

Korea - New Zealand Joint Intl. Research

Multimodal Fusion and Illusion:

A Way to Enrich Physical Immersion?



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Motivation

▶ Immersion / Presence

▶ One aspect of UX

▶ Physical immersion

▶ Feeling like “being there” (spatial)

▶ Big VR: Enclosure, Wide FOV, Surround sound, Touch/Haptics, ...

▶ (Psychological immersion – Books, Story, Interaction, ...)

Small FOV
Limited device support
Usability/Wearability
(vs. Immersion)
Mobility

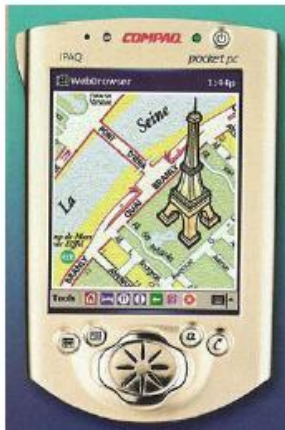
Question: Spatial immersion (presence) possible/enrichable with small VR?

Possible answer: Multimodal interaction

Cross modal integration / Substitution and Illusion

Multimodal Systems

- ▶ Systems that process two or more combined user input/output modes such as speech, pen, touch, gesture, body movement, etc. in a coordinated manner
 - ▶ Five senses: Visual, Aural, Haptic, Tactile, Olfactory, ...
 - ▶ Just different modes: Mouse, Touch, Voice, Gaze, Gesture, Pen, Brain wave, Foot, ...



Speech & Pointing



Speech & Rich Pen Input



Speech & Manual Gestures

Why Multimodality?

▶ Usual reasons

- ▶ Usability – Natural / Easy to Learn / Preference
- ▶ Flexible – Broader Target Users / Complementary
- ▶ Efficient – Fast / Lower error / Robust and Disambiguating / Modality match
- ▶ Experiential – Realistic / Affective

▶ Get something with something else (and maybe less)

▶ Cross modal integration, Modality Substitution, Illusion

- ▶ Force feedback with vibro-tactile
- ▶ McGurk effect
- ▶ Ventriloquist effect
- ▶ Phantom limb
- ▶ Synesthesia



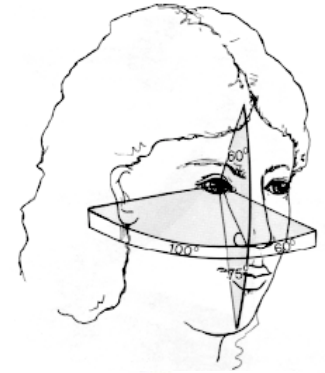


IEEE VR 2004

**Increasing the effective FOV
with proprioceptive and tactile feedback
(with Ungyeon Yang)**

Head Mounted Display

- ▶ General egocentric visual interface
 - ▶ Immersive and high presence
- ▶ Narrow **physical** field of view (FOV).
 - ▶ Popular edition: $20^{\circ} \sim 30^{\circ}$ (diagonal)
 - ▶ Oculus Rift: Inexpensive and wide FOV (2013)
 - ▶ Negative Effects
 - ▶ Unnatural
 - ▶ Task performance in virtual environment.
 - ▶ Decrease **Presence**
- ▶ **Geometric** FOV
 - ▶ S/W controllable parameter

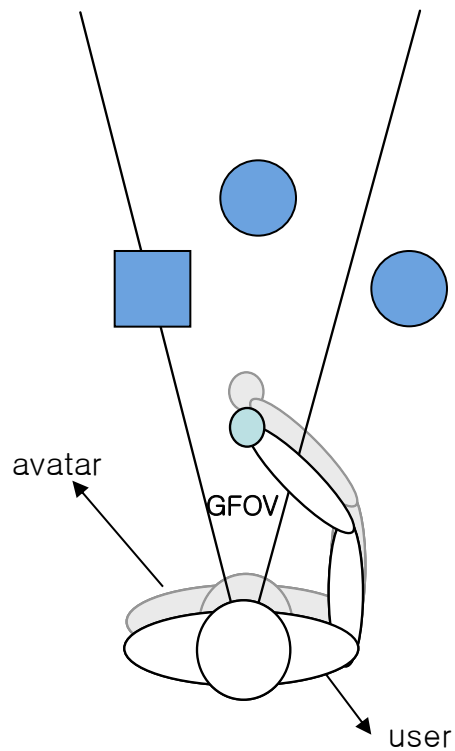


Virtual Research
V8 Diagonal 60°



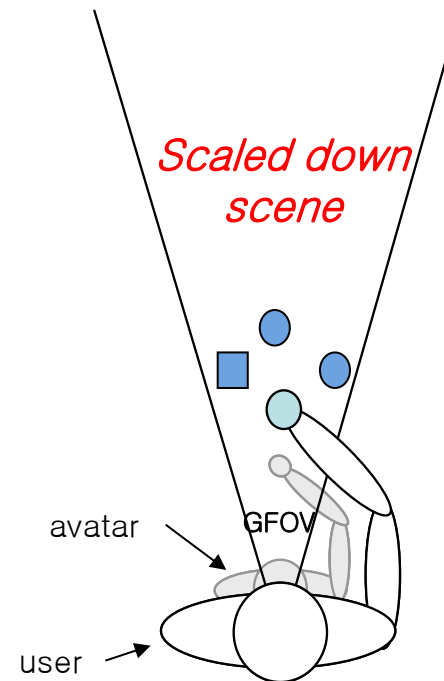
GFOV (Software FOV)

GFOV = PFOV



(a)

Enlarged GFOV

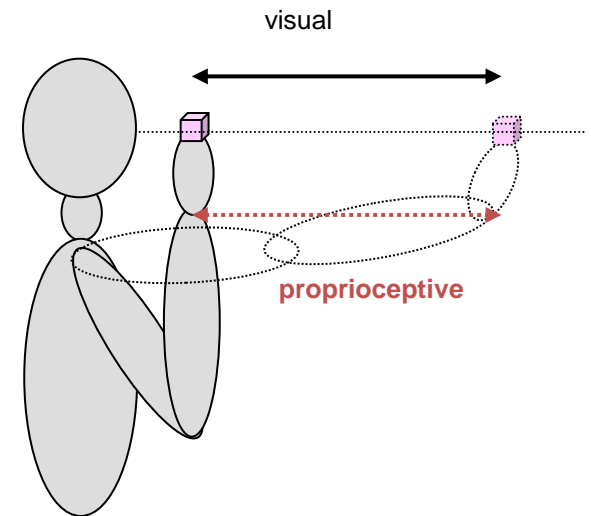


But possibly with distorted distance perception

(b)

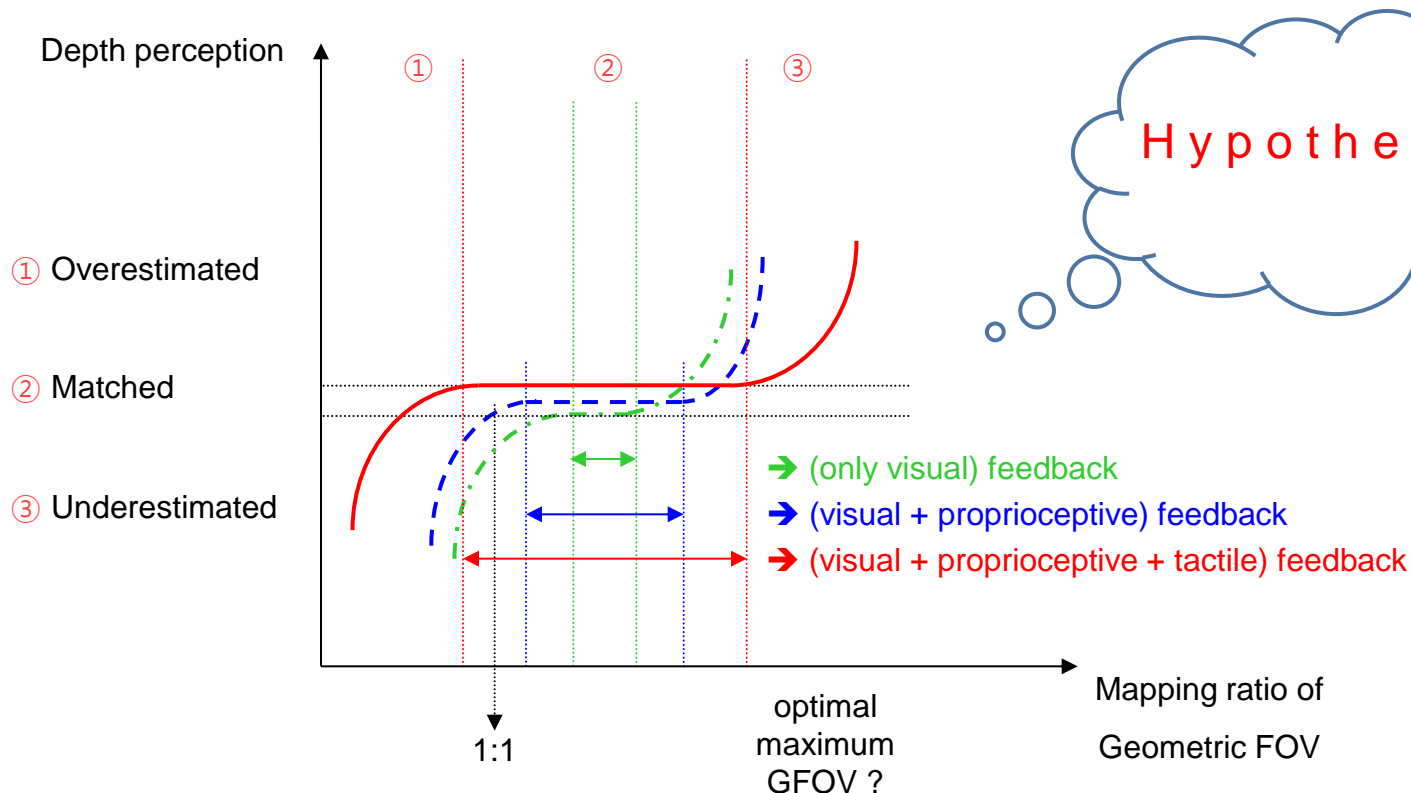
FOV and Distance Perception

- ▶ Egocentric distance perception
 - ▶ Under-estimation in real environment
 - ▶ **Significant** under-estimation in VE
 - ▶ Important to sensory feedback match between visual and proprioceptive cue
- ▶ Conventional Calibration with HMD
 - ▶ 100% mapping to physical FOV
 - ▶ **Under-estimation** condition
- ▶ How about increasing GFOV to MAX?
 - ▶ **To see more (wider effective FOV)**
 - ▶ **Constraint: Without loss** of distance perception



