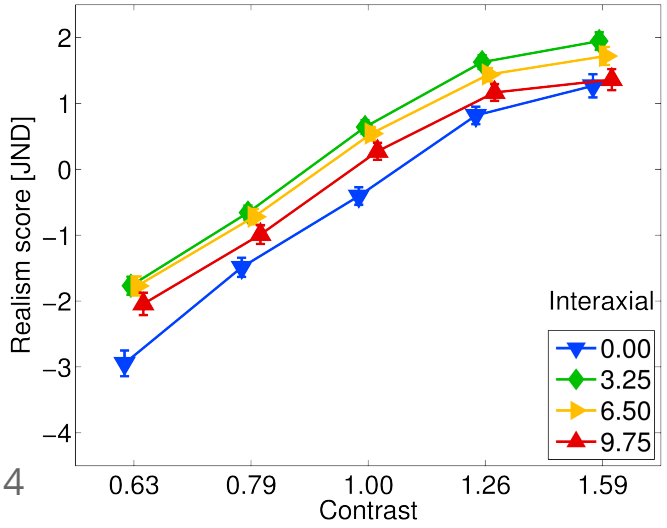

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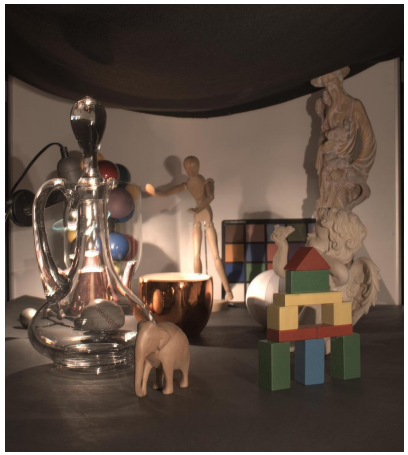
Increased Realism

- Conclusion
  - Very different choices
  - Personalization for optimal perceived realism
  - Calibration for optimal physical realism

  - 90% choose correct or exaggerated contrast
  - HDR contrast increases perceived realism, may help depth from HDR

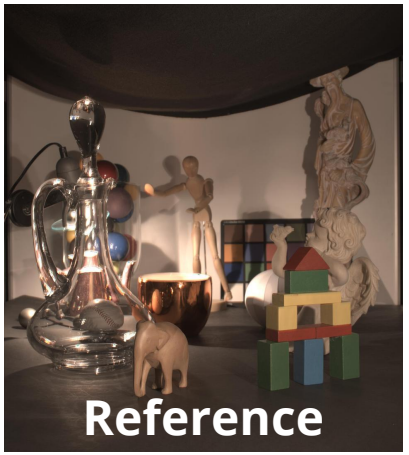
Direct Comparison to Real Scene

- Toggle between two images of the real scene
  - camera interaxial distance
  - contrast level γ
- *Which image looks more realistic?*



or

given



- *With reference* (realistic $\stackrel{?}{=}$ close to reference)

Direct Comparison to Real Scene

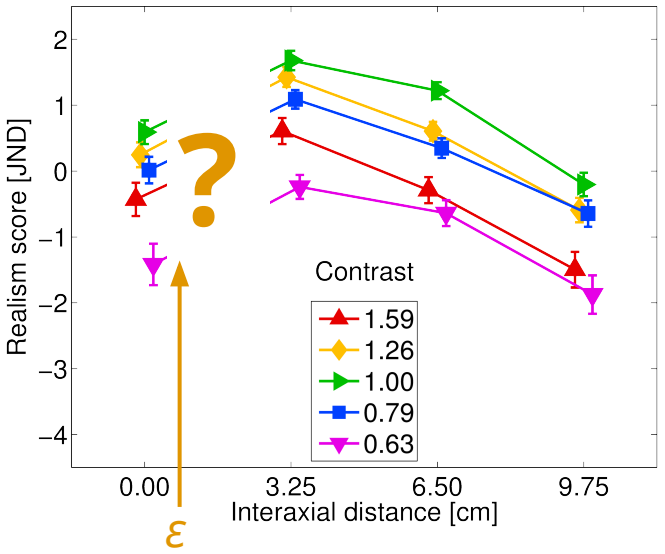
- Very similar results
- Some observers moved between clusters
  - towards lower contrast
  - towards moderate stereo

Conclusions

- Depth from HDR: confirmed
- Depth Induction: very weak
- Increased Realism: possibly
  - *“like looking through a window at the real world”*

Future Work

- Realism of microdisparity
  - interaxial distance ε



- Test realism hypothesis with HDR stereo displays that better approximate reality
  - “retina” resolution
  - wide-gamut
  - head motion parallax
  - accommodation

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