ARIVE

ARIVE Lecture Series
XR: Virtual and Augmented Reality

Interactions and Design for Virtual Reality

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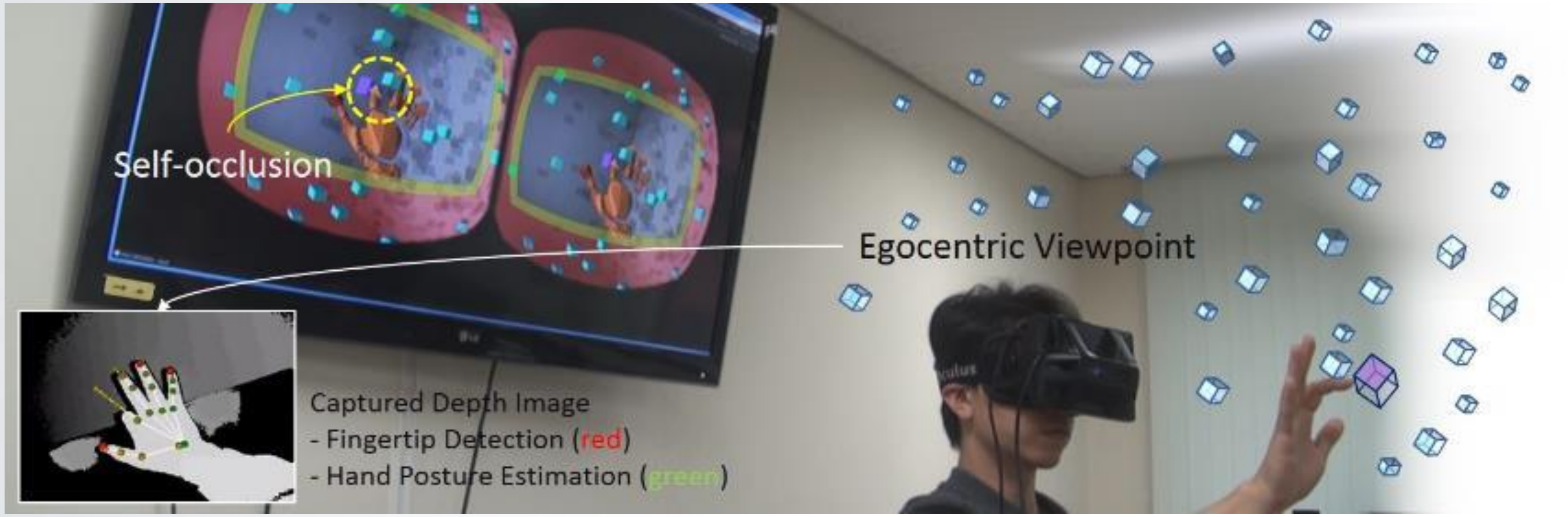
What makes 3D interaction difficult?

- Lack of precision
- Fatigue
- Layout more complex
- Perception
- Spatial input
- Lack of constraints
- Lack of standards
- Lack of tools



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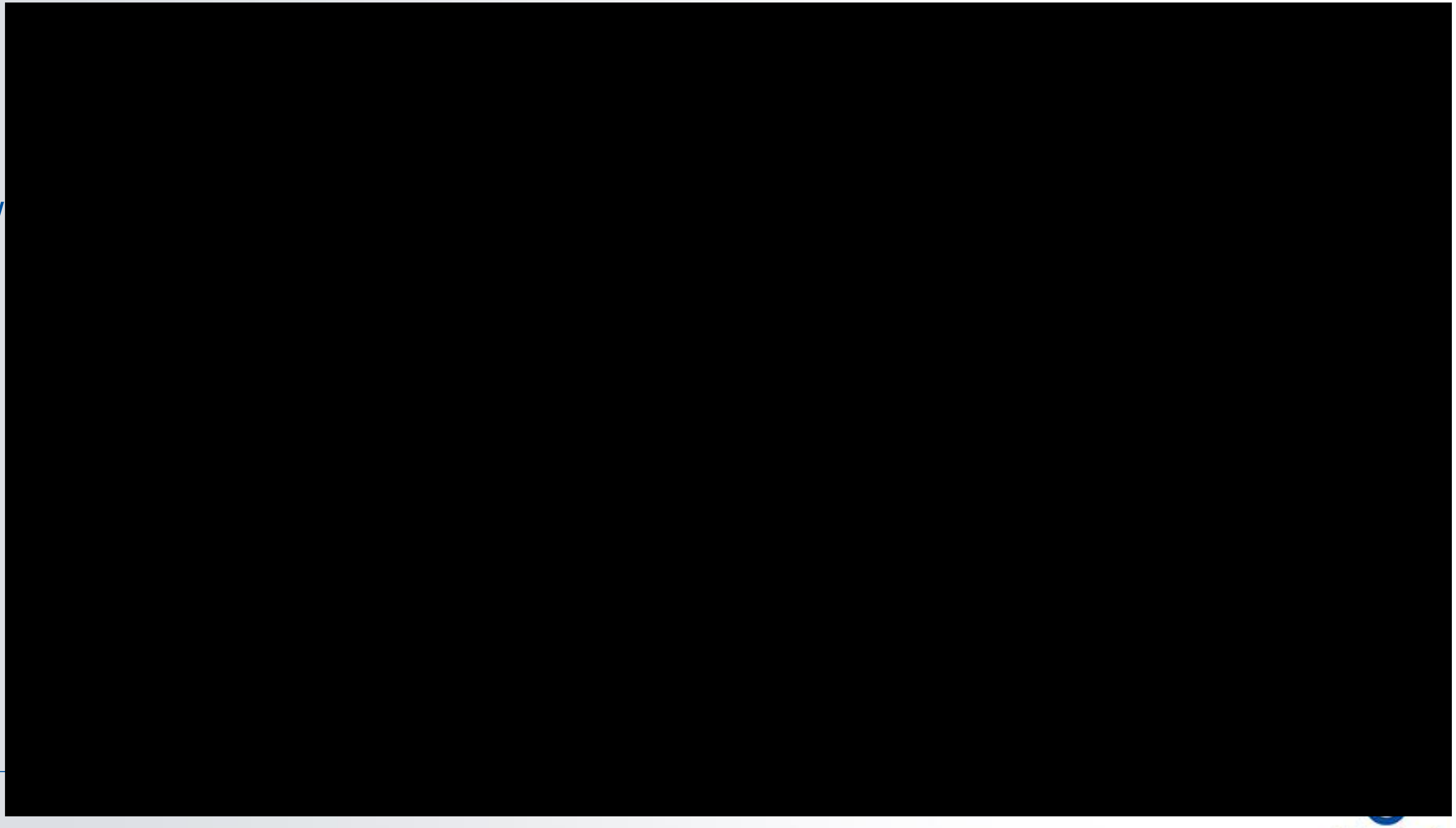
Natural Interface Concept - WorldBuilder

https://www



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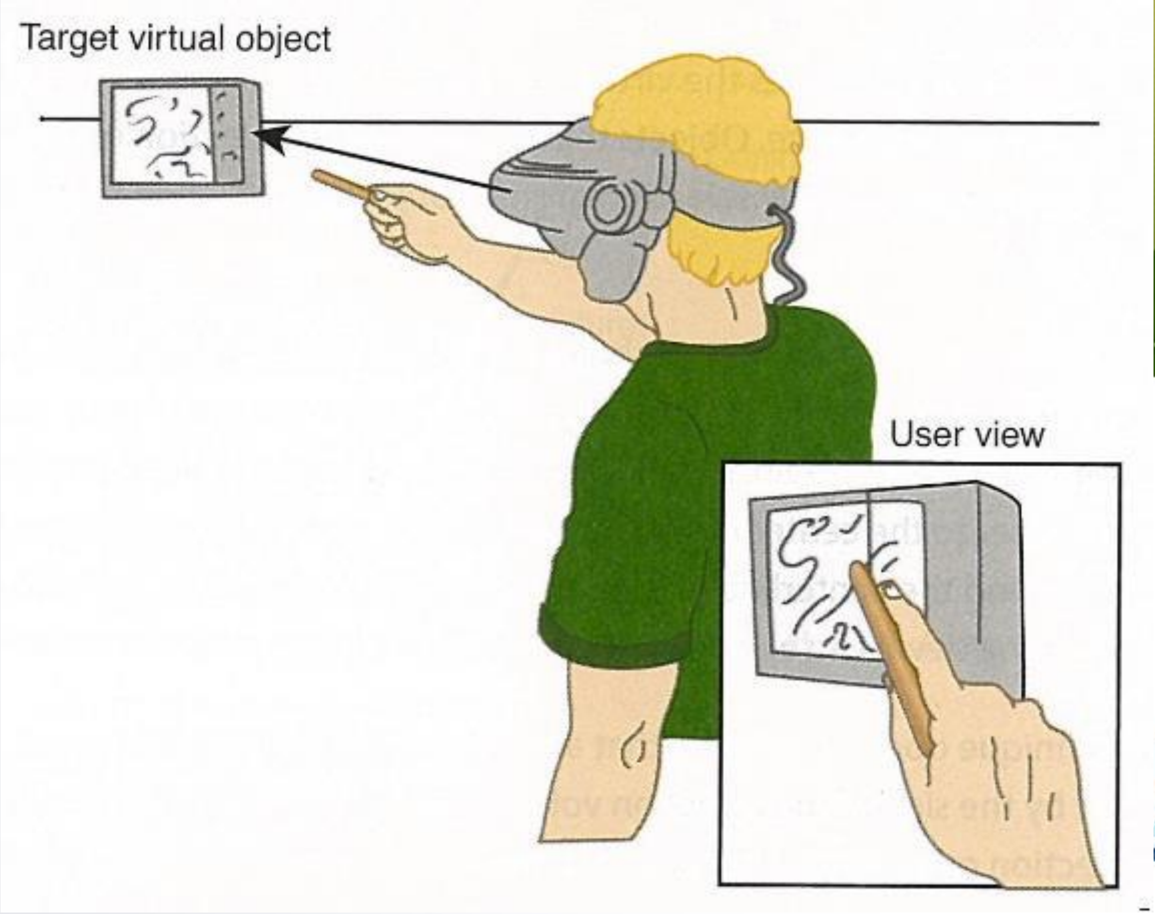
Some techniques we forgot about :(

Image Plane Interaction

Pierce, J., Forsberg, A., Conway, M., Hong, S., Zeleznik, R., & Mine, M. (1997). *Image Plane Interaction Techniques in 3D Immersive Environments.* Proceedings of the ACM Symposium on Interactive 3D Graphics, 39-44.