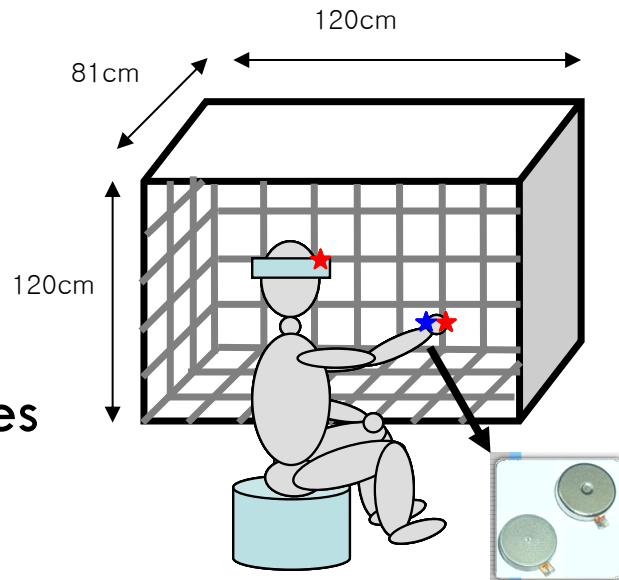
Suggested Solution: Multimodal Feedback

- ▶ Increase GFOV for HMD and
- ▶ Compensate degraded depth perception with multimodal interaction (**Proprioceptive** – Reach out to the object, not just looking at it ...)

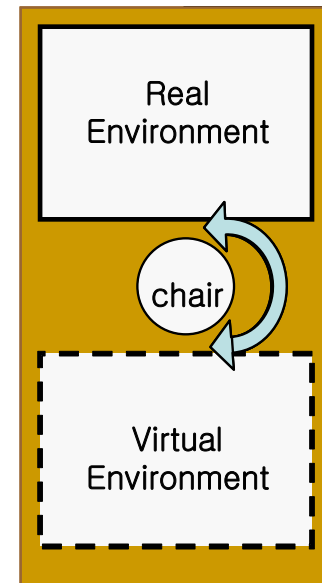


Experiment

- ▶ Compare distance perception (Matching task)
 - ▶ Real vs. virtual under different conditions
- ▶ Test condition
 - ▶ GFOV: 11 levels
 - ▶ 100% ~ 200%
 - ▶ Matching feedback types
 - ▶ Visual only
 - ▶ Tactile only
 - ▶ Visual and tactile (multimodal)

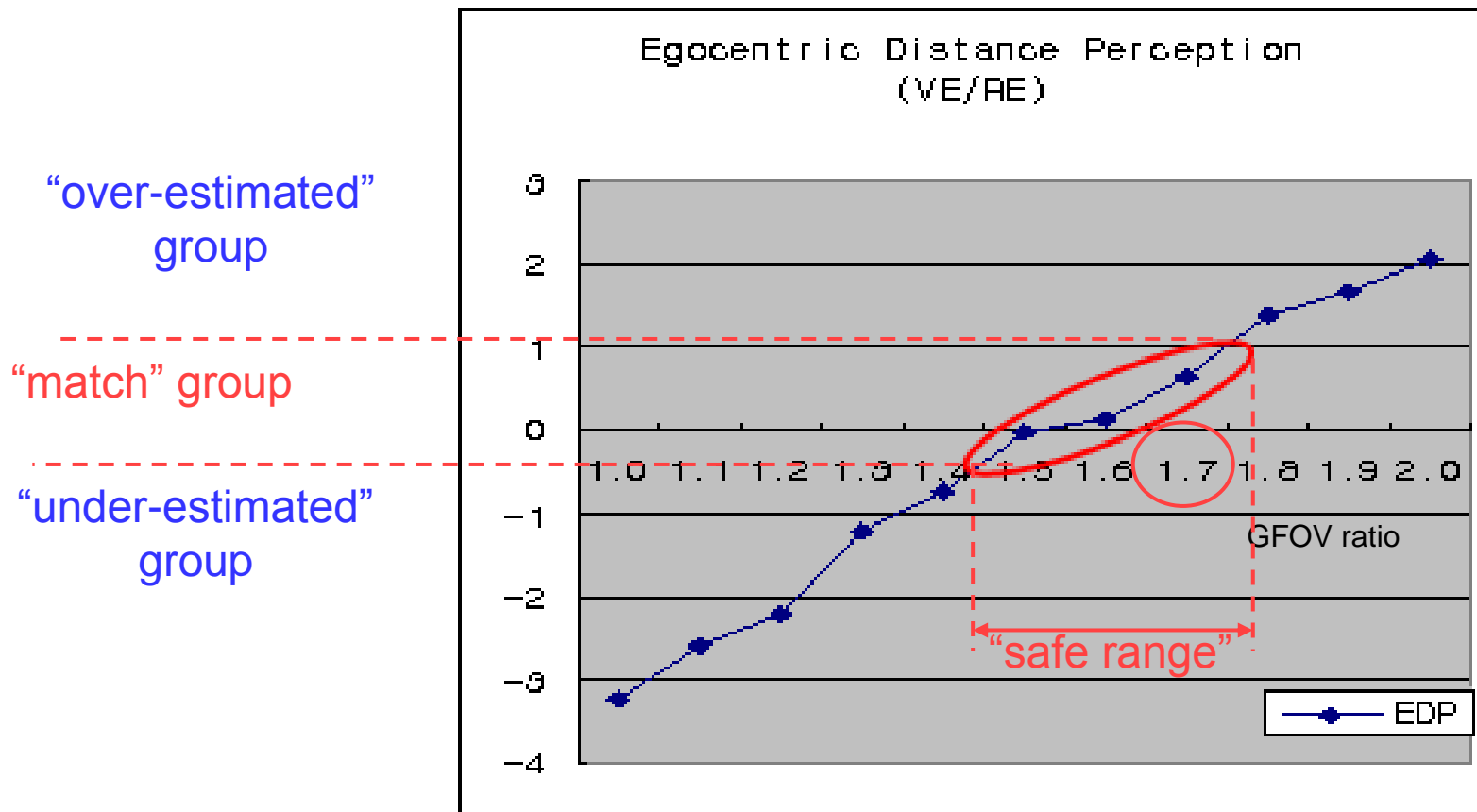


Top view



Results

- ▶ Maximum over-mapping GFOV to 170%
- ▶ diagonal FOV 31.2° → diagonal GFOV 53.04°





ACM VRST 2006

Hand-held virtual reality:

A feasibility study

(with Jane Hwang)

Objective

- ▶ Q: Is “minimum” level of immersion or presence possible with hand-held devices? (is hand-held VR a possibility?)
 - ▶ Can we overcome the small “display” problem with multimodality and interaction design?
 - ▶ Plus: what about usability and task performance?



What we did

- ▶ Vary Interaction style
 - ▶ Button based
 - ▶ Motion based multimodal interface (proprioceptive / body based)
- ▶ Against different displays by size of FOV
 - ▶ Mobile
 - ▶ Monitor
 - ▶ Large monitor
- ▶ Measure
 - ▶ Presence/immersion and Perceived FOV
 - ▶ Usability
 - ▶ Performance

Motion based interface: (optical flow)



