

# 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

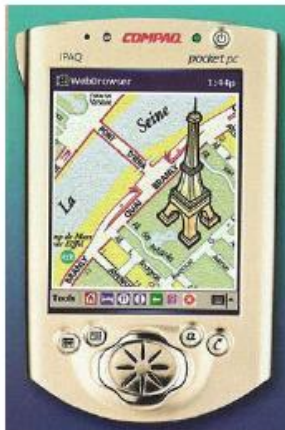
**Question:** Spatial immersion (presence) possible/enrichable with small VR?

**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



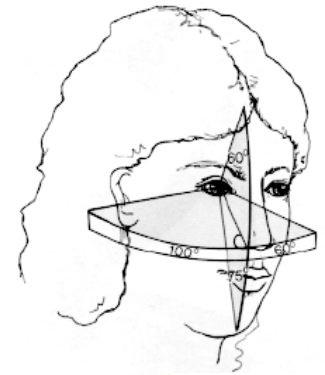


**IEEE VR 2004**

**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

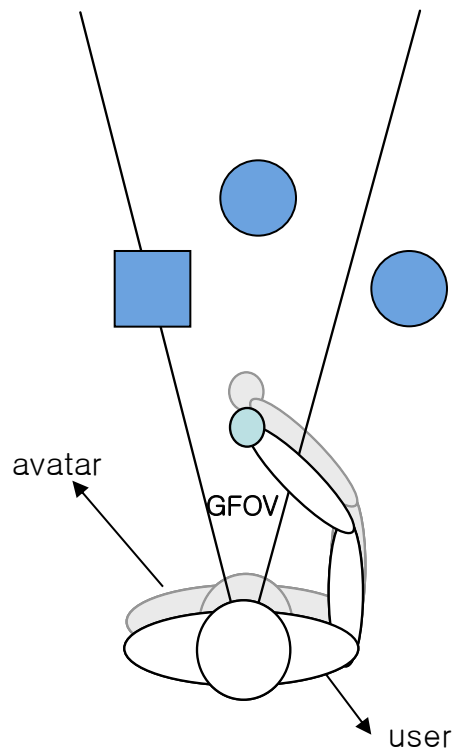


Virtual Research  
V8 Diagonal  $60^{\circ}$



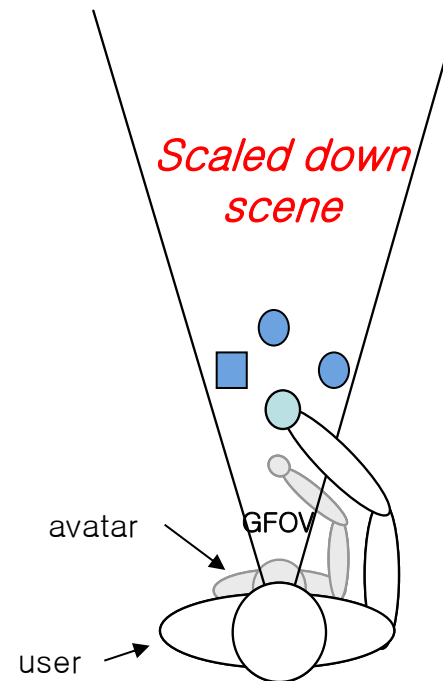
# GFOV (Software FOV)

GFOV = PFOV



(a)

Enlarged GFOV

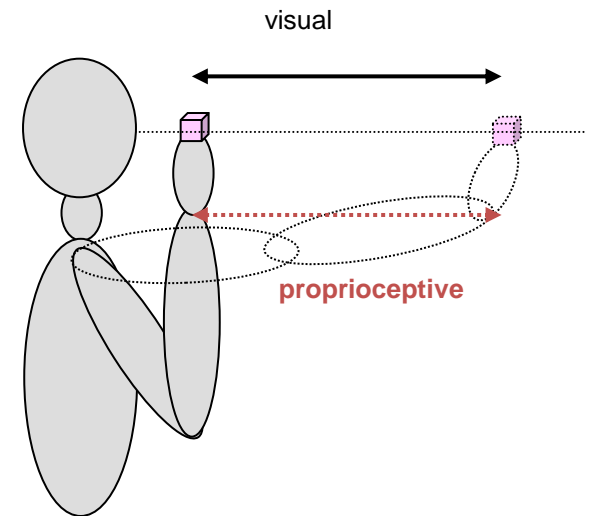


But possibly with distorted distance perception

(b)