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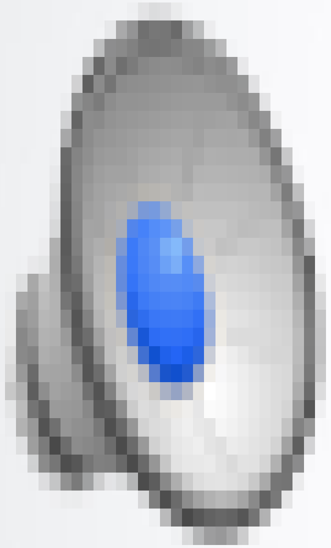
Example

https://www.youtube.com/watch?v=DBPkE9wsqlY



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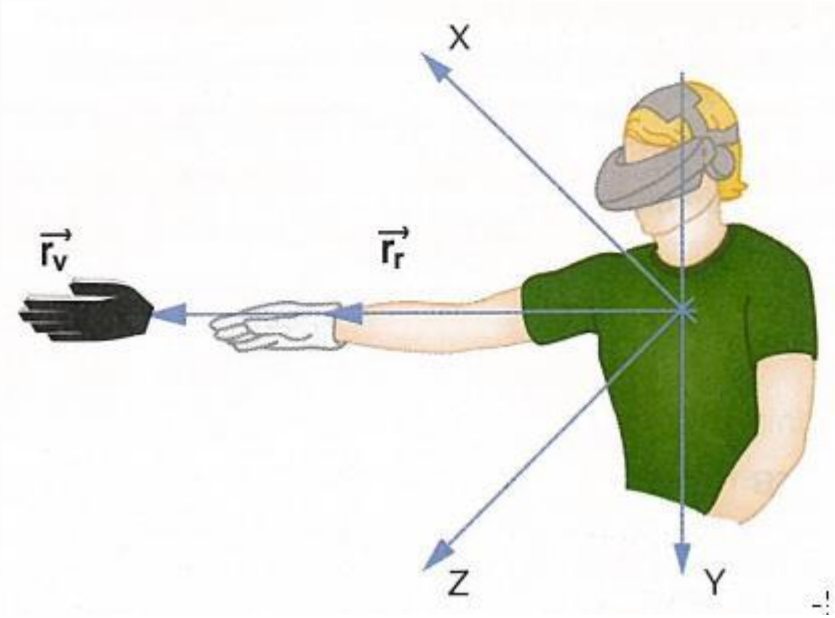
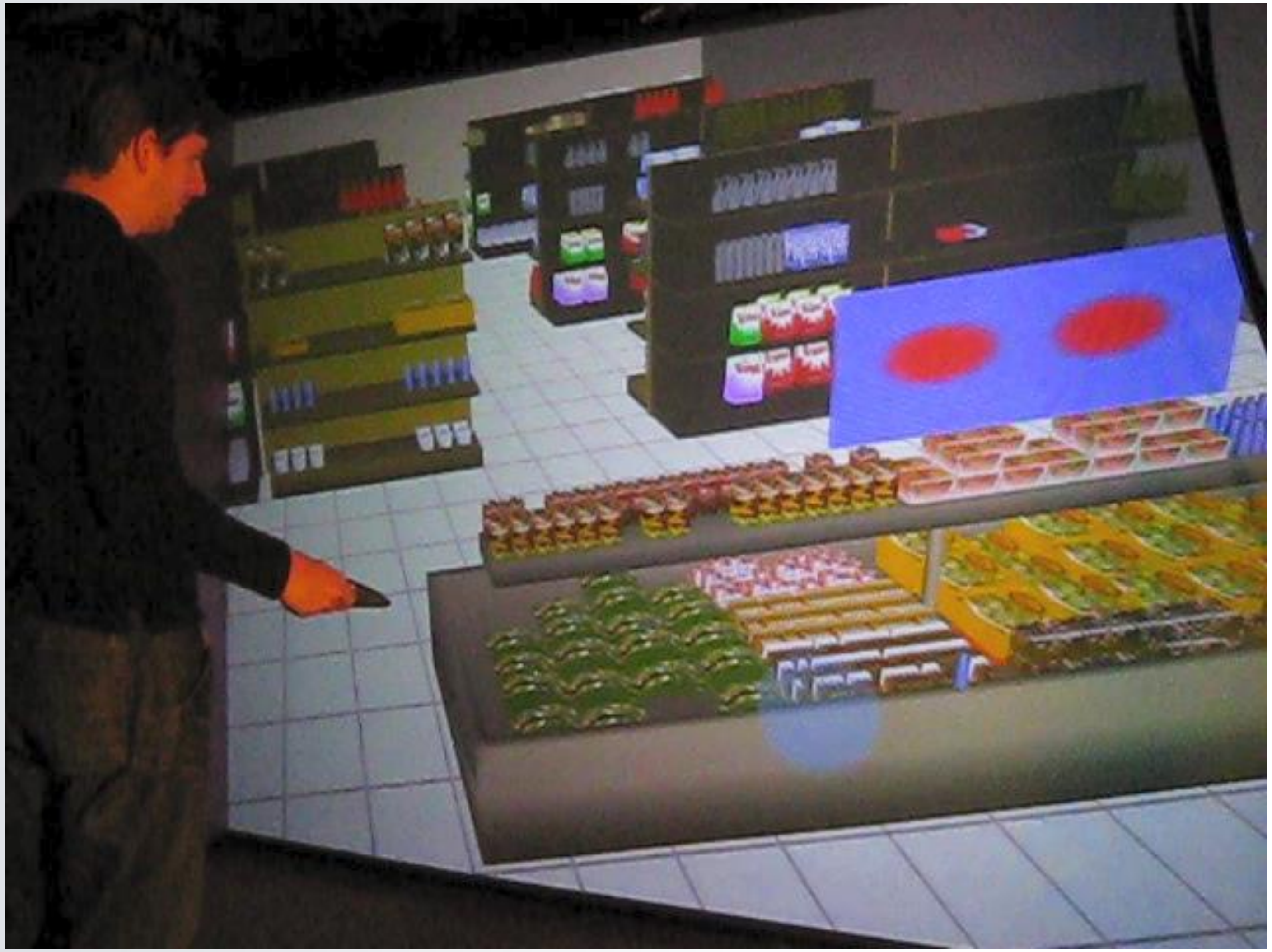
Go-Go Technique



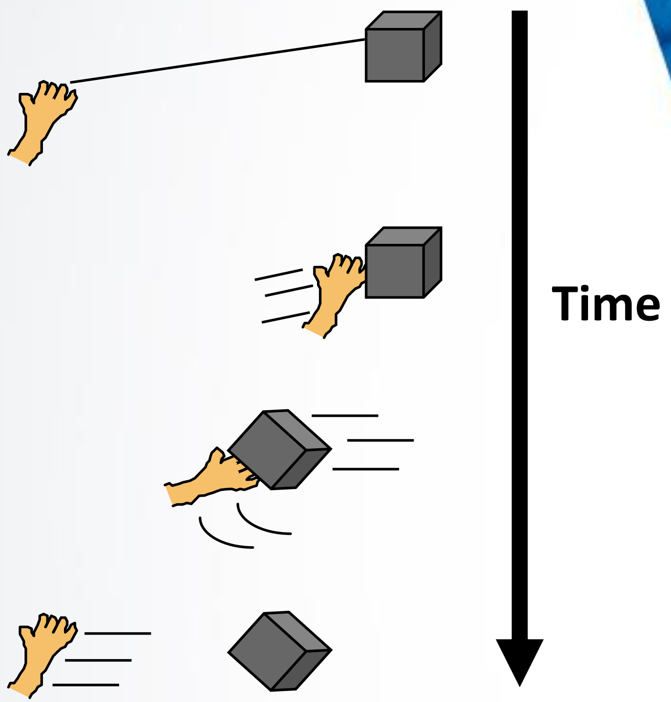
- Arm-extension technique
- Non-linear mapping between physical and virtual hand position
- Local and distant regions (linear < D, non-linear > D)

Poupyrev, I., Billinghurst, M., Weghorst, S., & Ichikawa, T. (1996). The Go-Go Interaction Technique: Non-linear Mapping for Direct Manipulation in VR. *Proceedings of the ACM Symposium on User Interface Software and Technology,* 79-80.