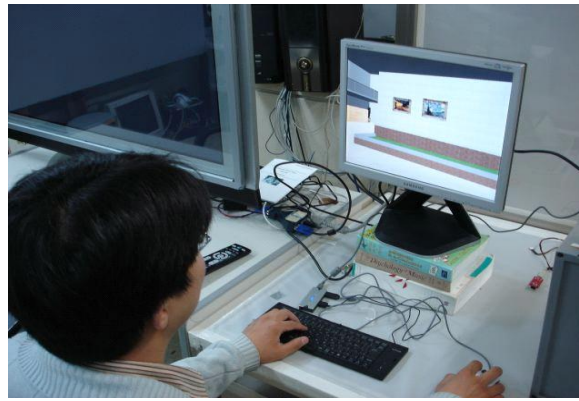
5 Treatments



Motion-based hand-held VR



Button-based hand-held VR

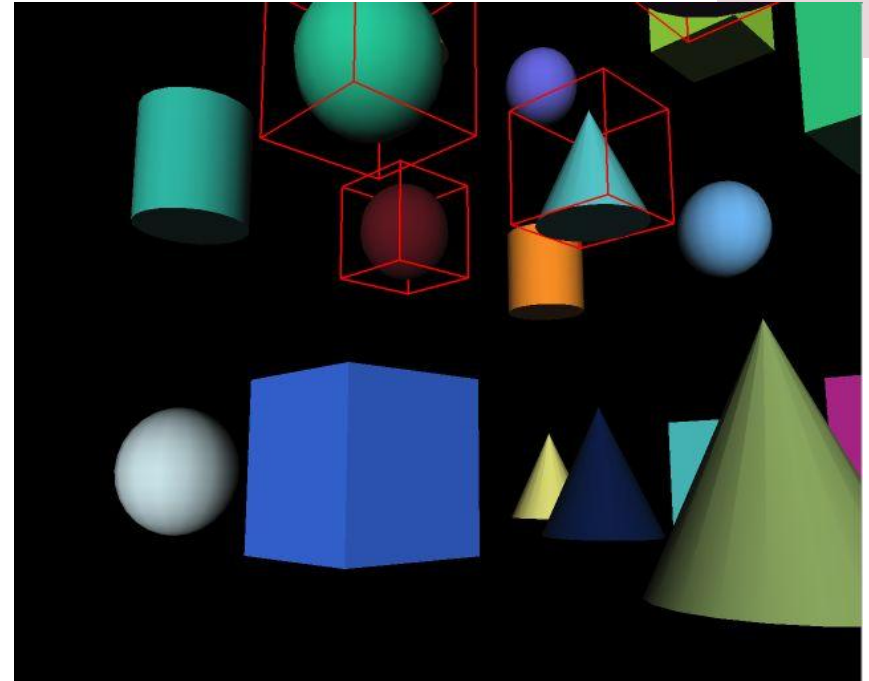


Mouse/Keyboard interaction in small screen/desktop/large screen

Tasks

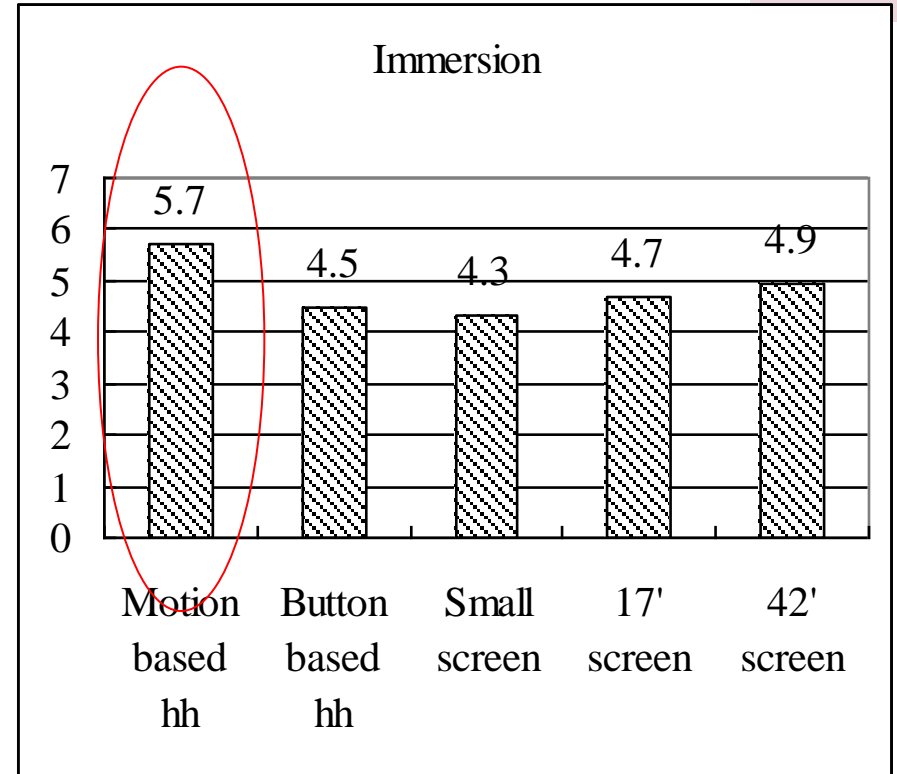
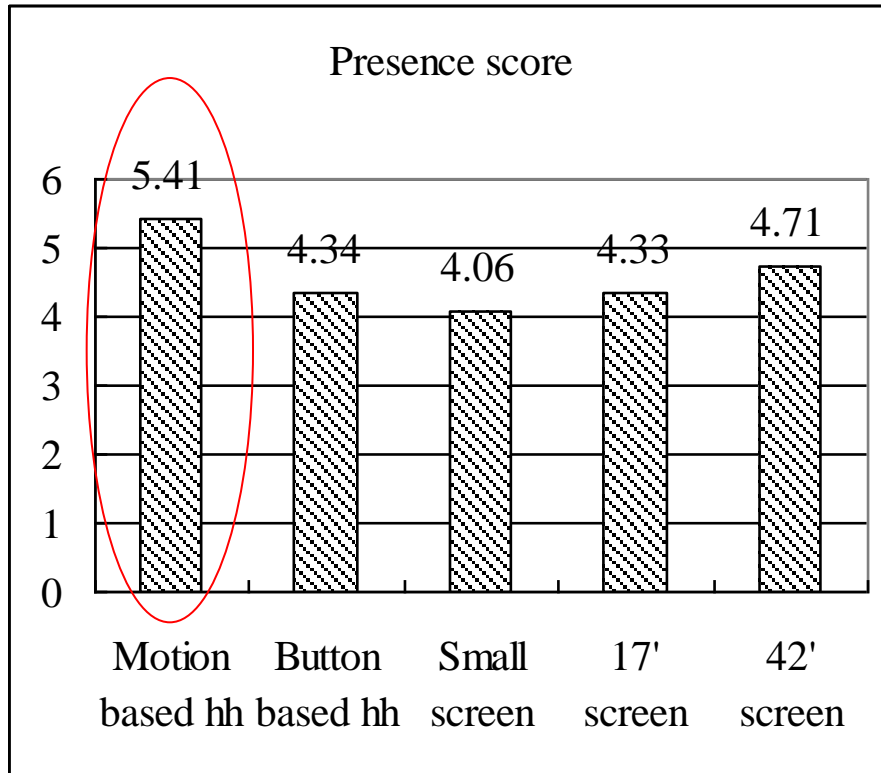


Navigating in virtual environment
➔ Usability, presence/immersion, enjoyment, and perceived FOV