# FOV and Distance Perception

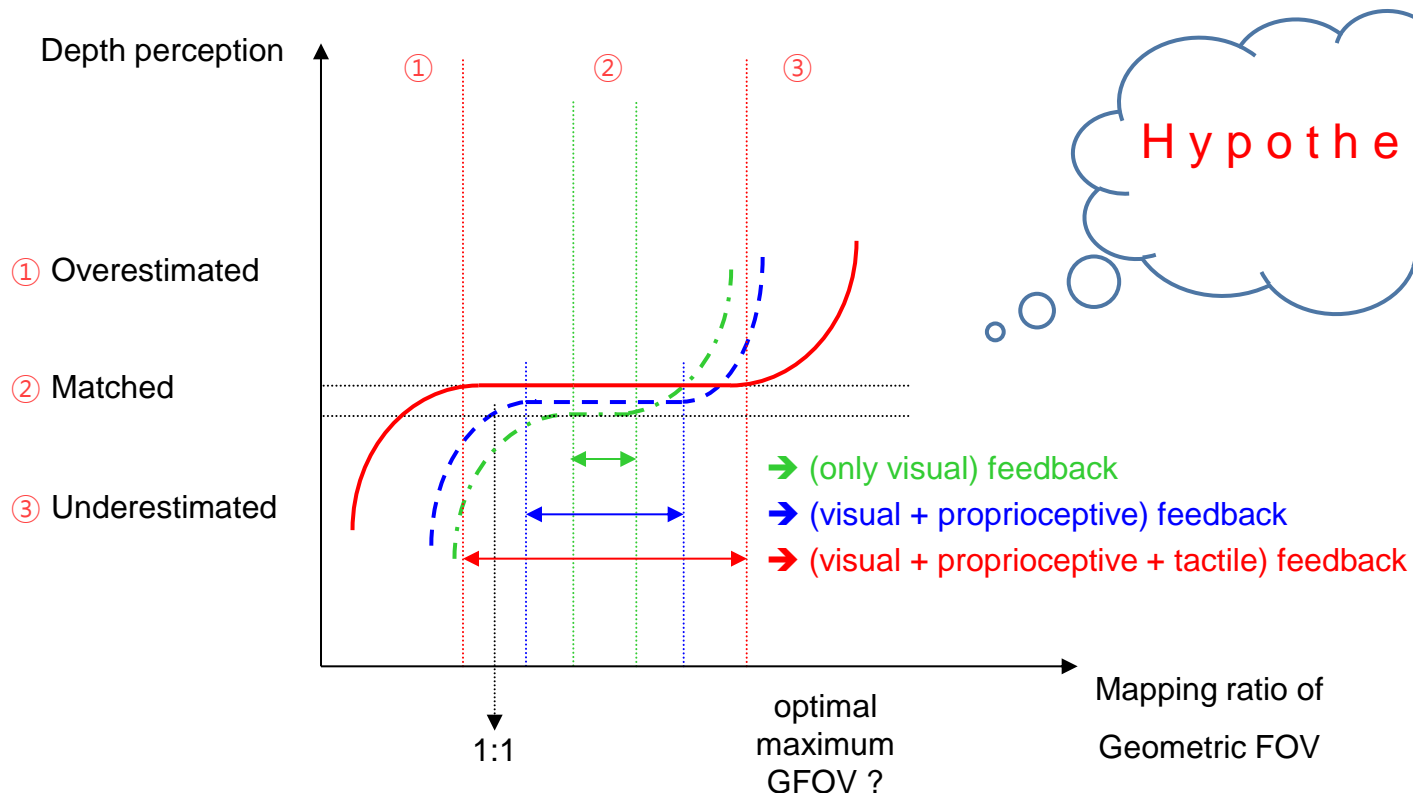
- ▶ Egocentric distance perception
  - ▶ Under-estimation in real environment
  - ▶ **Significant** under-estimation in VE
  - ▶ Important to sensory feedback match between visual and proprioceptive cue
- ▶ Conventional Calibration with HMD
  - ▶ 100% mapping to physical FOV
  - ▶ **Under-estimation**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





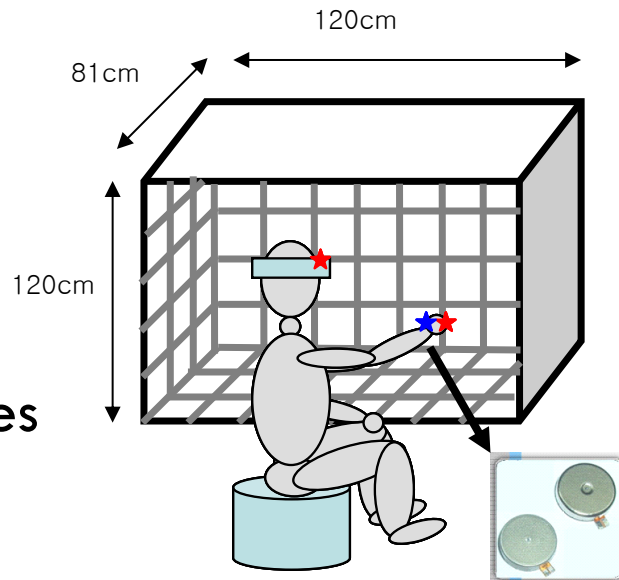
# Suggested Solution: Multimodal Feedback

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

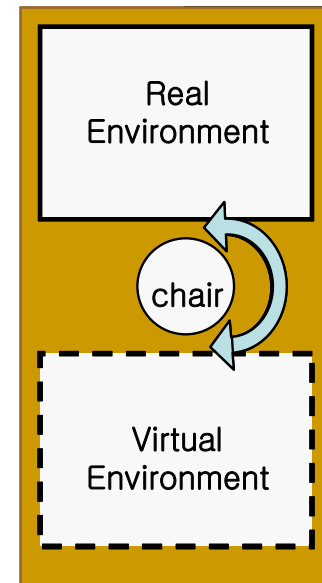


# Experiment

- ▶ 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)