Example: SQUAD Selection



HOMER technique



Hand-Centered
Object
Manipulation
Extending
Ray-Casting

Selection: ray-casting

Manipulate: directly with virtual hand

Include linear mapping to allow wider range of placement in depth

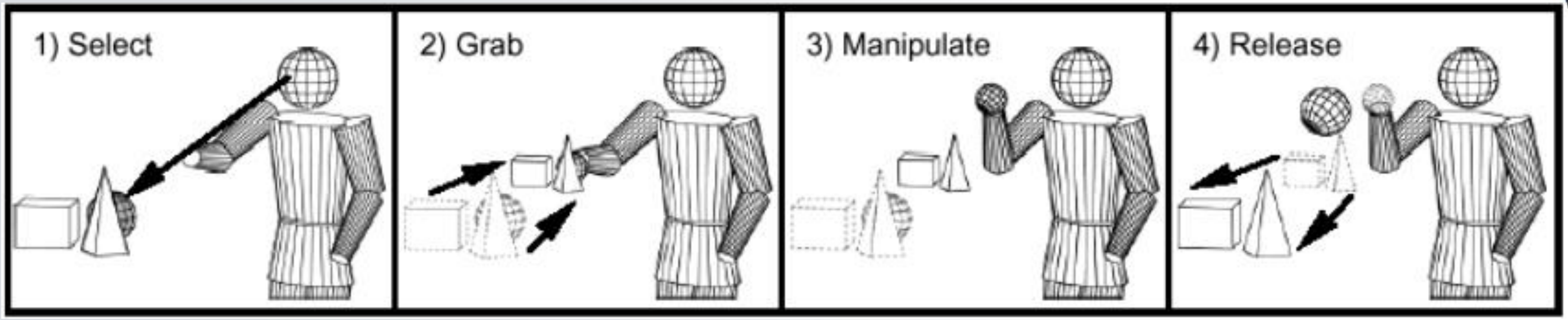
Bowman, D., & Hodges, L. (1997). *An Evaluation of Techniques for Grabbing and Manipulating Remote Objects in Immersive Virtual Environments.* Proceedings of the ACM Symposium on Interactive 3D Graphics, 35-38.

Scaled-world Grab Technique

Often used w/ occlusion

At selection, scale user up (or world down) so that virtual hand is actually touching selected object

User does not notice a change in the image until he moves



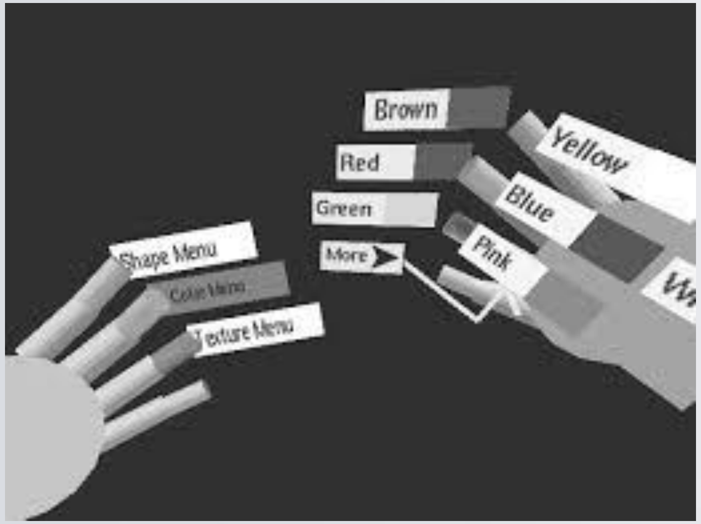
Mine, M., Brooks, F., & Sequin, C. (1997). *Moving Objects in Space: Exploiting Proprioception in Virtual Environment Interaction.* Proceedings of ACM SIGGRAPH, 19-26

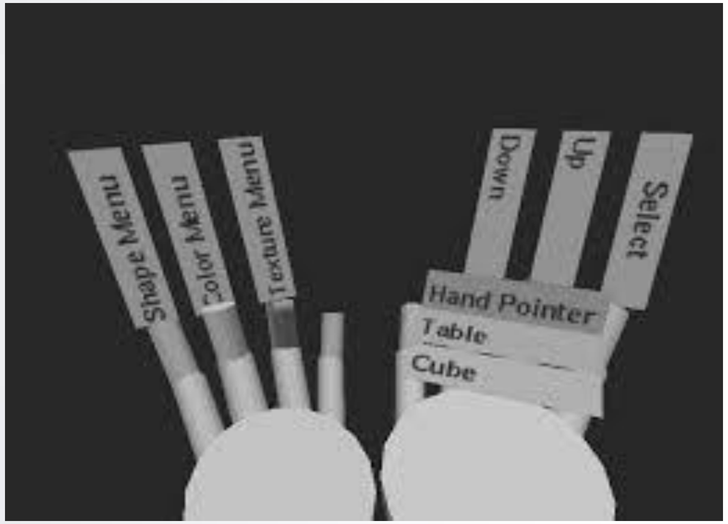
TULIP Menu

Menu items attached to virtual finger tips

Ideal for pinch glove interaction

Use one finger to select menu option from another





Bowman, D. A., & Wingrave, C. A. (2001, March). Design and evaluation of menu systems for immersive virtual environments. In *Virtual Reality, 2001. Proceedings. IEEE* (pp. 149-156). IEEE.

Paper Session: 02
Conference Paper

IEEE VR 2019
OSAKA

Remapped Physical-Virtual Interfaces with Bimanual Haptic Retargeting

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Motivation

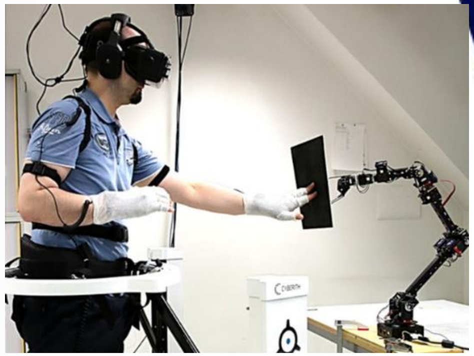
Virtual Reality haptics and tactile feedback present an ongoing research challenge.

How can we provide accurate tactile feedback that correlates with the visual representation of a dynamic virtual interface?

Some possibilities:

- Haptic Gloves
- Shape Displays
- Encounter Haptics
- Electrical Stimulation
- Psuedo-Haptics

FinGAR electrical stimulation wearable tacile device
(Yem and Kajimoto, *IEEE Virtual Reality (VR) 2017)*



VRobot, an encounter type haptic
(Vonach et al., *IEEE Virtual Reality (VR)* 2017)

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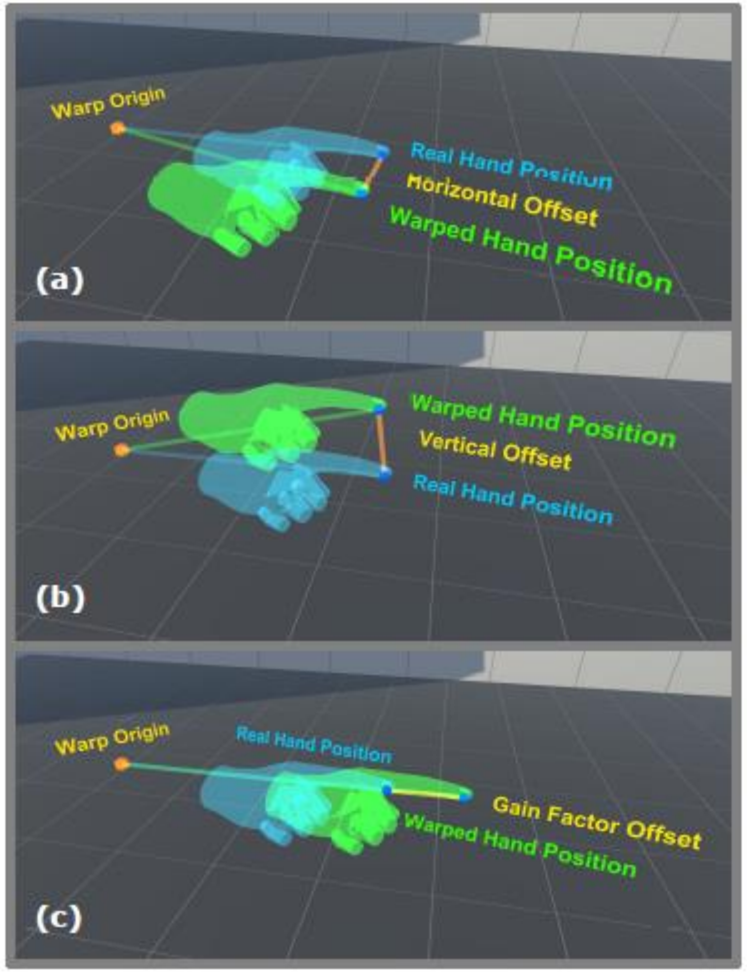
Hand Redirection

Users shown a virtual hand which mimics their real hand's finger movements and pose, but in a different spatial position, tend to perceive their real hand as being in the virtual hand's position.