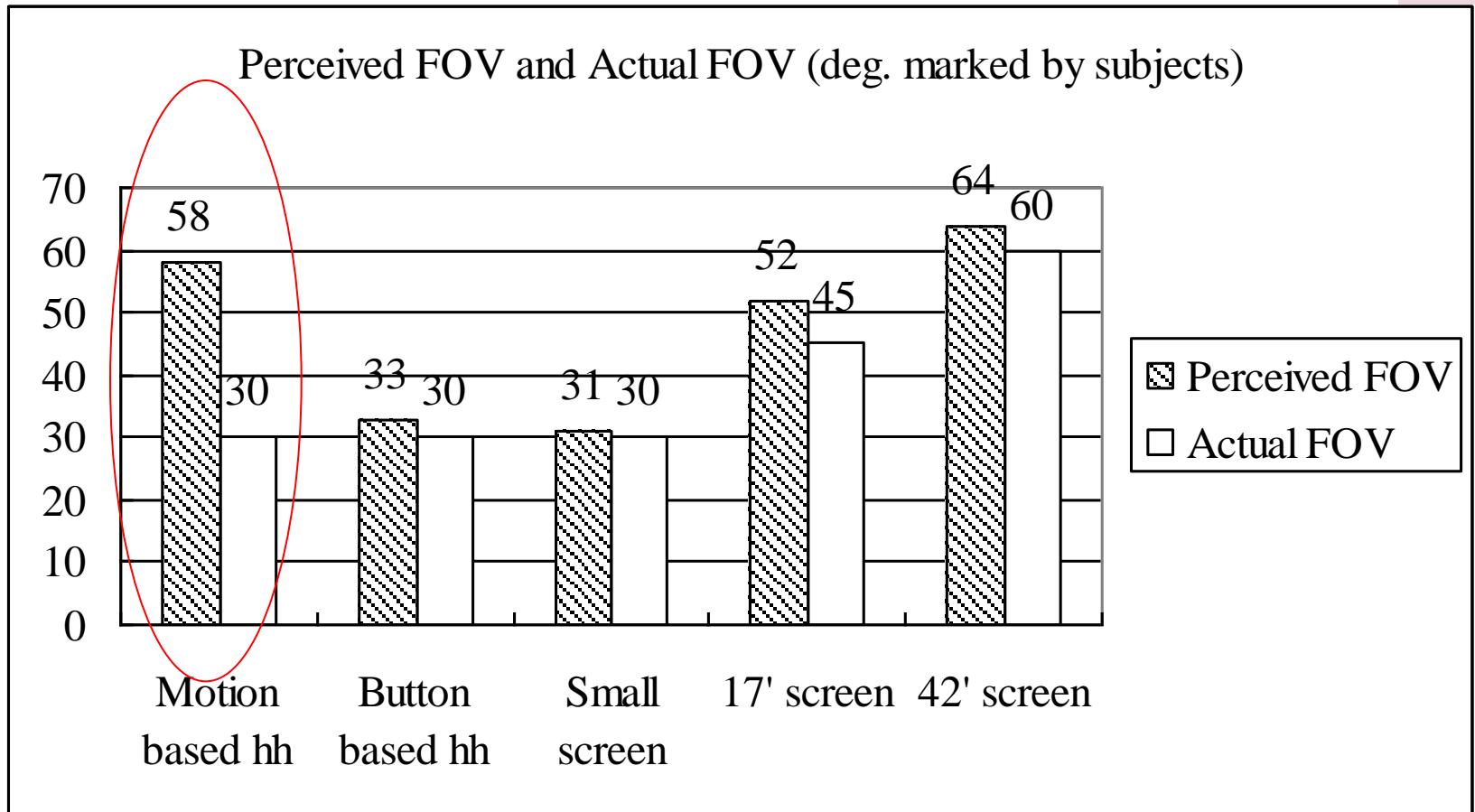


Locating and selecting objects
➔ Task performance

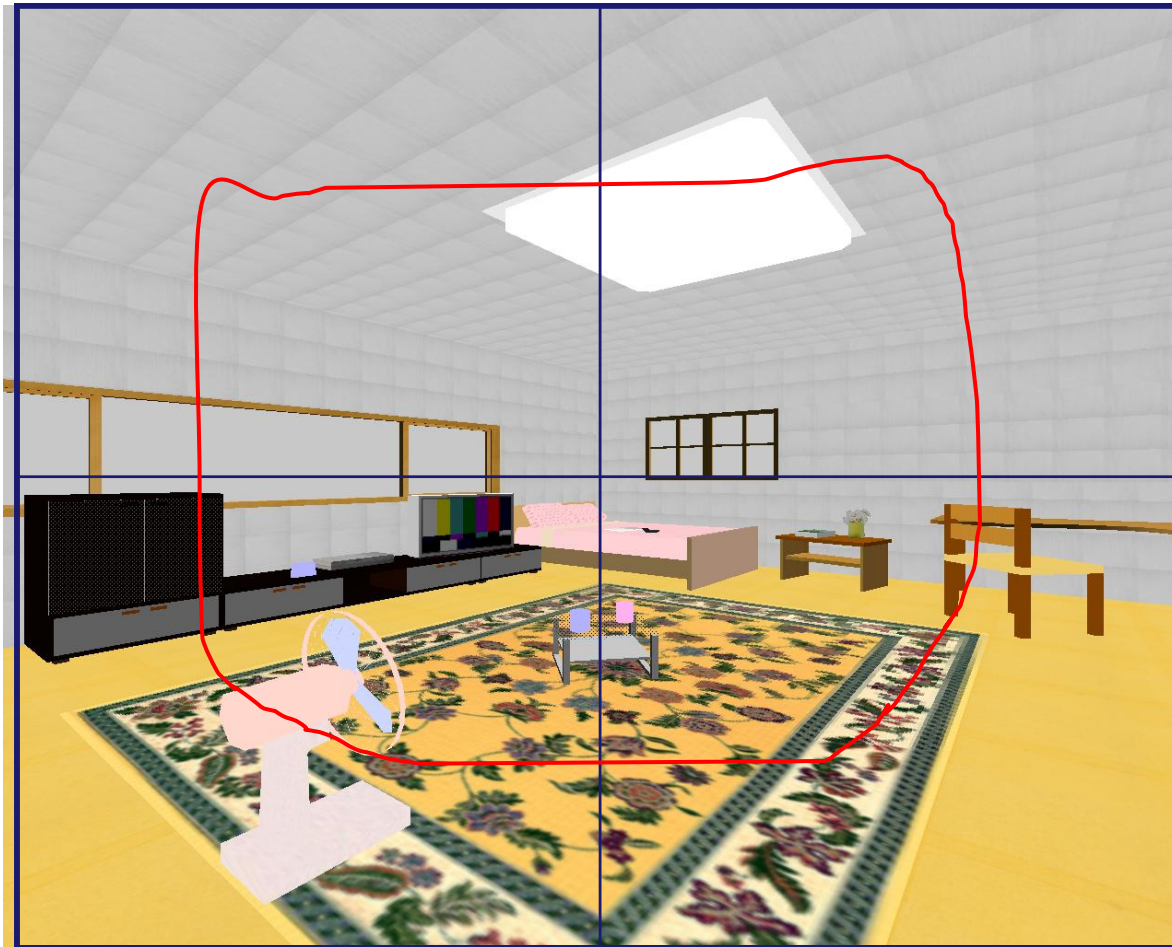
Presence/Immersion



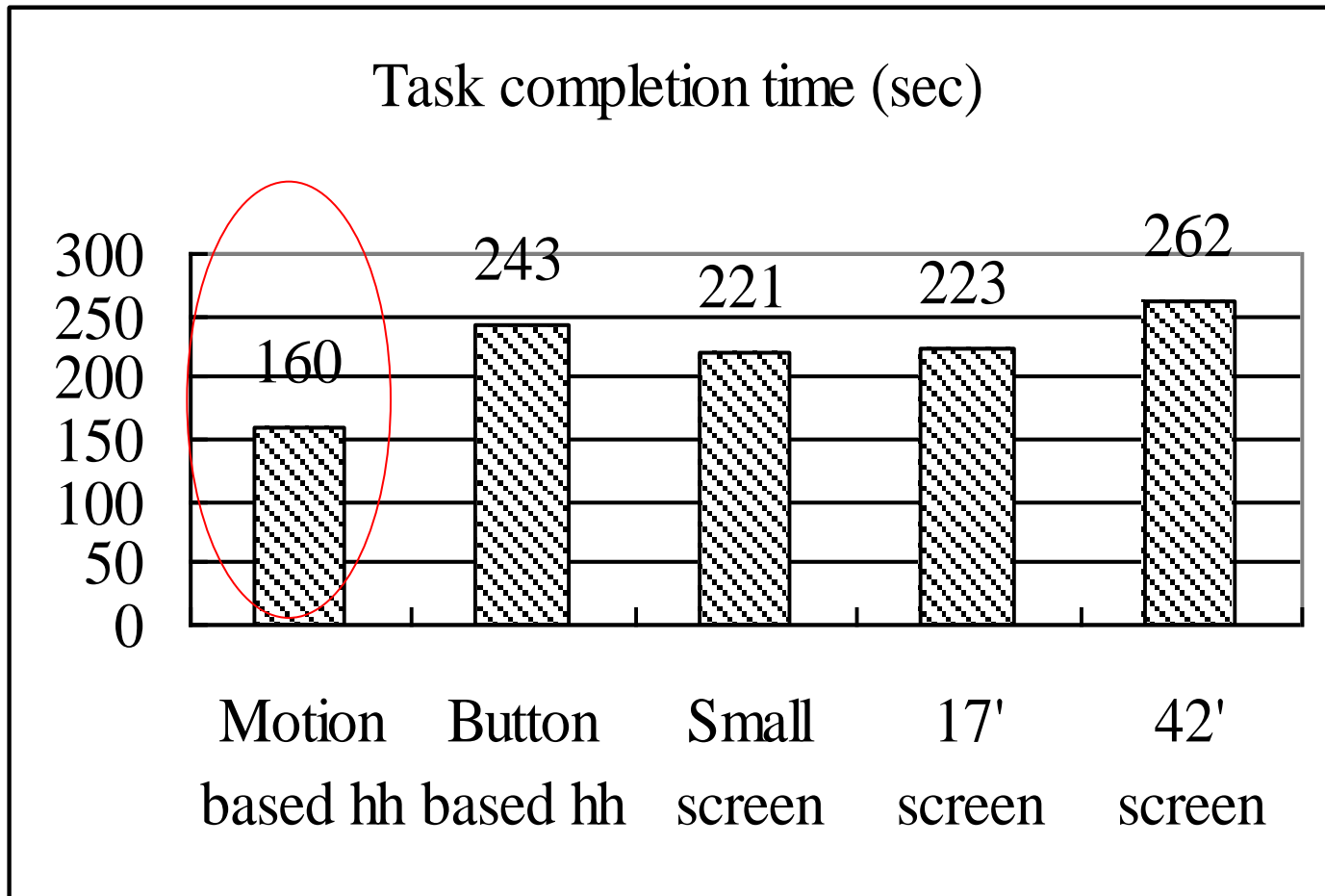
Perceived FOV



Measuring perceived FOV

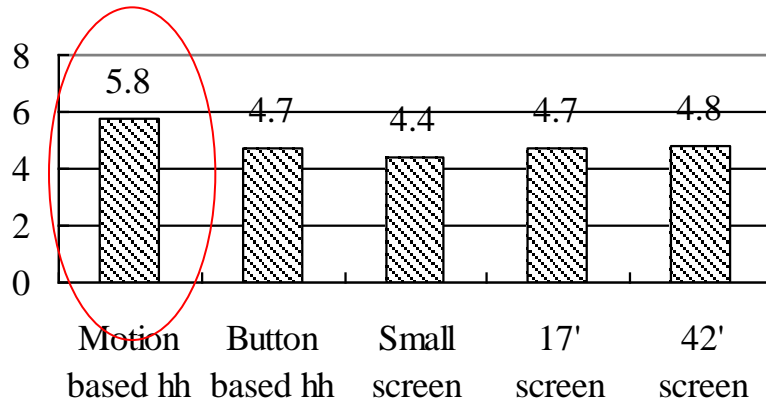


Task Performance

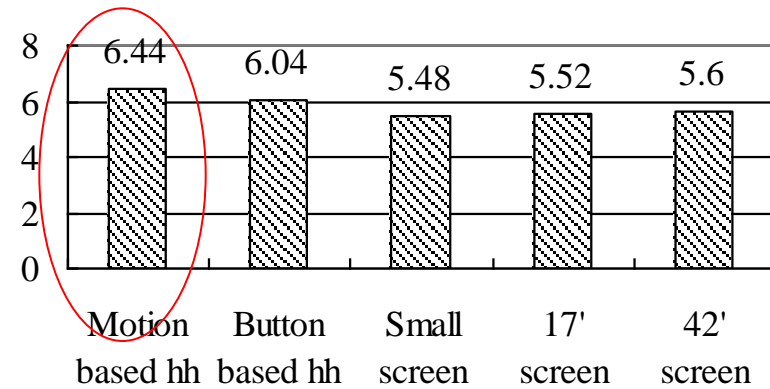


Usability

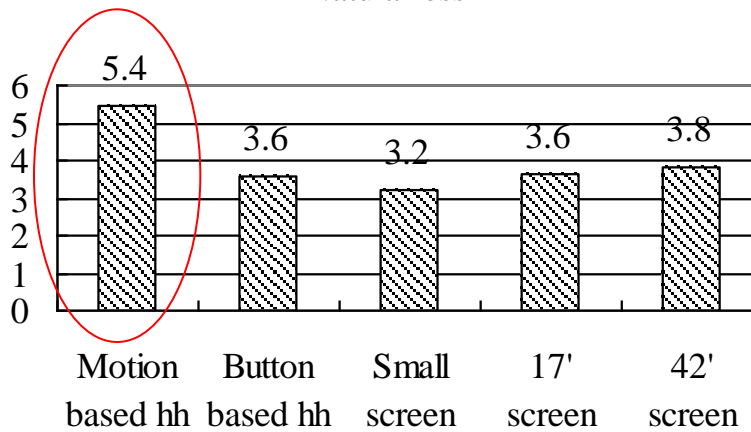
Easy to use



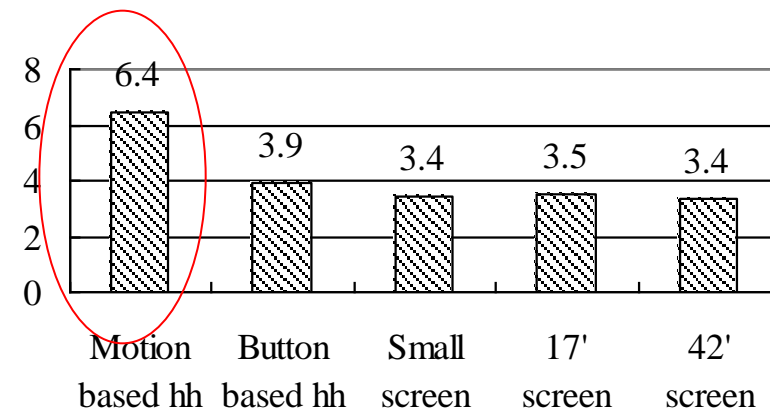
Easy to learn



Naturalness



Intuitiveness



Summary

- ▶ Assessed the feasibility of VR on hand-held devices
 - ▶ High presence/Immersion possible
 - ▶ Widened **perceived** FOV
 - ▶ Usability, enjoyment and task performance
- ▶ Interaction style is important