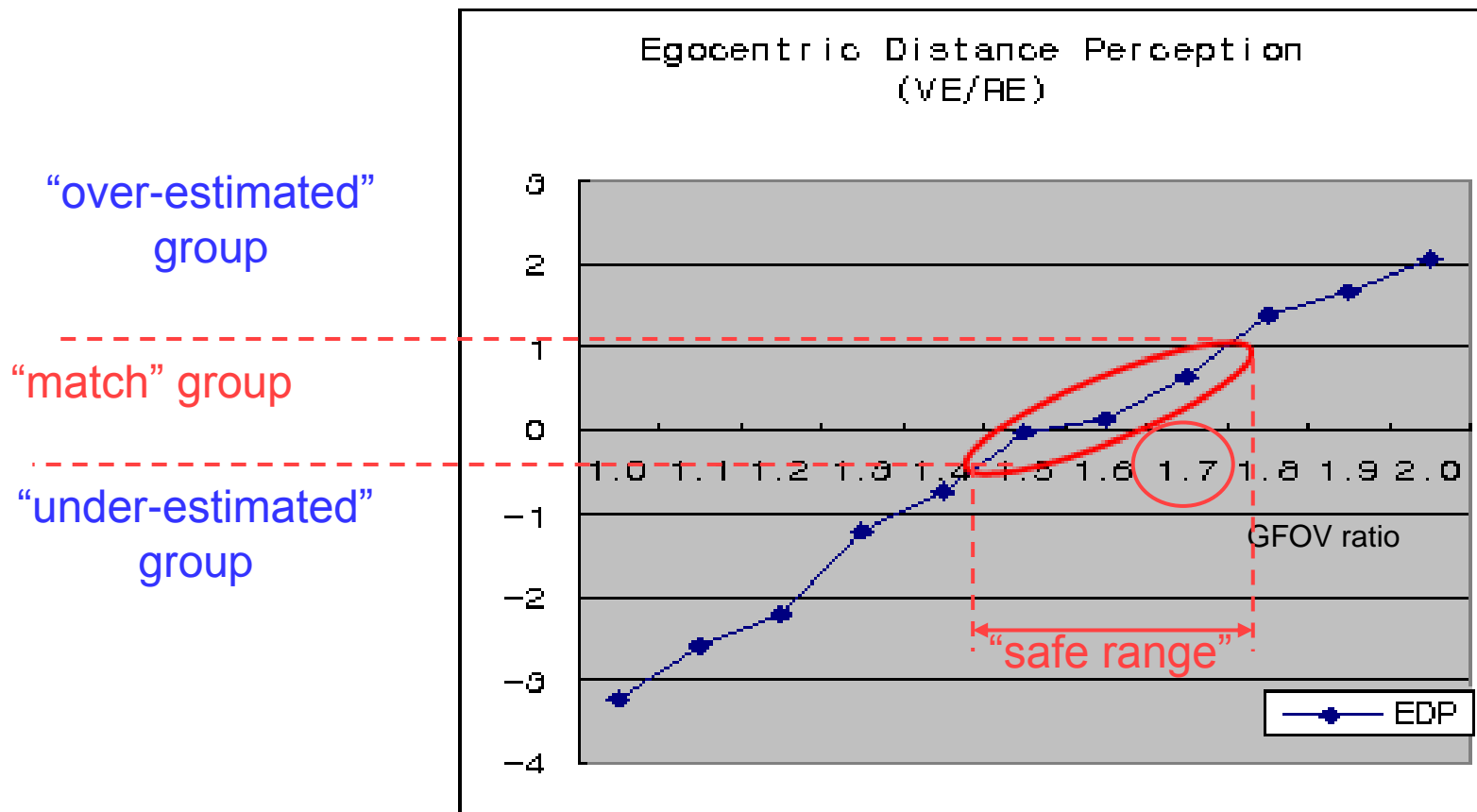


Top view



# Results

- ▶ Maximum over-mapping GFOV to 170%
- ▶ diagonal FOV  $31.2^\circ \rightarrow$  diagonal GFOV  $53.04^\circ$





**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

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- ▶ 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



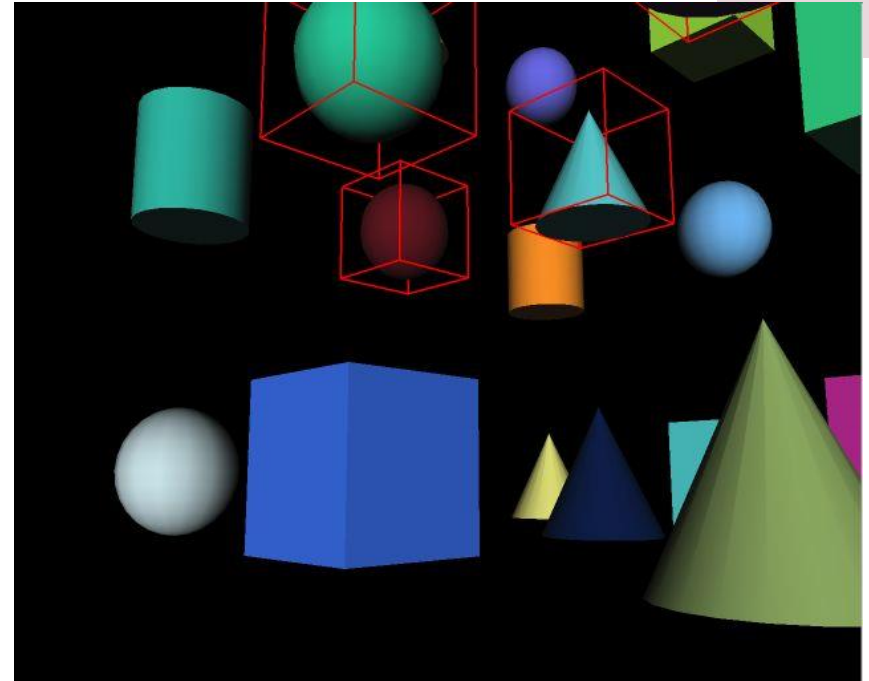
Mouse/Keyboard interaction in small screen/desktop/large screen