The movement of the real hand can be manipulated by adjusting the movement of the virtual hand. Users will unknowingly compensate for the discrepancy such that their virtual hand moves how they intend.



Types of manipulation in hand redirection. Angular (top and middle) and Translational (bottom) (Zenner and Krüqer, 2019)

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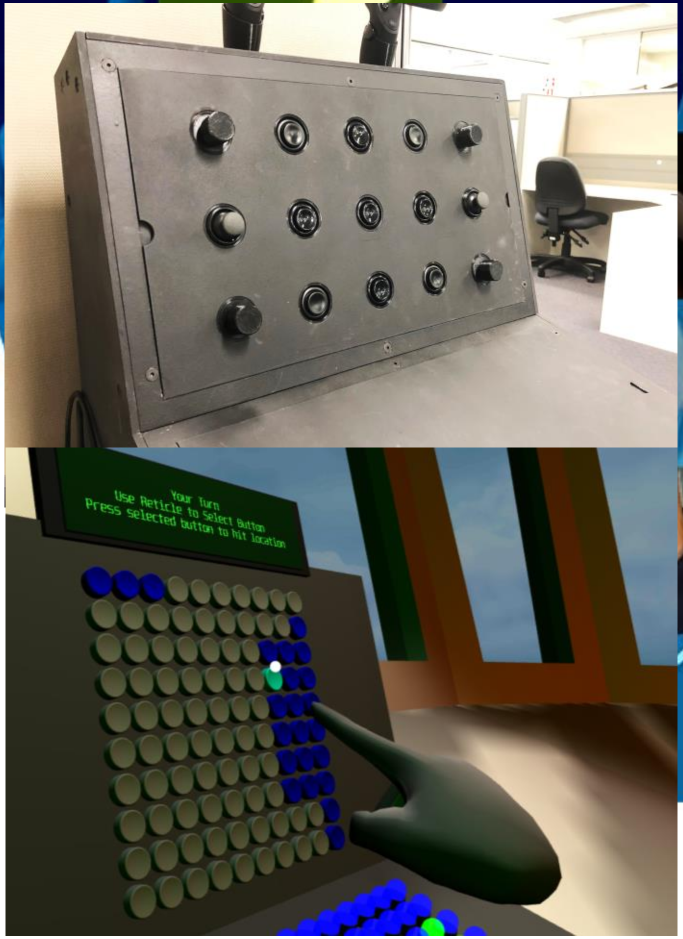
L. Kohli, "Redirected Touching," University of North Carolina at Chapel Hill, 2013.
A. Zenner and A. Krüqer, "Estimating Detection Thresholds for Desktop-Scale Hand Redirection in Virtual Reality," in *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, Mar. 2019, pp. 47–55.

Redirection for Physical User Interfaces

How can we provide the true haptic feedback of a physical user interface while providing dynamic layouts and context awareness?

The answer: Hand Redirection



SIGGRAPH Asia 2019 Demonstration System and Interactive Virtual Environment

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B. J. Matthews and R. T. Smith, “Head Gaze Target Selection for Redirected Interaction,” in *SIGGRAPH Asia 2019 XR*, New York, NY, USA, 2019, pp. 13–14, doi: 10.1145/3355355.3361883.

Remapped Physical-Virtual Interfaces

Physical handheld or fixed passive haptic interface

Enables tactile feedback and interaction in Virtual Reality through Visuo-Haptic illusions

Provides dynamic virtual interfaces with accurate tactile feedback.

Applications:

- Interface Design
- Simulation and Training
- Entertainment

Extending a Vive Controller with this system

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Related Research – Haptic Retargeting

Haptic Retargeting

- Re-use of passive haptics
- Body, World and Hybrid warping
- Provides increased haptic presence

(Azmandian et al., CHI 2016)

Re-using one physical cube to represent three virtual cubes.
(Azmandian et al., CHI 2016)

Sparse Haptic Proxy

- Generic proxy for tactile interaction with environments
- On-the-fly target remapping

(Cheng et al. CHI 2017)

Remapping a Haptic Proxy to Surfaces in VR (Cheng et al. CHI 2017)

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Interface Warp and Bimanual Interaction Support

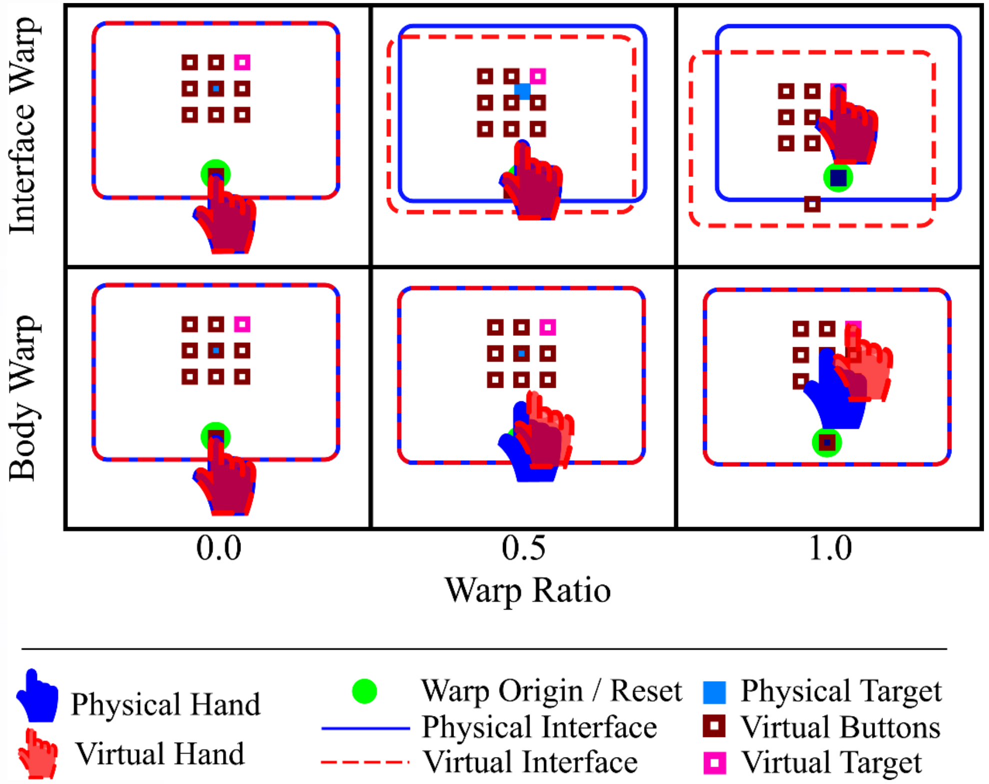
Interface Warp

- Based on Body warp Haptic Retargeting algorithm
- Offset applied inversely to the virtual interface
- Moves as the physical hand approaches the physical button

Bimanual Interaction Support

- Local space of the tracked interface

Combined with *body* warp to reduce the individual warp amounts



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Exploratory User Study

Is there a measurable effect of haptic targeting techniques and asymmetric bimanual on:

- task performance
- perceived manipulation
- presence

Hypotheses

- Both Mode and Warp will have a measurable effect on all measures.

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Exploratory User Study

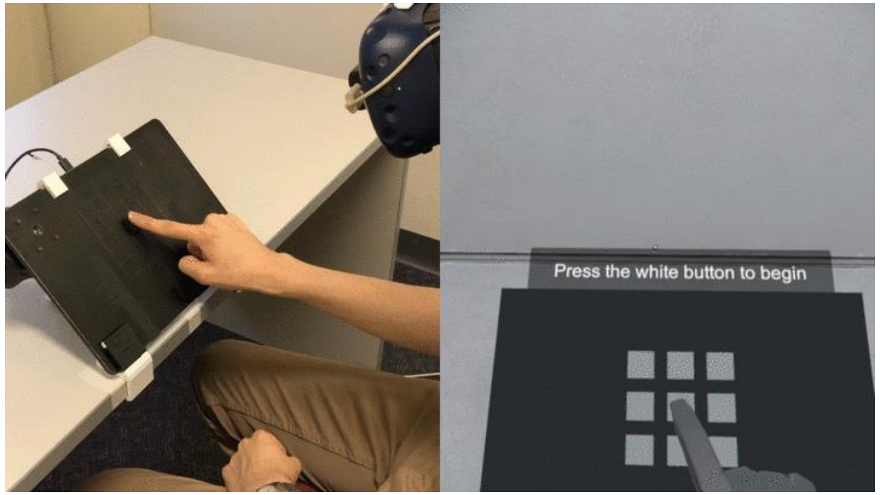
22 participants (15 male, 7 female)