 - ▶ Involve the body
 - ▶ Multimodal synergy



CHI 2012

Funneling and saltation effects for tactile interaction with virtual objects

(with Jaedong Lee and Youngsun Kim)

Motivation

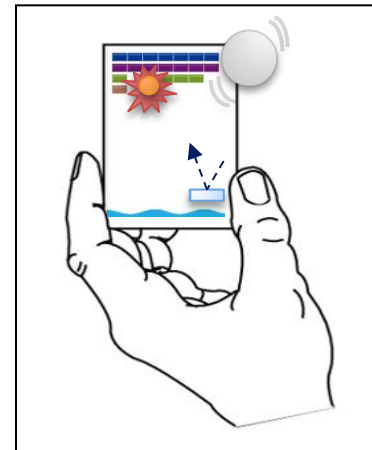
▶ Vibro-tactile feedback

- ▶ Inexpensive and effective way to enhance interaction experience

▶ Limitations of tactile interaction



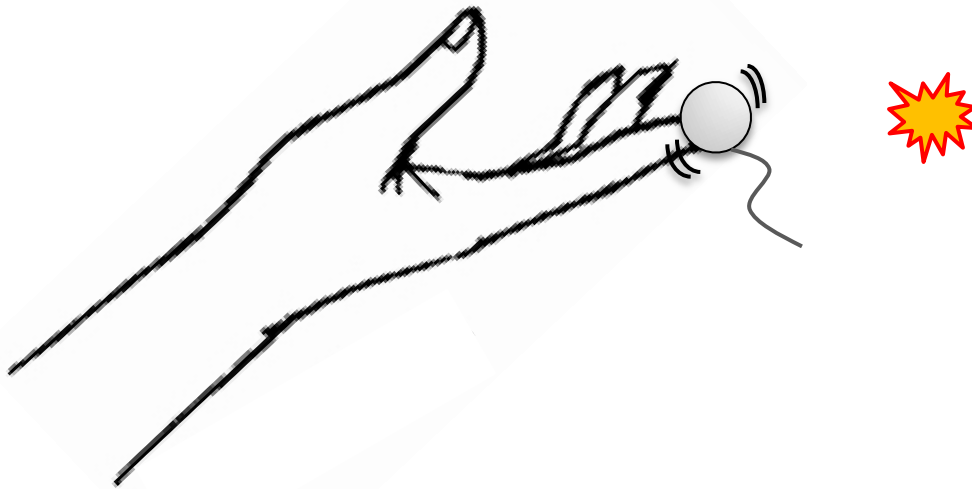
High mechanical complexity
Costly hardware
Unnatural interaction



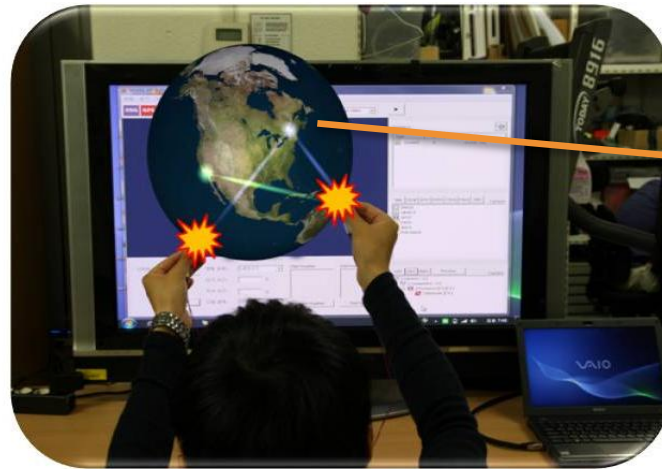
Indirect stimulation / Single vibrator :
Difficult to associate detailed
content

Use “Out of the body” Tactile Illusion

- ▶ Minimize the number of vibrators
- ▶ Provide indirect but richer tactile feedback