# Tasks

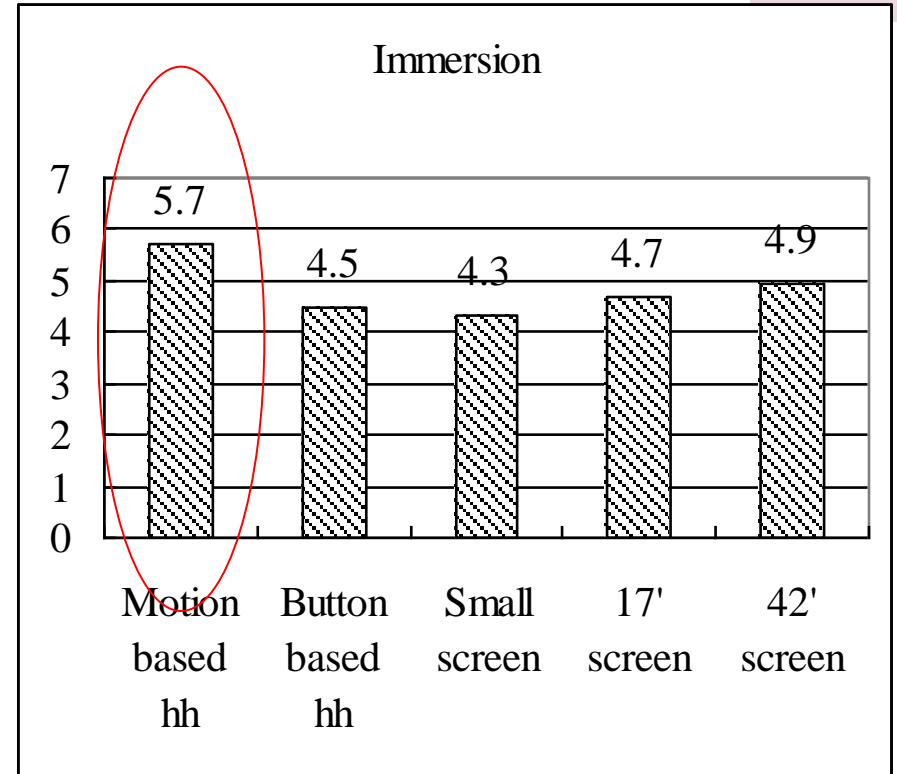
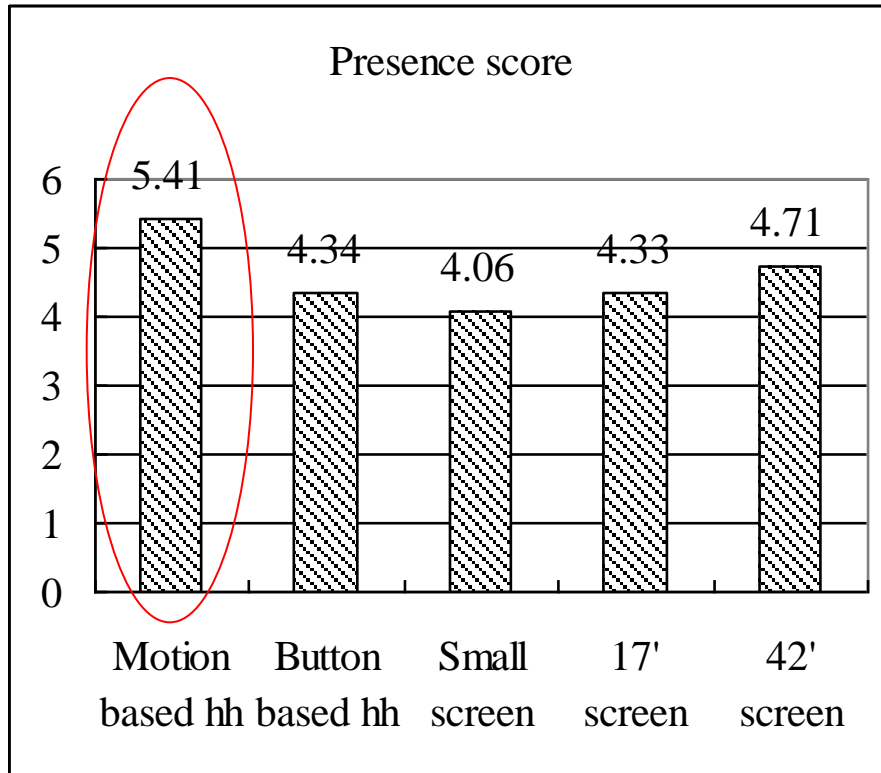


Navigating in virtual environment  
➔ Usability, presence/immersion, enjoyment, and perceived FOV