Within Participants

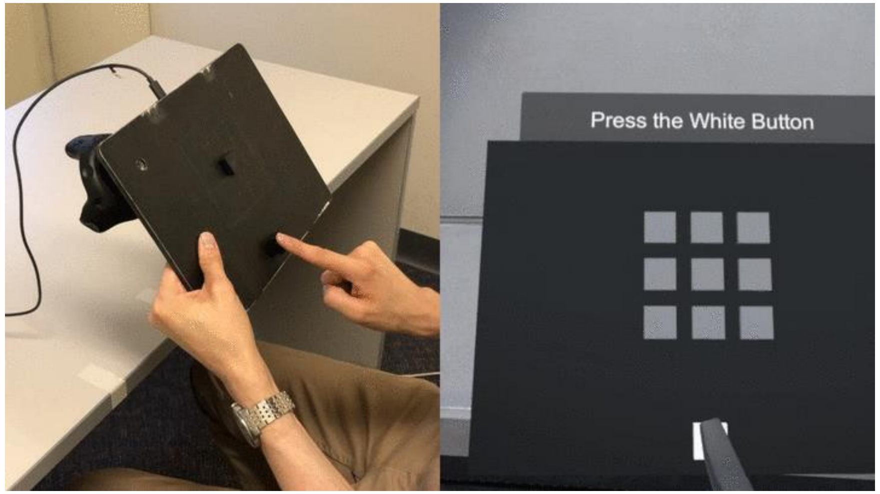
2x3 conditions + 1 practice condition

Mode: *Unimanual, Bimanual*

Warp: *Body, Interface, Combined*



Unimanual (fixed to desk) with Interface Warp



Bimanual (held in non-dominant hand) with Interface Warp

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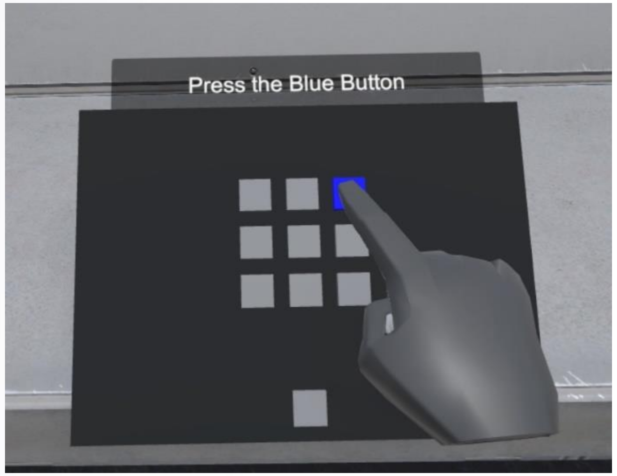
Study Procedure

Physical Interface

- 2cm x 2cm 3D printed cover on pushbutton
- Controlled by Arduino Uno
- Tracked using HTC Vive Tracker



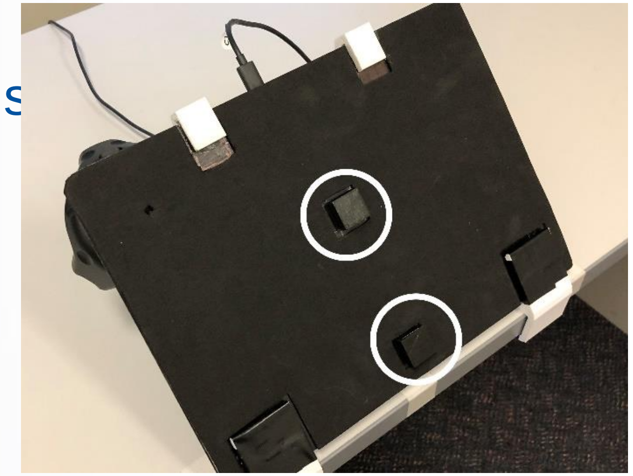
Virtual Interface

Calibration procedure to align Leap and Vive tracking s

Randomized condition order

3x3 virtual layout centred on the physical button

9 presses per condition in a random order



Physical Interface with physical buttons circled

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Results - Task Performance

Response Times

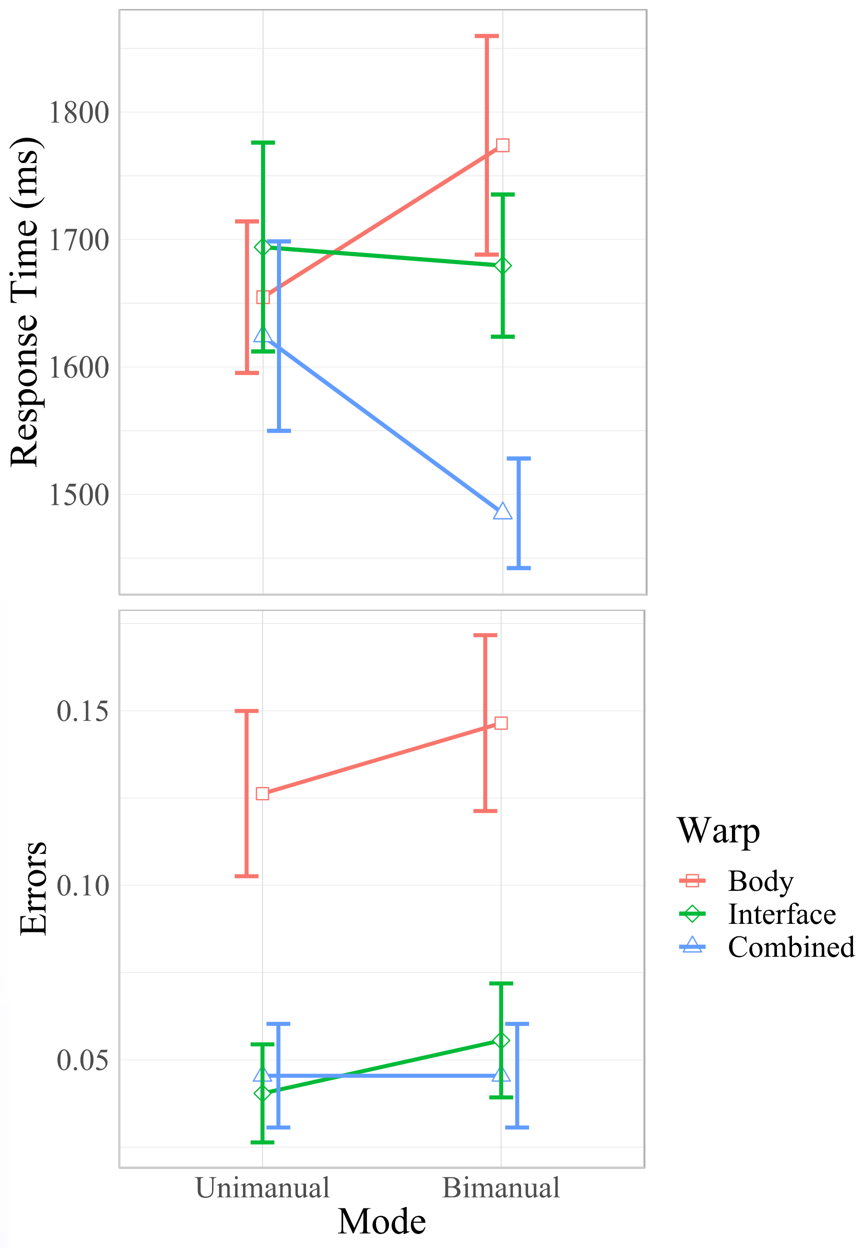
Significant effect of warp on response times

Combined warp significantly faster than *body* warp (*p=0.032*)

Errors

Significant effect of warp on errors

Significantly fewer errors for the *combined* warp (*p<0.001*) and *interface* warp (*p<0.001*) than *body* warp.



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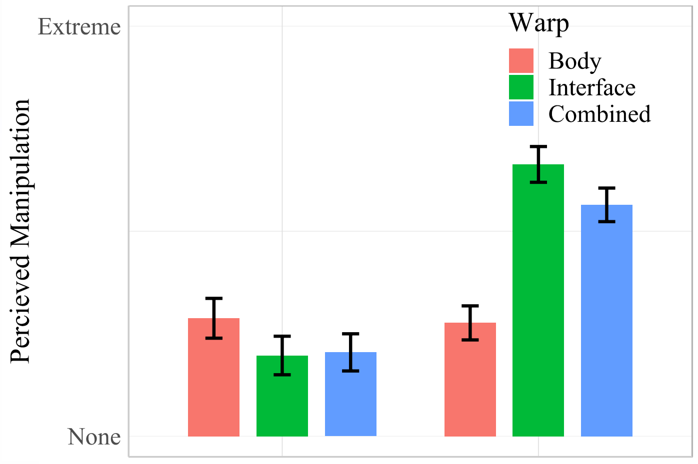
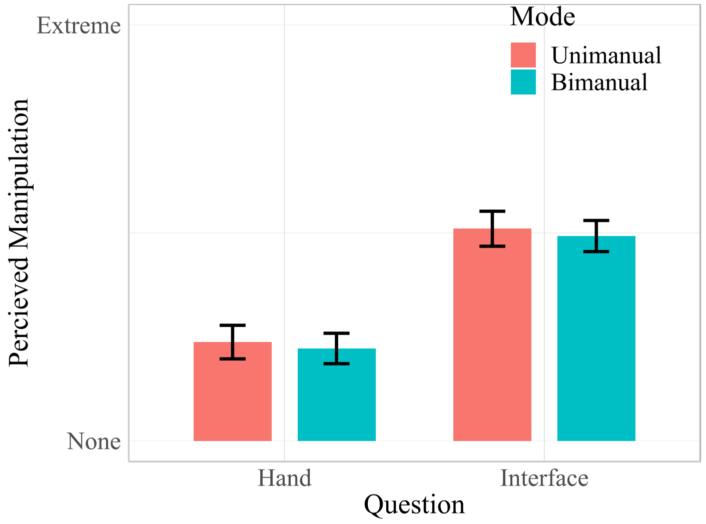
Results - Questionnaire

Perceived Manipulation

- Significant effect of warp on perceived manipulation of the **virtual interface**
  - Significantly lower perceived manipulation for *body* warp than the *interface* (p<0.001) and *combined* (p=0.015) warp

No significance was found in Presence Questionnaire scores or individual participant preferences





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Summary

System which provides accurate tactile feedback for a dynamic handheld interface in virtual reality

One physical button -> variable number of virtual buttons

Interface Warp technique

- Can reduce *body* warp amount
- More noticeable than *body* warp
- Provides increased task accuracy

Combined warp reduces response time

Interface and *combined* warp had fewer errors

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A Comparison of Predictive Spatial Augmented Reality Cues for Procedural Tasks

Benjamin Volmer, James Baumeister, Stewart Von Itzstein,

Ina Bornkessel-Schlesewsky, Matthias Schlesewsky, Mark Billinghurst and Bruce H. Thomas

University of South Australia

IEEE transactions on visualization and computer graphics, 24(11), pp.2846-2856.