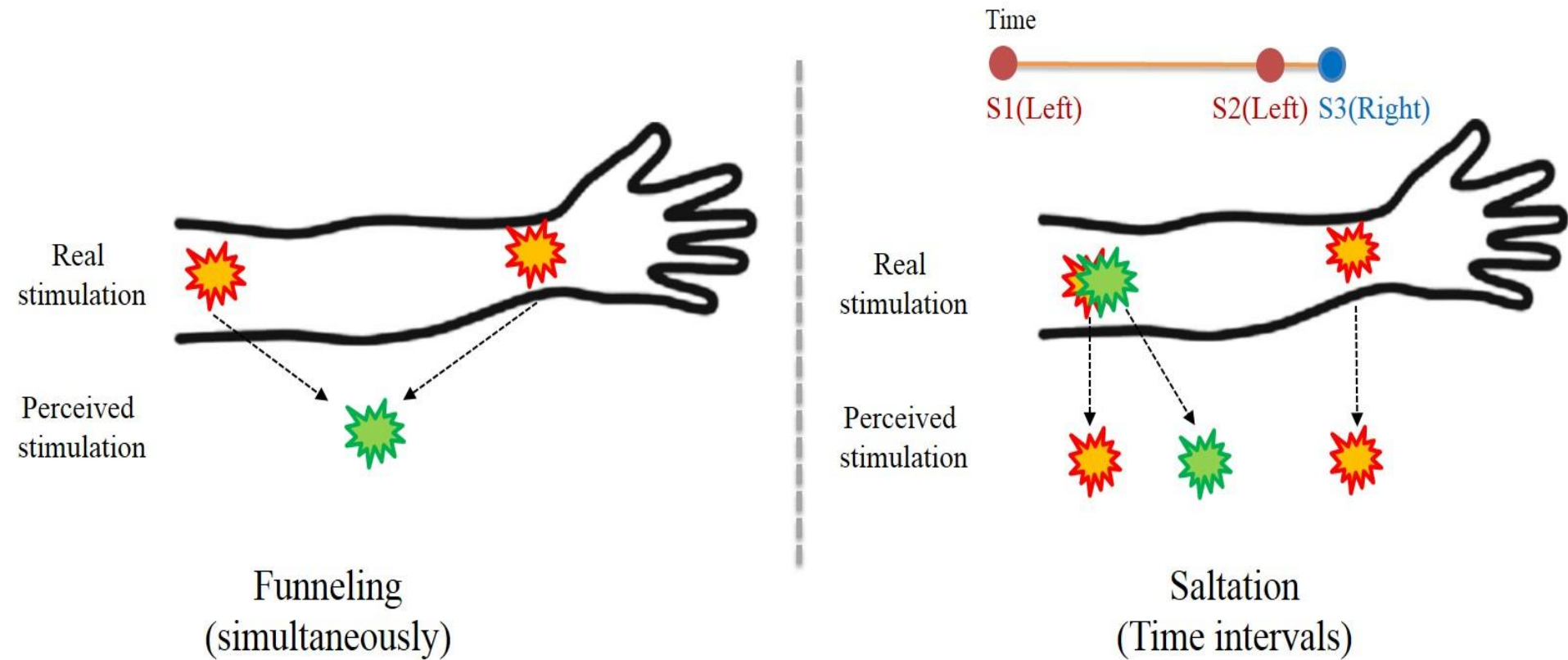
Applications



Stereoscopically
rendered object



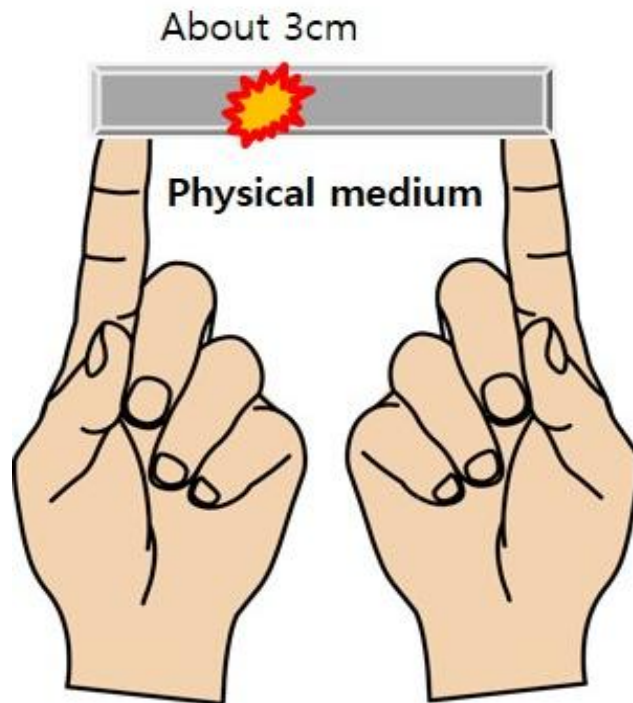
Funneling and Saltation



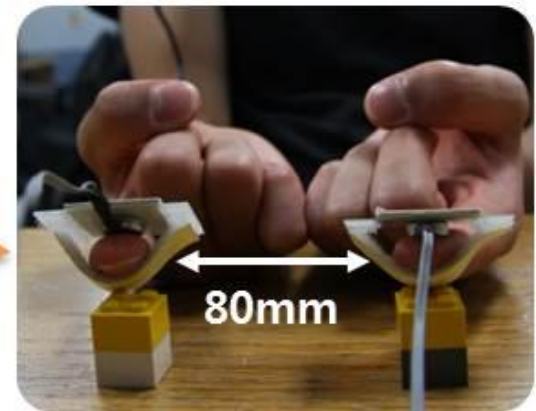
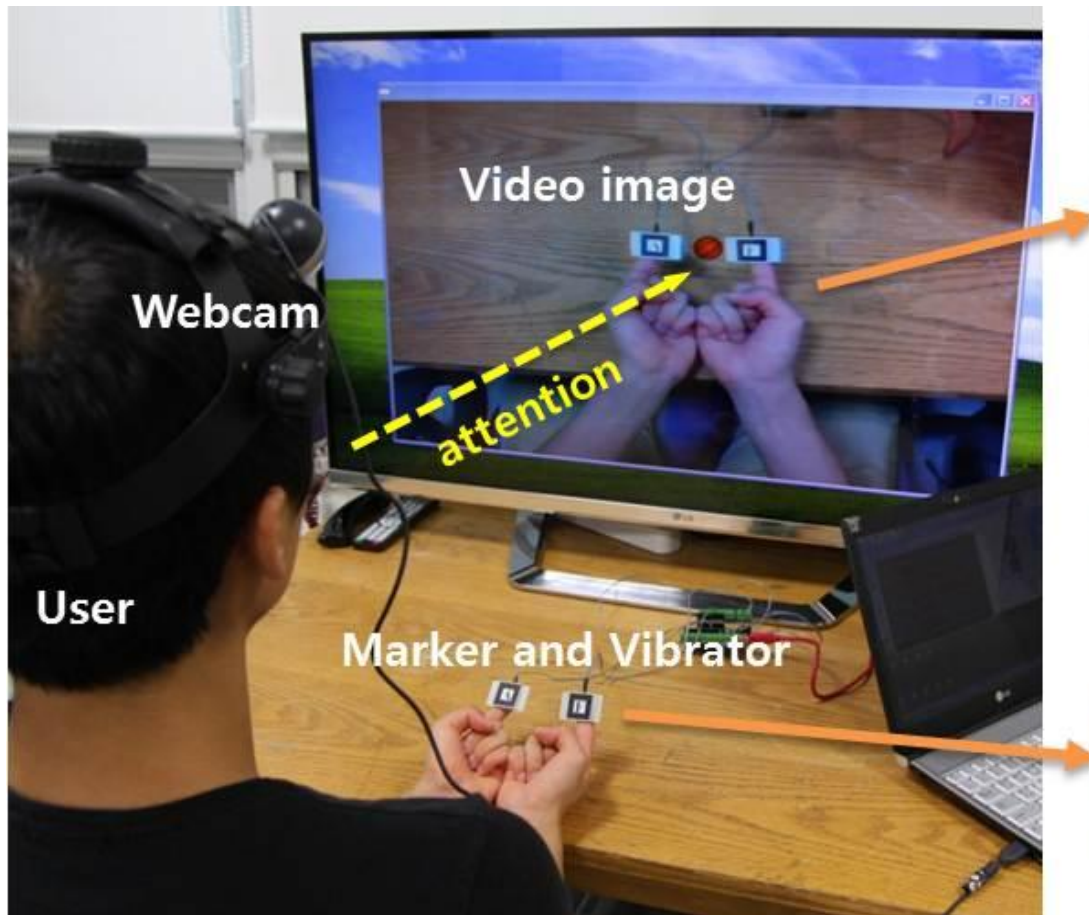
Information Transmission by Phantom Sensations.
IEEE Transactions on Man-Machine Systems,
(Alles, 1970)

The Cutaneous Rabbit: A Perceptual Illusion.
Science, (Geldard, 1972)

Out of the Body Illusion



Experiment

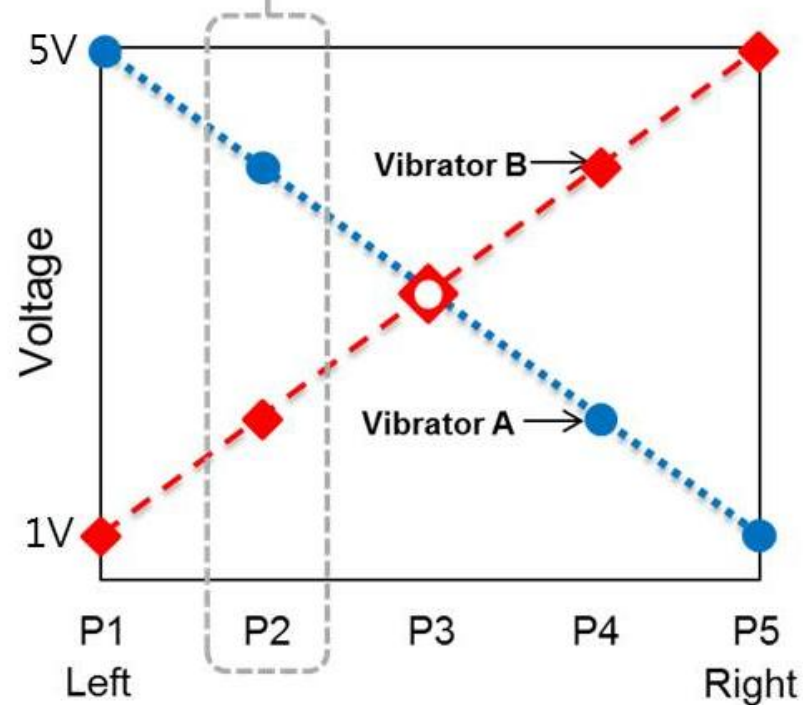
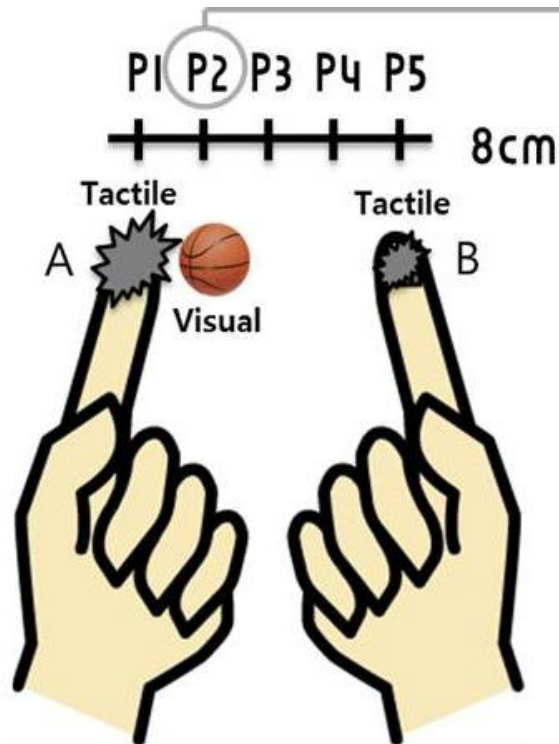