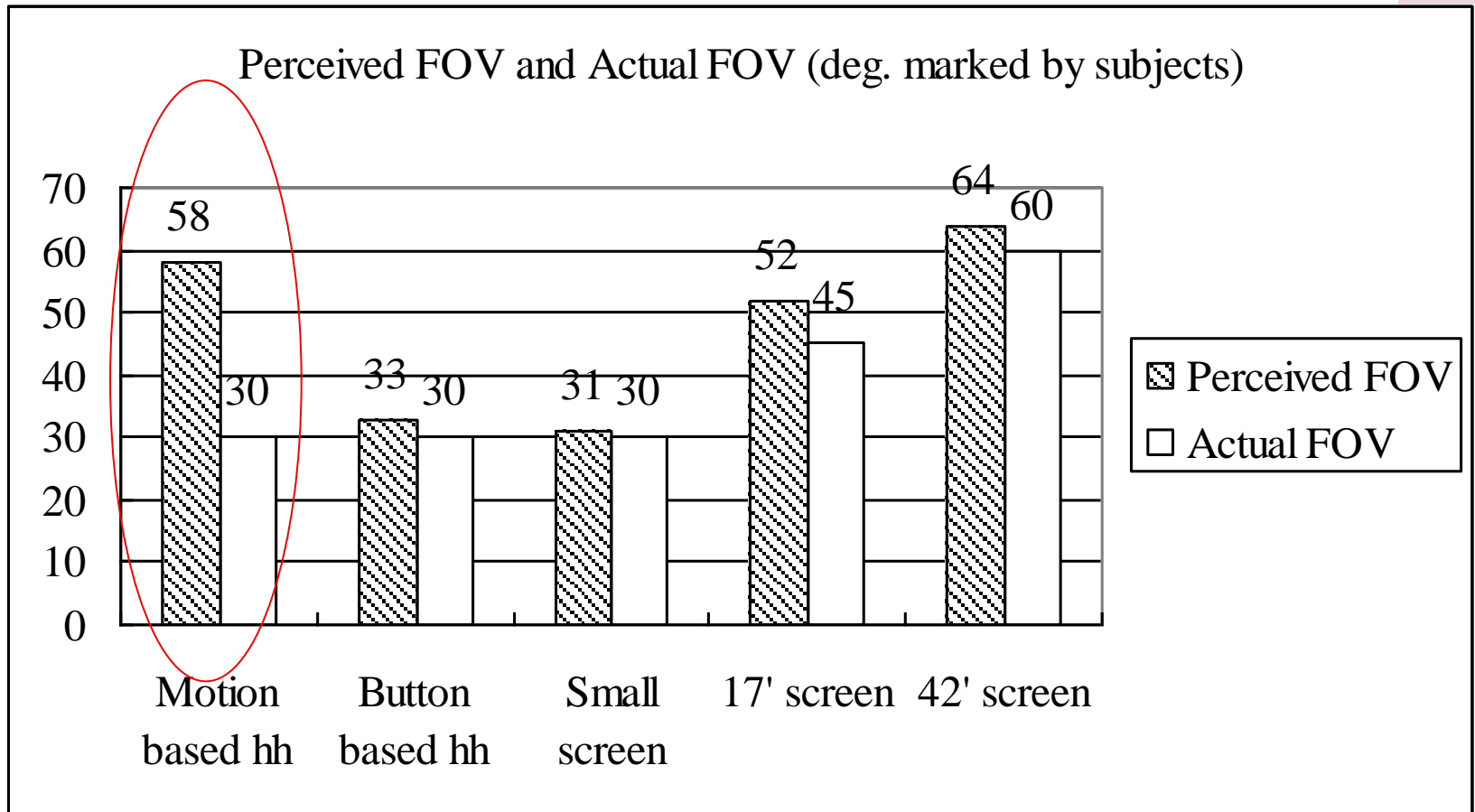


Locating and selecting objects  
➔ Task performance

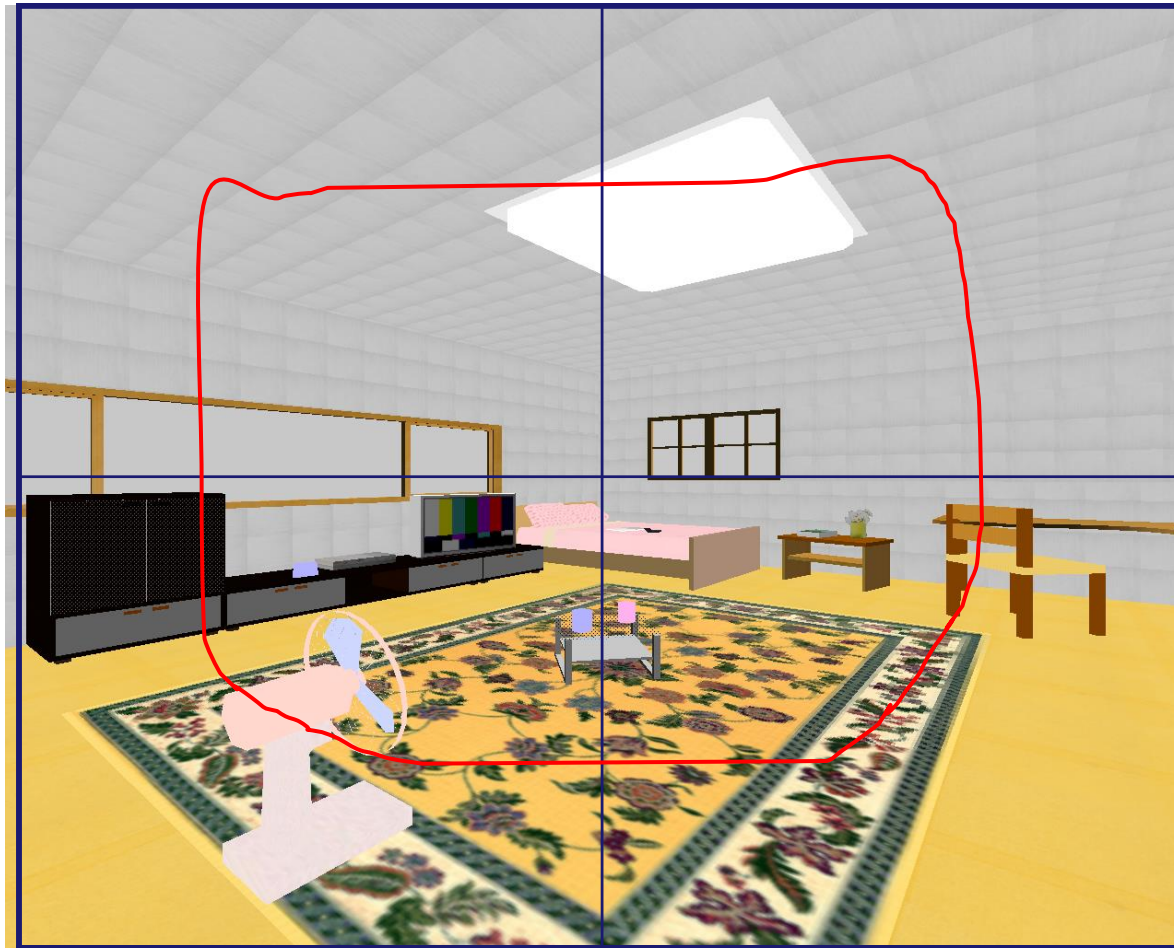
# Presence/Immersion



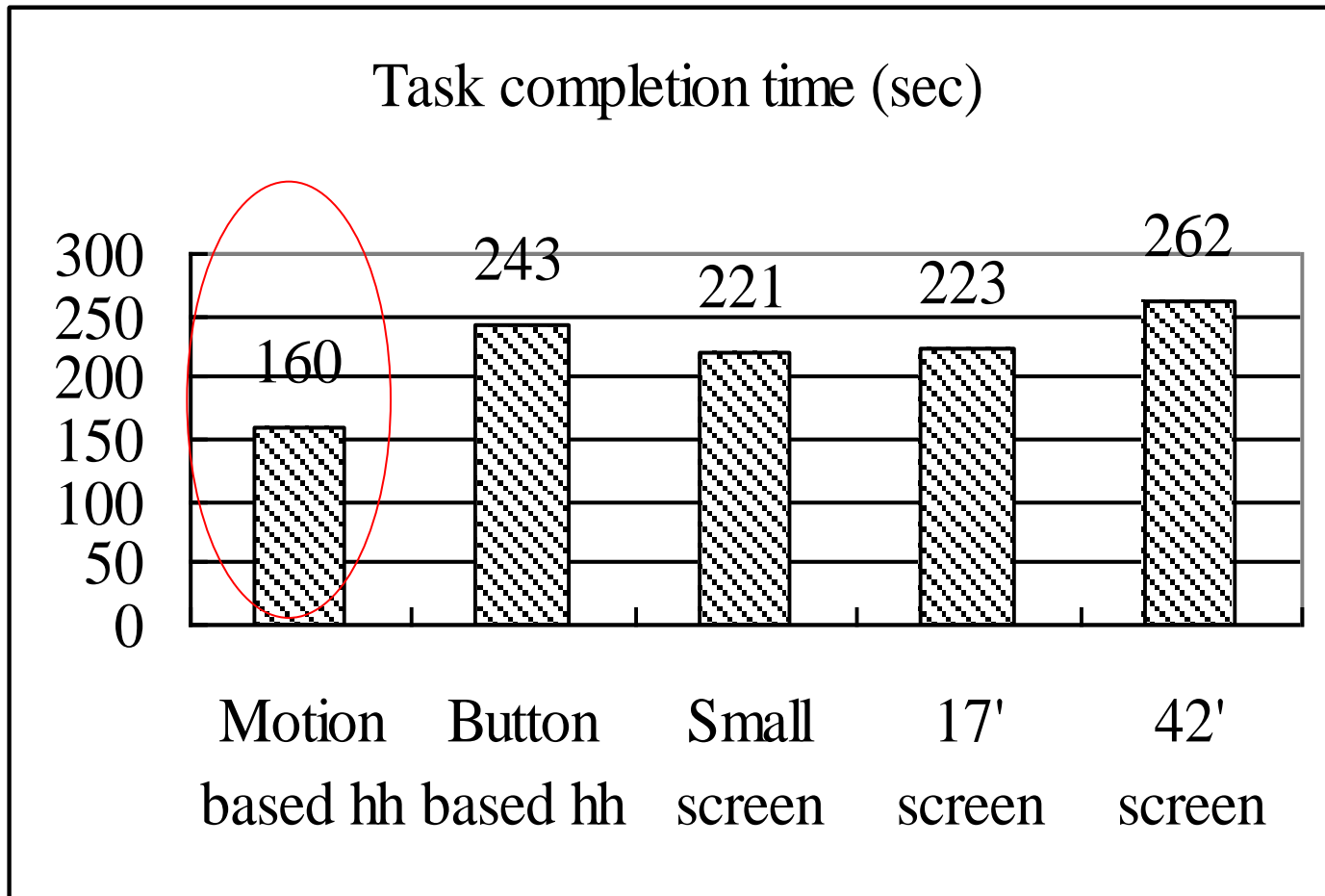
# Perceived FOV



# Measuring perceived FOV

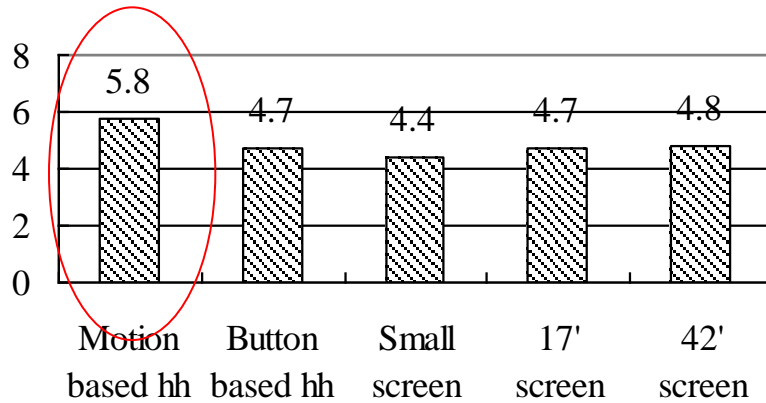


# Task Performance

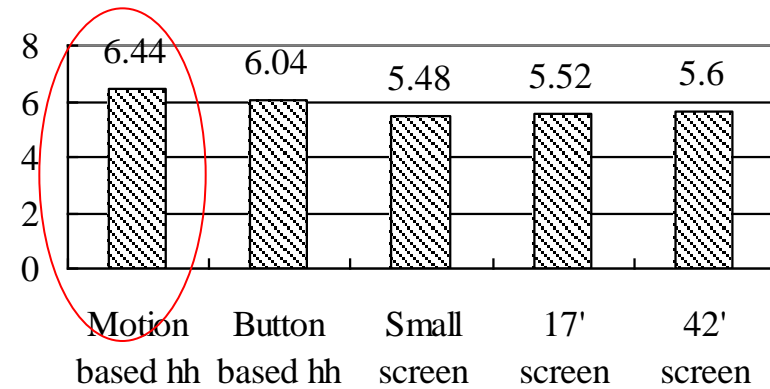