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Motivation

- **Research is about**

  Improving procedural task performance time

  Reducing procedural task mental effort

  Providing a set of predictive SAR cues for procedural instructions

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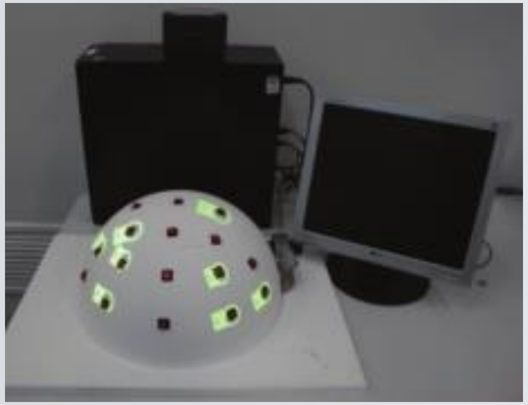
Comparison to previous work

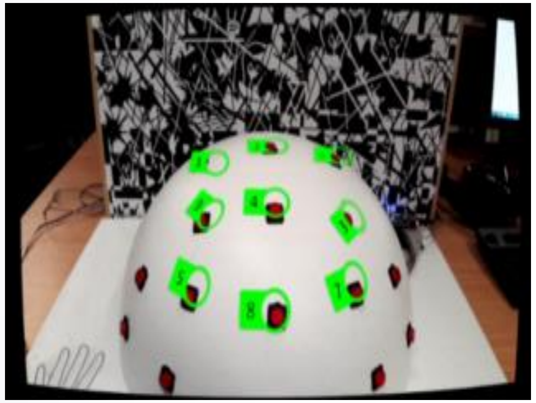
- Marner (2013)
  - Button pressing procedural task
  - SAR vs Montior
  - Annotations
    - Single
    - All



SAR Condition

M. R. Marner, A. Irlitti, and B. H. Thomas. Improving procedural task performance with augmented reality annotations. In Proceedings of International Symposium on Mixed and Augmented Reality (ISMAR), pages 39–48. IEEE, 2013.

- **Baumeister (2017)**
  - Button pressing procedural task
  - SAR vs VST vs OST vs Monitor
  - Annotations
    - Single
    - All



VST All Condition

J. Baumeister, S. Y. Ssin, N. A. M. ElSayed, J. Dorrian, D. P. Webb, J. A. Walsh, T. M. Simon, A. Irlitti, R. T. Smith, M. Kohler, and B. H. Thomas. Cognitive cost of using augmented reality displays. IEEE Transactions on Visualization and Computer Graphics, PP(99):1–1, 2017.

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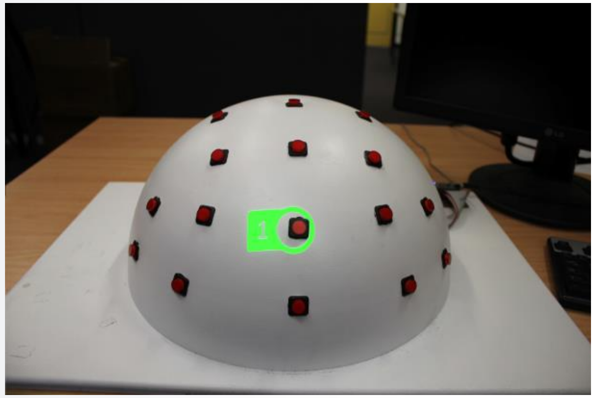
Contribution

Extend button pressing procedural task

SAR

Predictive Cues

- Target-based (Blink and Colour)
- Directional (Arrow, Line and Arc)



Single None Condition

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Hypothesis

- **H1 – All predictive cues have a positive effect on performance**
- **H2 – Direction-based cues lead to superior performance over target-based cues**
- **H3 – Task complexity will impact the user performance of the predictive cues**

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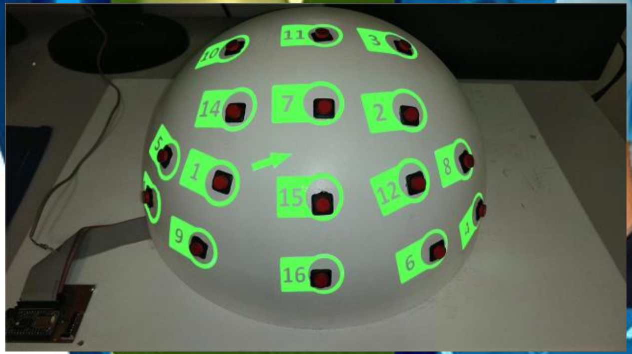
Experiment Design

- **Two Experiments (Single and All)**
    - 16 button presses in 5 blocks
        - Randomized
    - Post-experiment survey (Paas scale)

- **Participants**
    - Single case study: 20, 3 female, 3 left handed, over age of 18
    - All case study: 20 new participants, 4 female, 3 left handed, over age of 18