Out of the Body on the Virtual



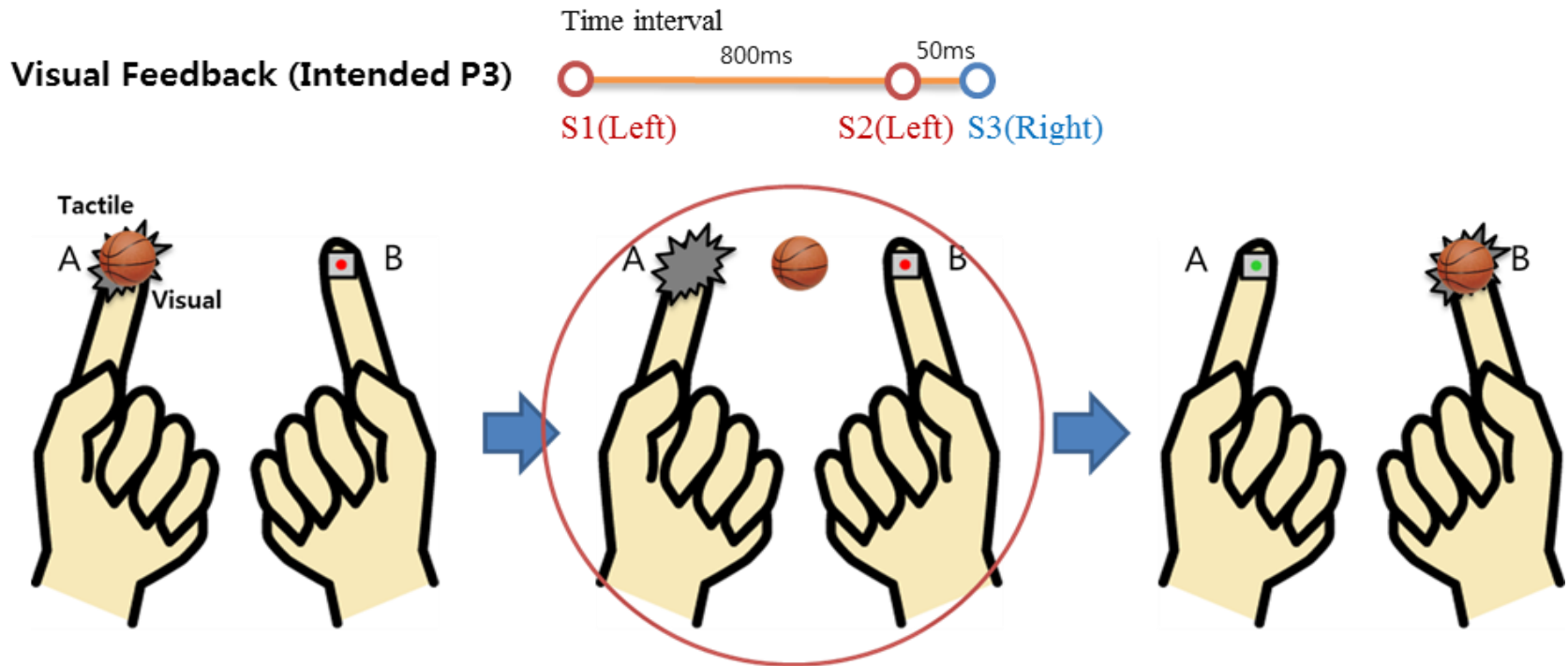
Out of the Body: without Body Extension

Funneling



Out of the Body: without Body Extension

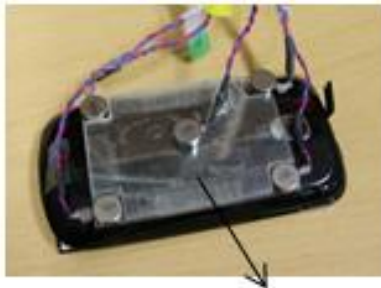
Saltation



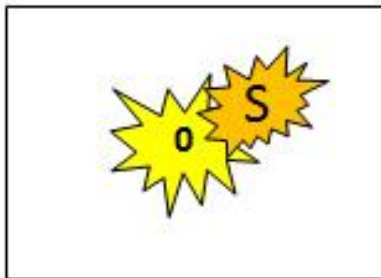
Extending to 2D



Single



Used

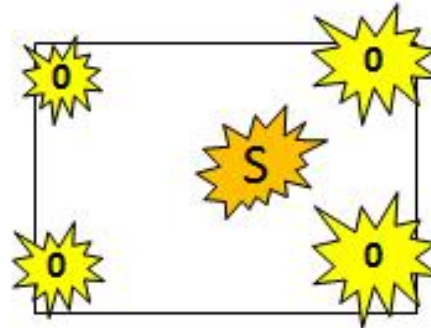


Stimulation at the middle
Location of sensation not
controllable

Funneling



Not used

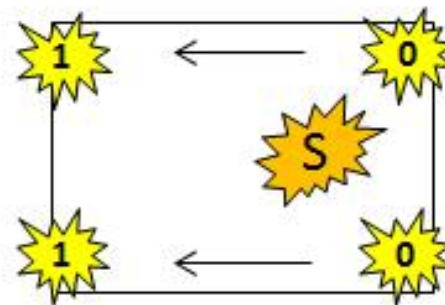


Simultaneous stimulation
at 3 corners
Location of sensation
controlled with relative
amplitudes

Saltation



Not used

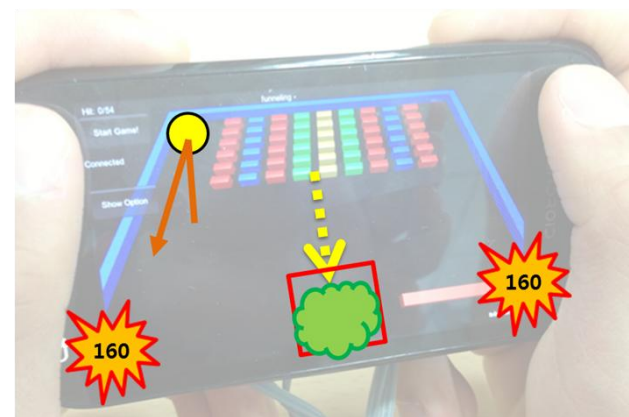
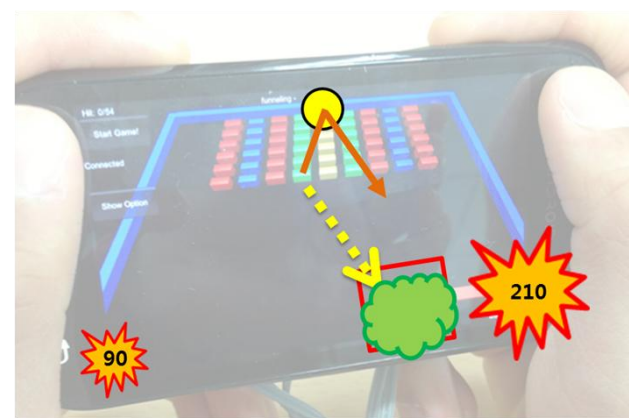
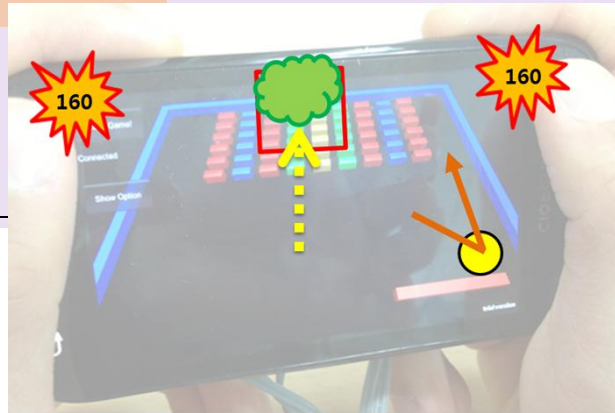


Timed stimulation
at 4 corners
Location of sensation
controlled with ISI's

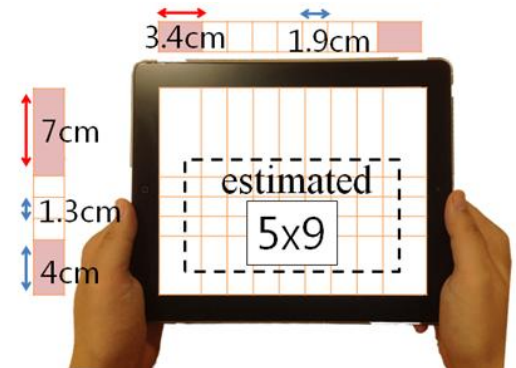
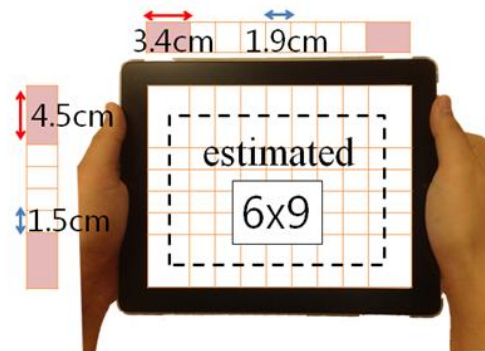
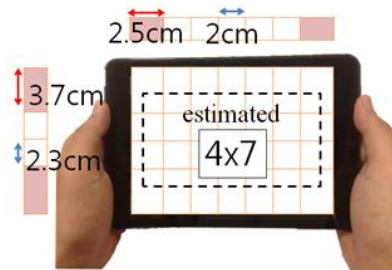
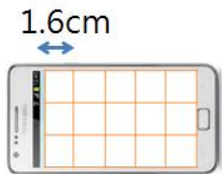
Arkanoid



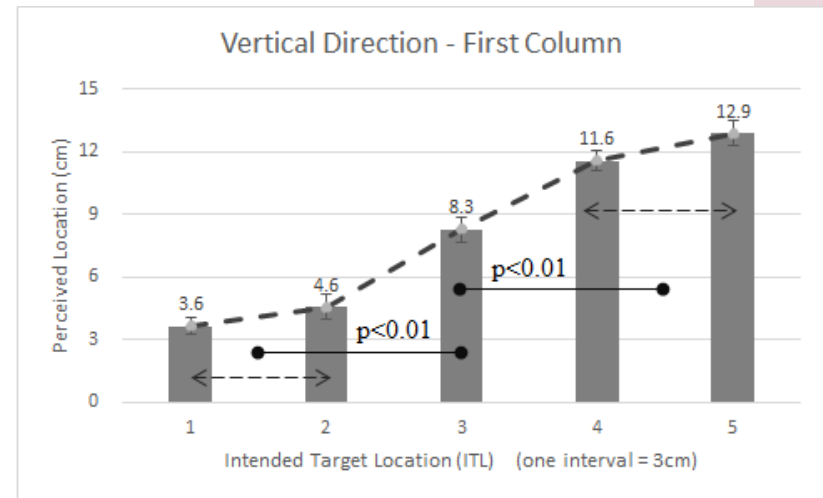
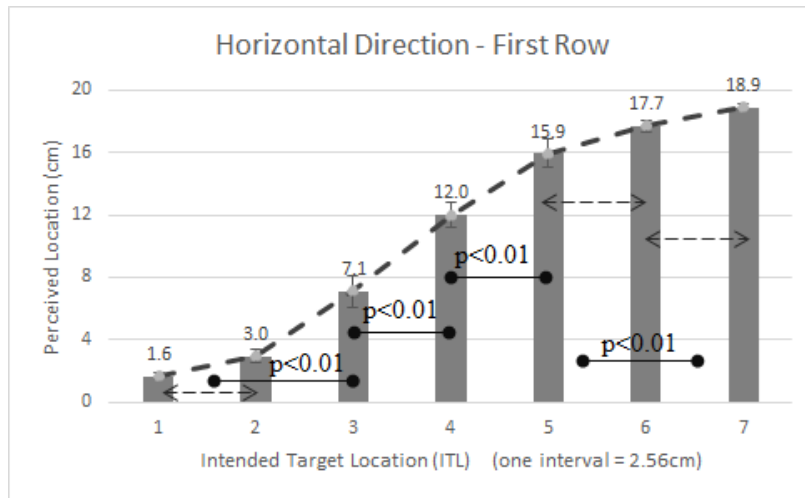
movie