# Usability

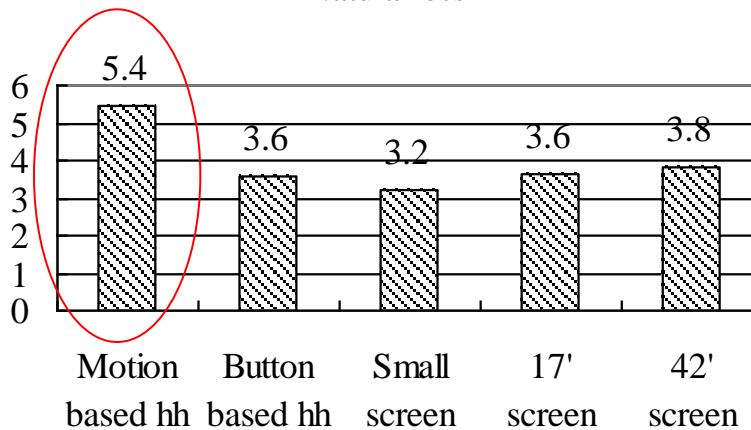
Easy to use



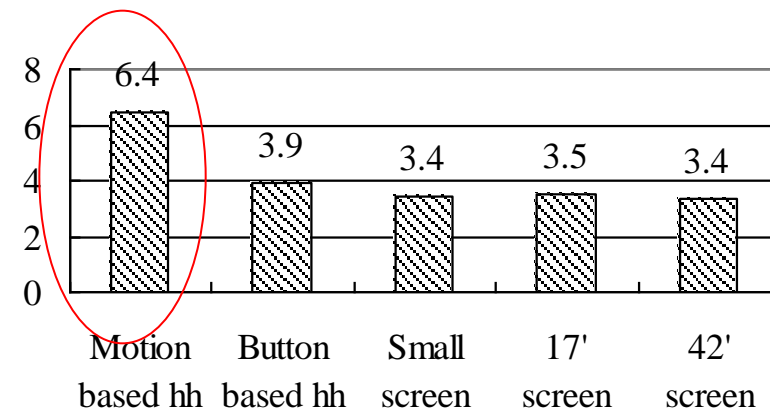
Easy to learn



Naturalness



Intuitiveness



# Summary

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- ▶ 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

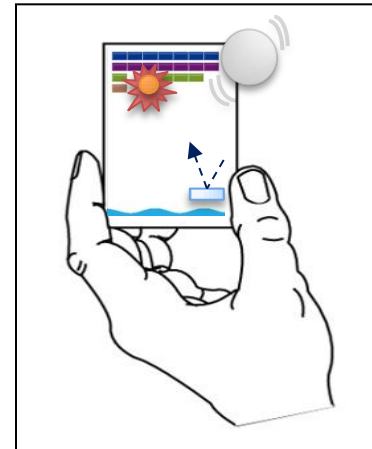