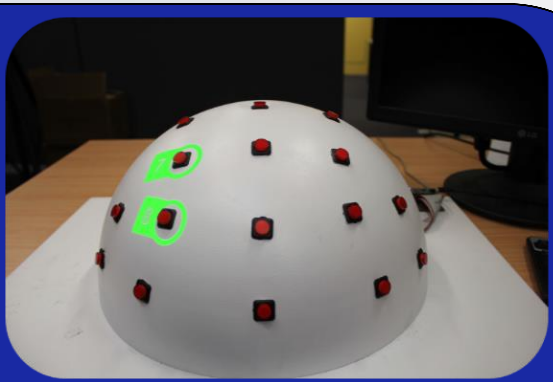


All Arrow Condition

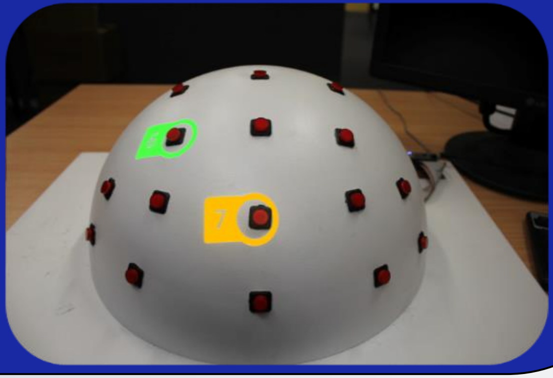
Single Case Predictive Cues

Target-based

Blink

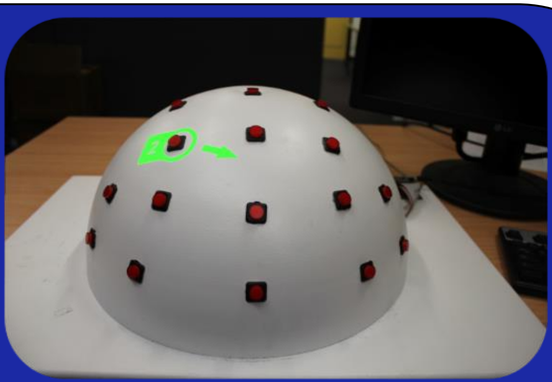


Colour

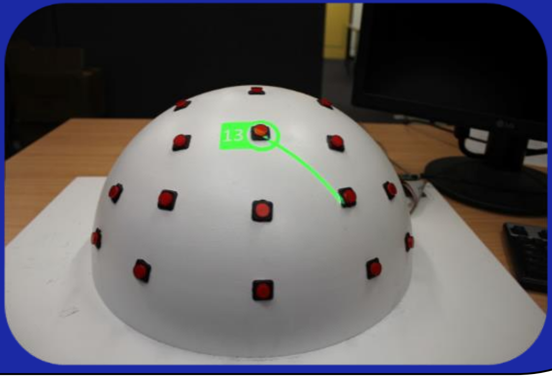


Directional

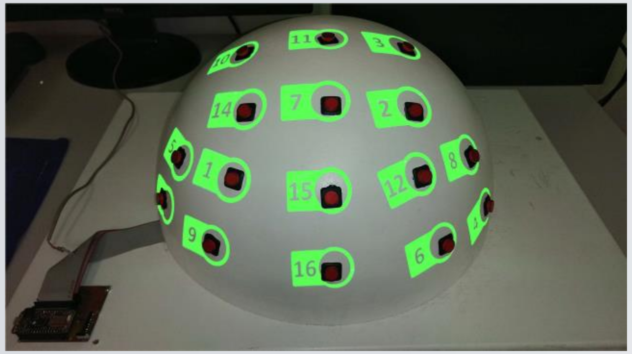
Arrow



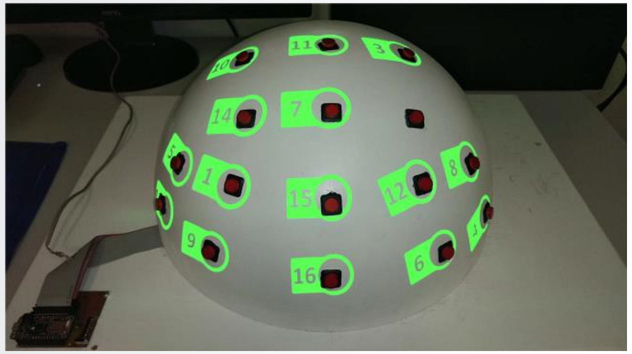
Line



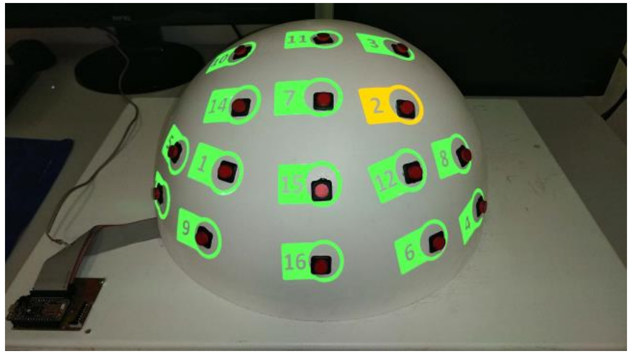
All Case Predictive Cues



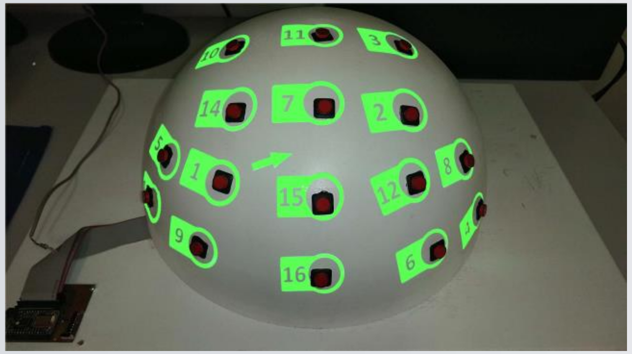
None



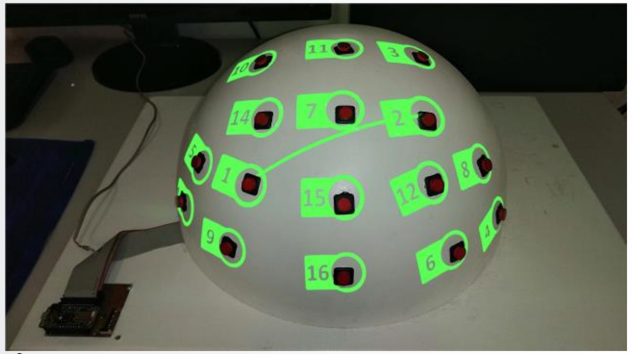
Blink



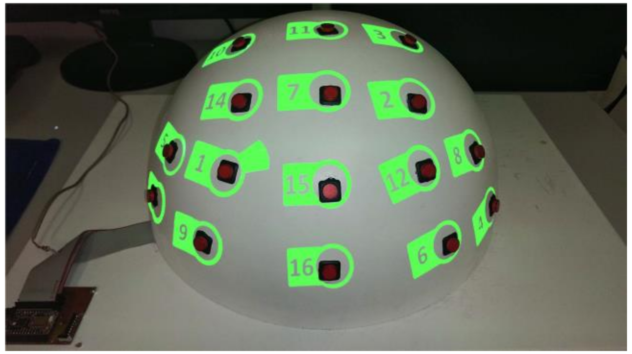
Colour



Arrow



Line



Arc

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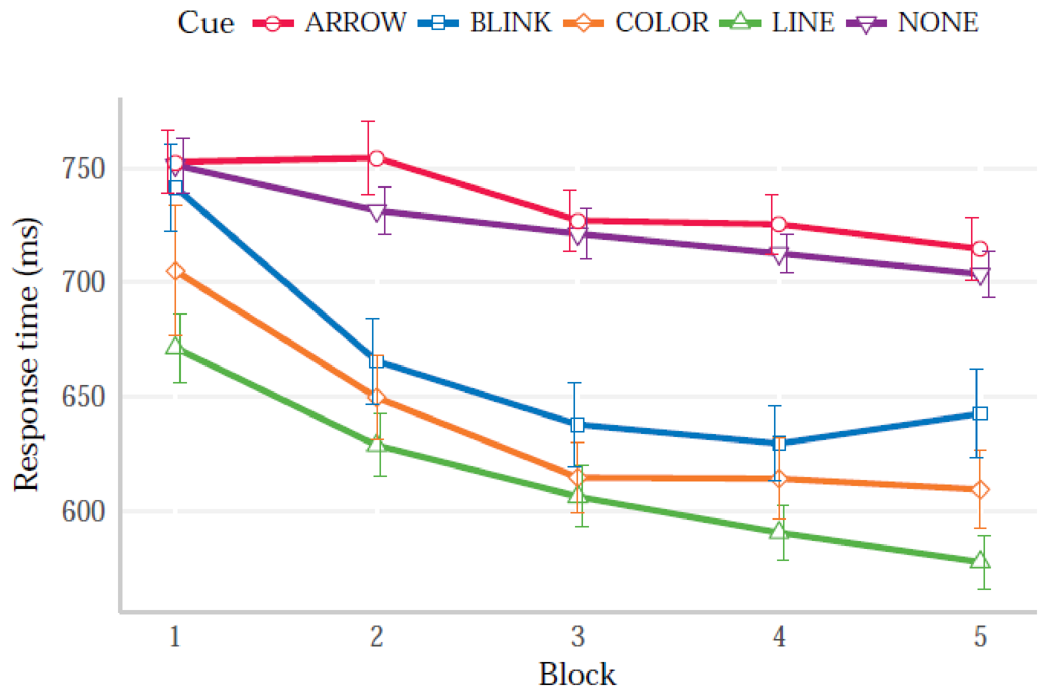
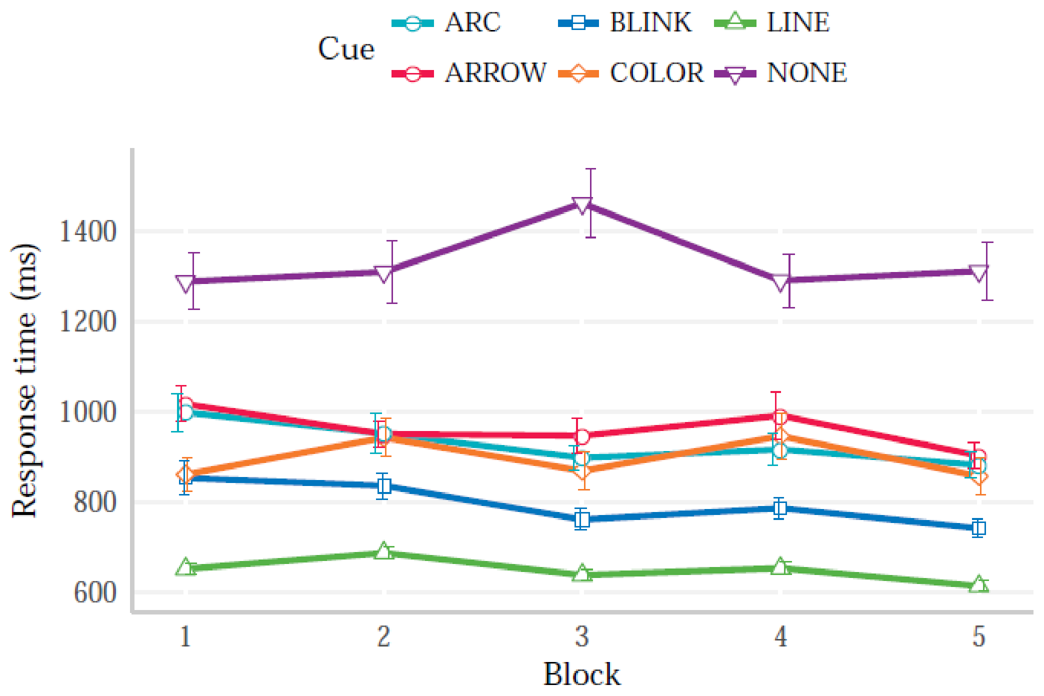
Results - Response Times



(a) Experiment 1: Mean response times in each block for each cue.



(b) Experiment 2: Mean response times in each block for each cue.