To a larger sized device? (like an i-Pad)

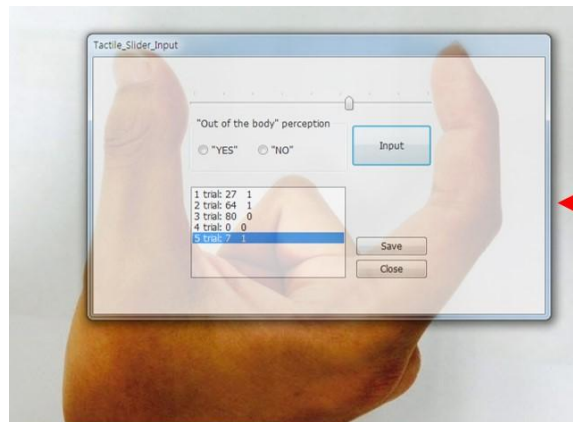
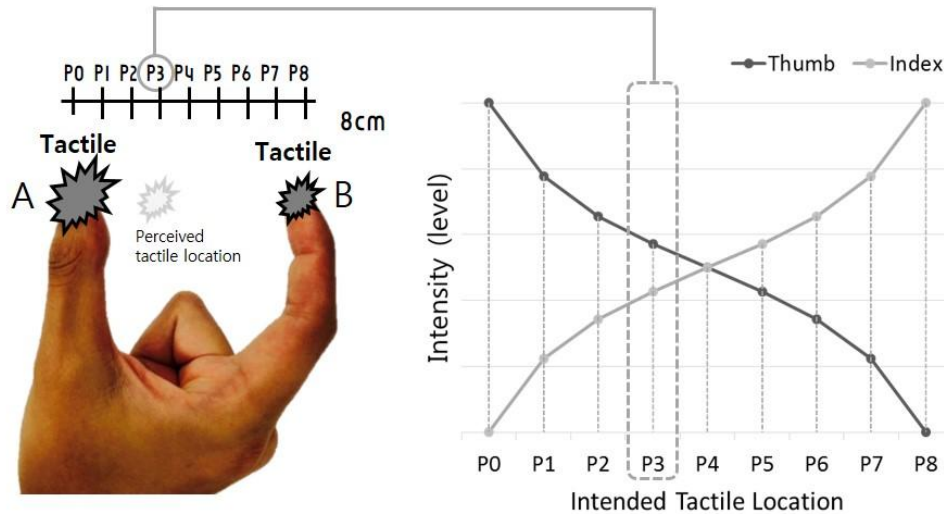


To a larger sized device? (like an i-Pad)

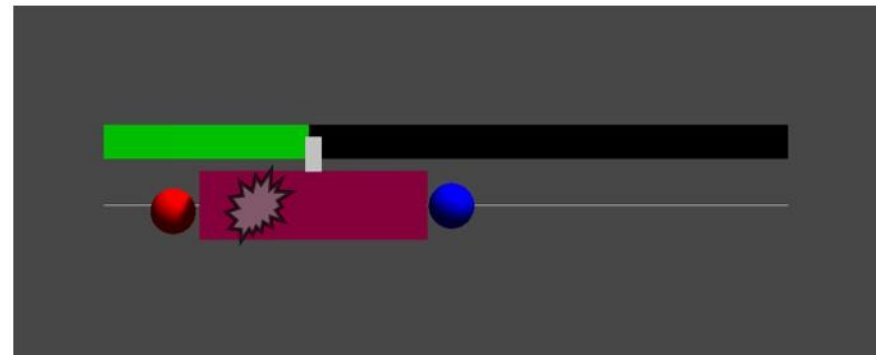
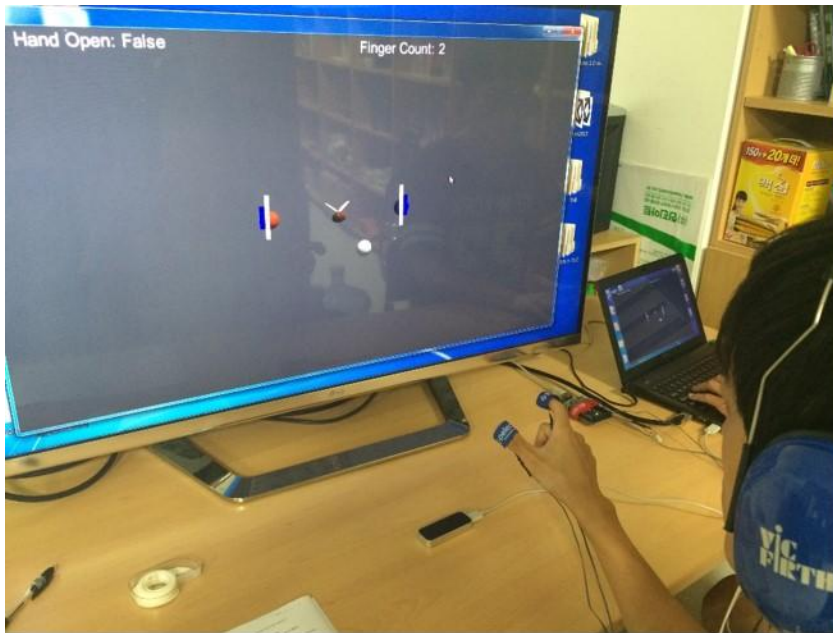


73.9	65.2	56.5	60.8	52.1	82.6	86.9
78.2	91.3	65.2	69.5	78.2	73.9	78.2
86.9	86.3	78.2	86.9	91.3	73.9	91.3
95.6	91.3	56.5	69.5	73.9	95.6	91.3
91.3	73.9	73.9	52.1	73.9	69.5	73.9

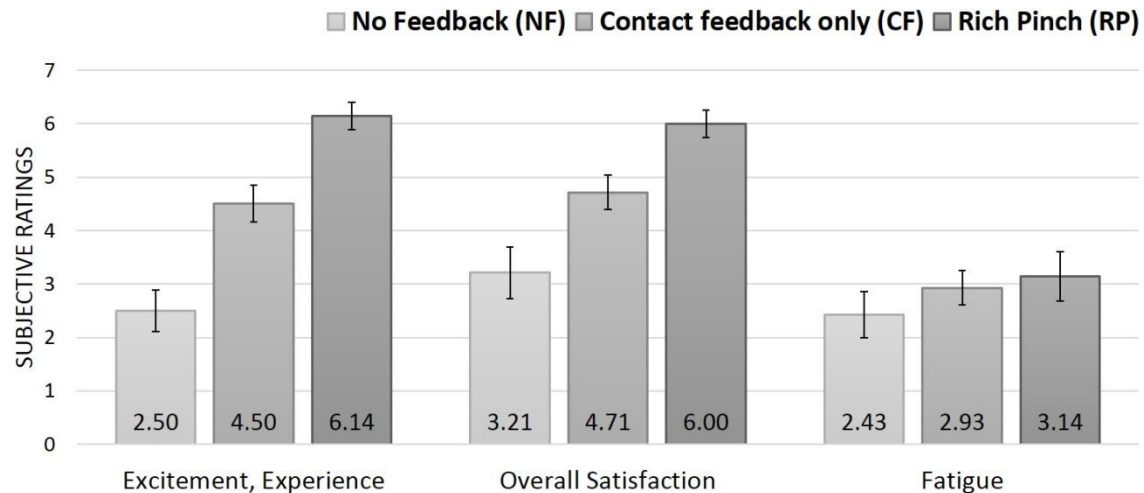
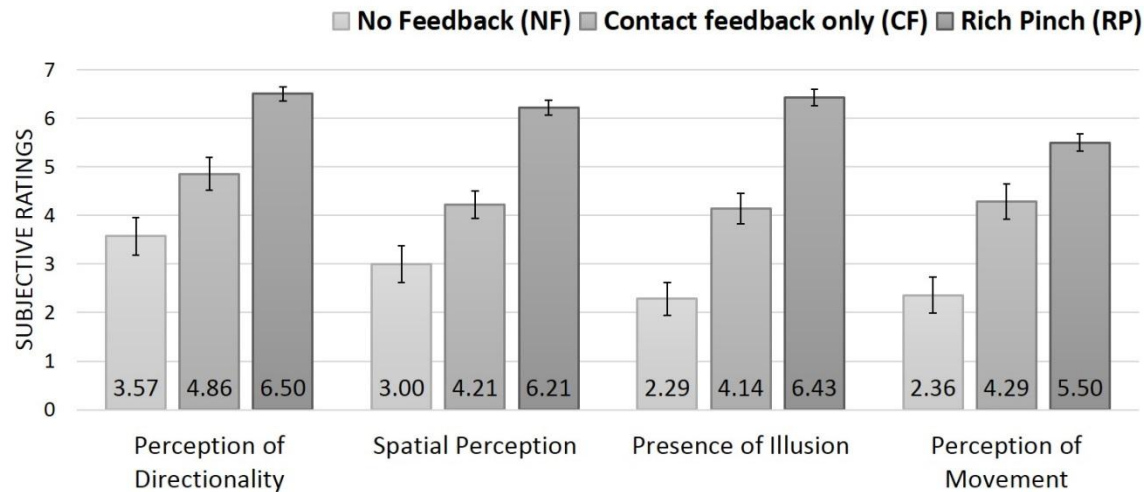
More direct application to HCI: Rich Pinch



More direct application to HCI: Rich Pinch



More direct application to HCI: Rich Pinch



Conclusion

- ▶ Today's media devices are relatively equipped well (however may not be as good as "Big VR")
- ▶ Lots of possibilities to still produce rich experience by:
 - ▶ Synergistic effects of multimodal integration/illusion
 - ▶ Combined with proper interaction design
 - ▶ Look out for negative interaction (interference)!
 - ▶ Importance of the story (and empathy)



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Thank you