## ► Vibro-tactile feedback

- Inexpensive and effective way to enhance interaction experience

## ► Limitations of tactile interaction



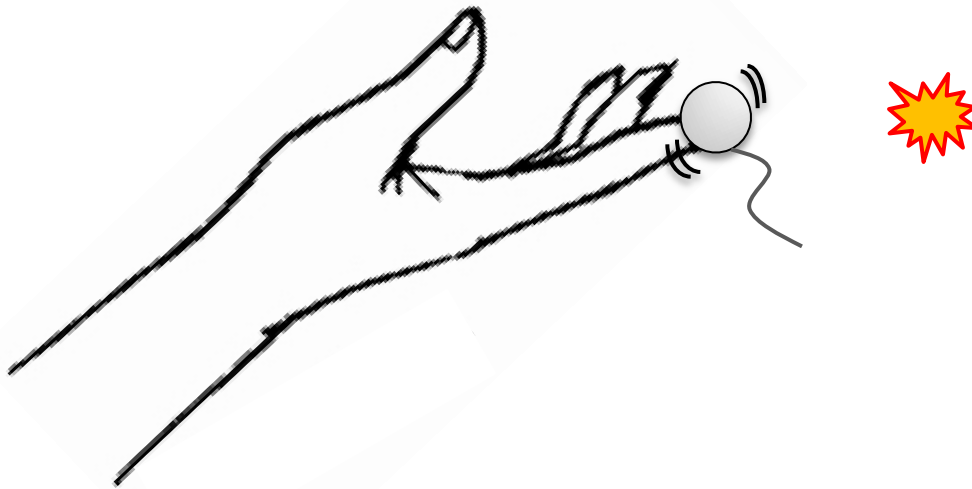
High mechanical complexity  
Costly hardware  
Unnatural interaction



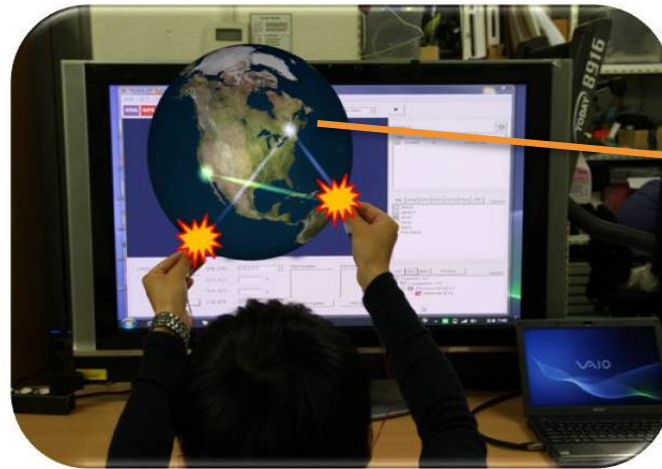
Indirect stimulation / Single vibrator :  
Difficult to associate detailed  
content