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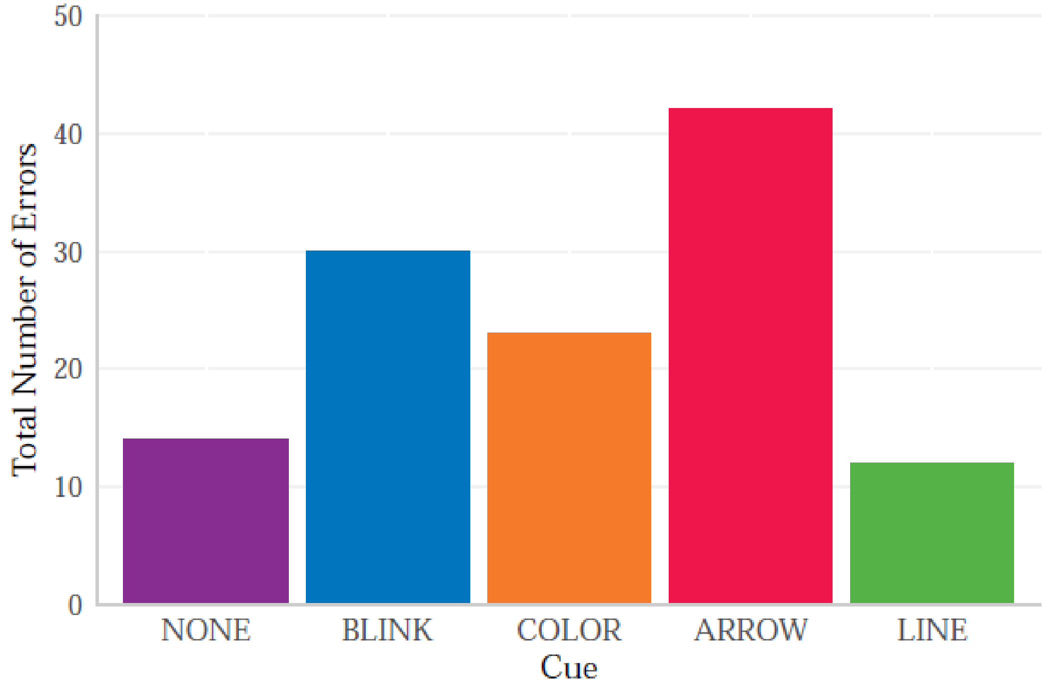
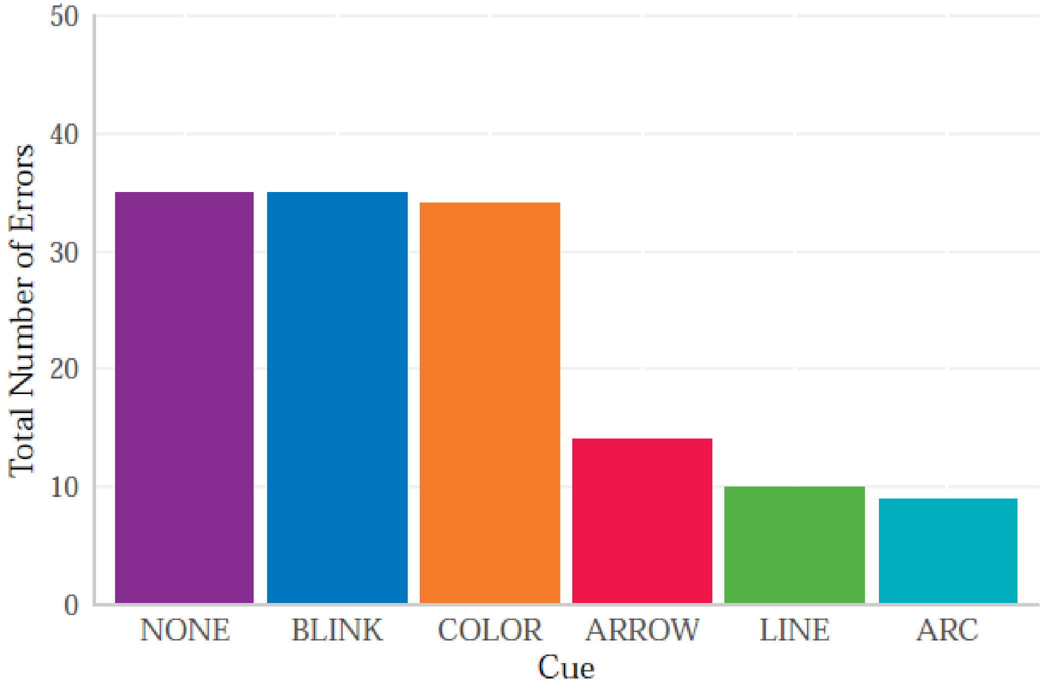
Results - Error Rate



(c) Experiment 1: Total error count for each cue.



(d) Experiment 2: Total error count for each cue.

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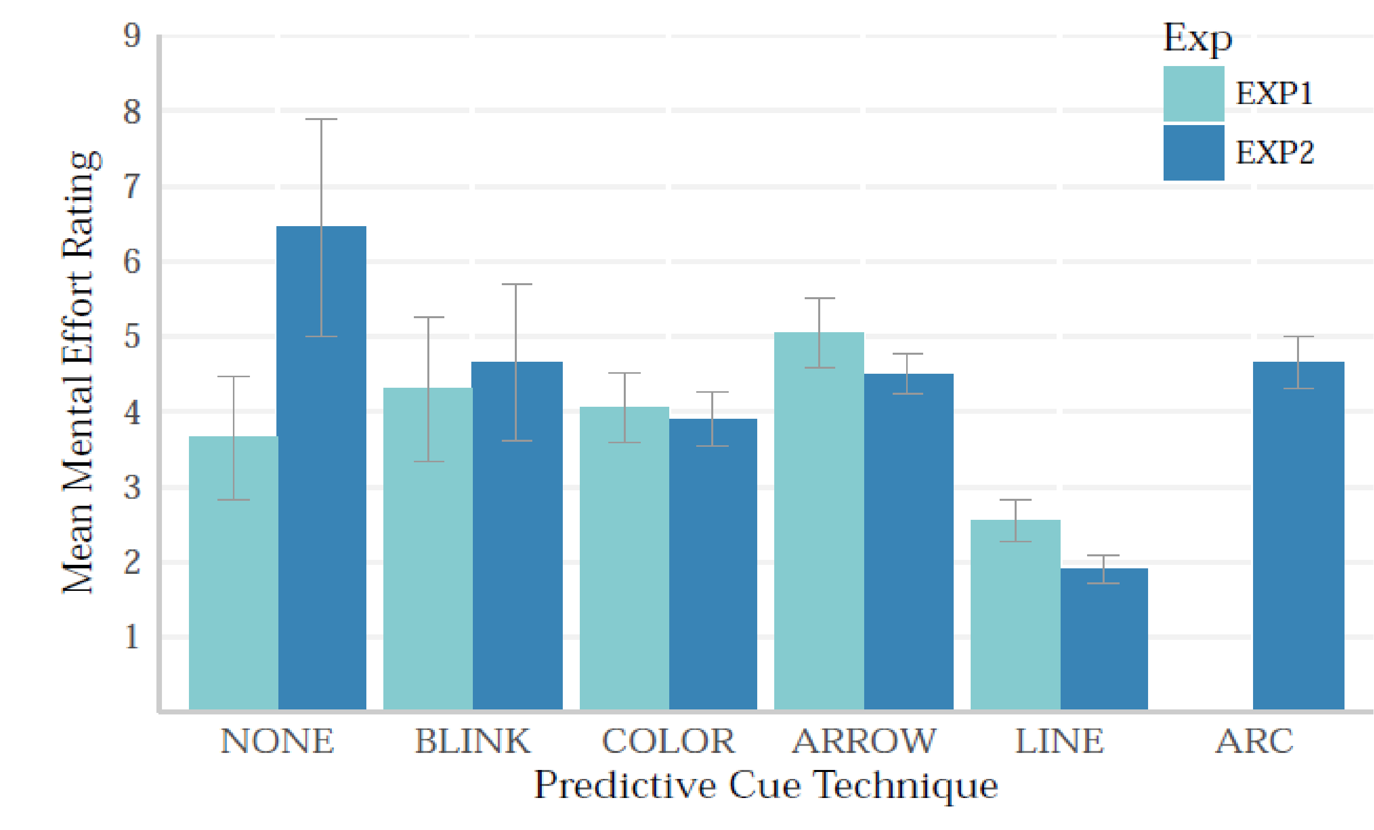
Results – Paas* Scale Scores



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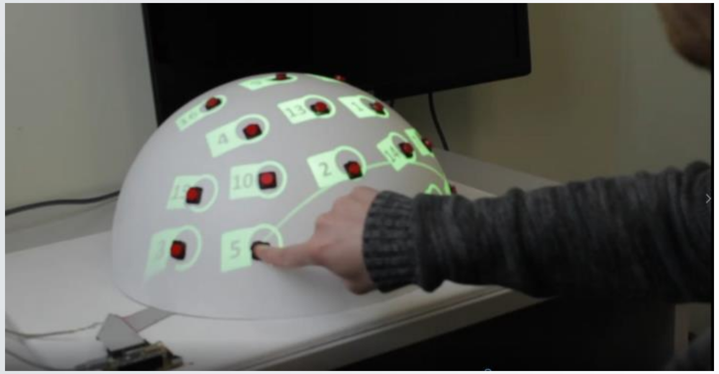
Conclusion

- Providing predictive cues benefits user performance and mental load for procedural tasks
- Line predictive cue overall superior to all conditions
- Arrow predictive cue more complex to understand than we originally thought



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Future work

Explore long term sleep deprivation

Use of EEG odd-ball paradigm for mental effort measures

CONCLUSION

Thank you

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