# Use “Out of the body” Tactile Illusion

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



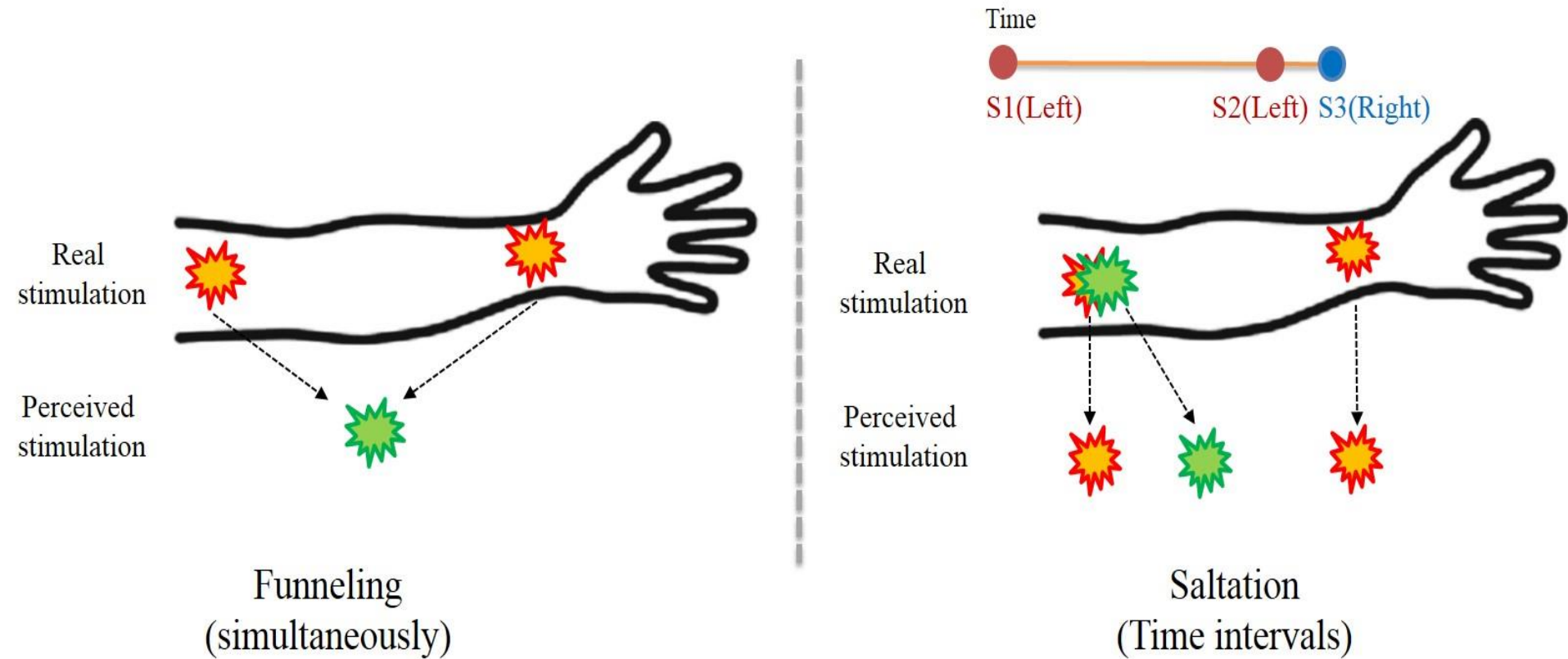
# Applications



Stereoscopically  
rendered object



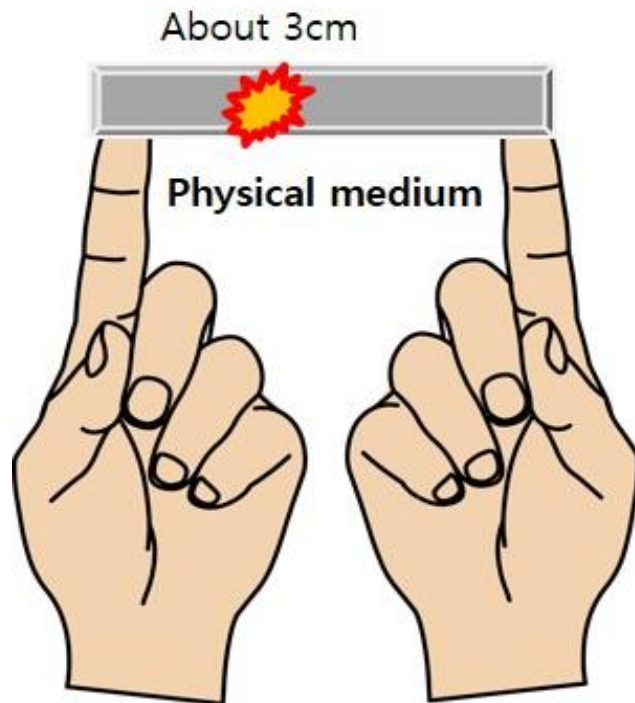
# Funneling and Saltation



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

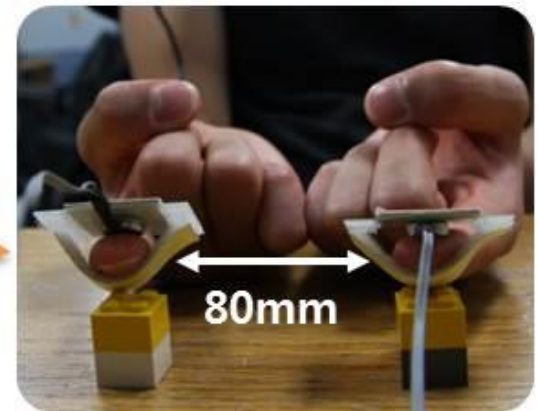
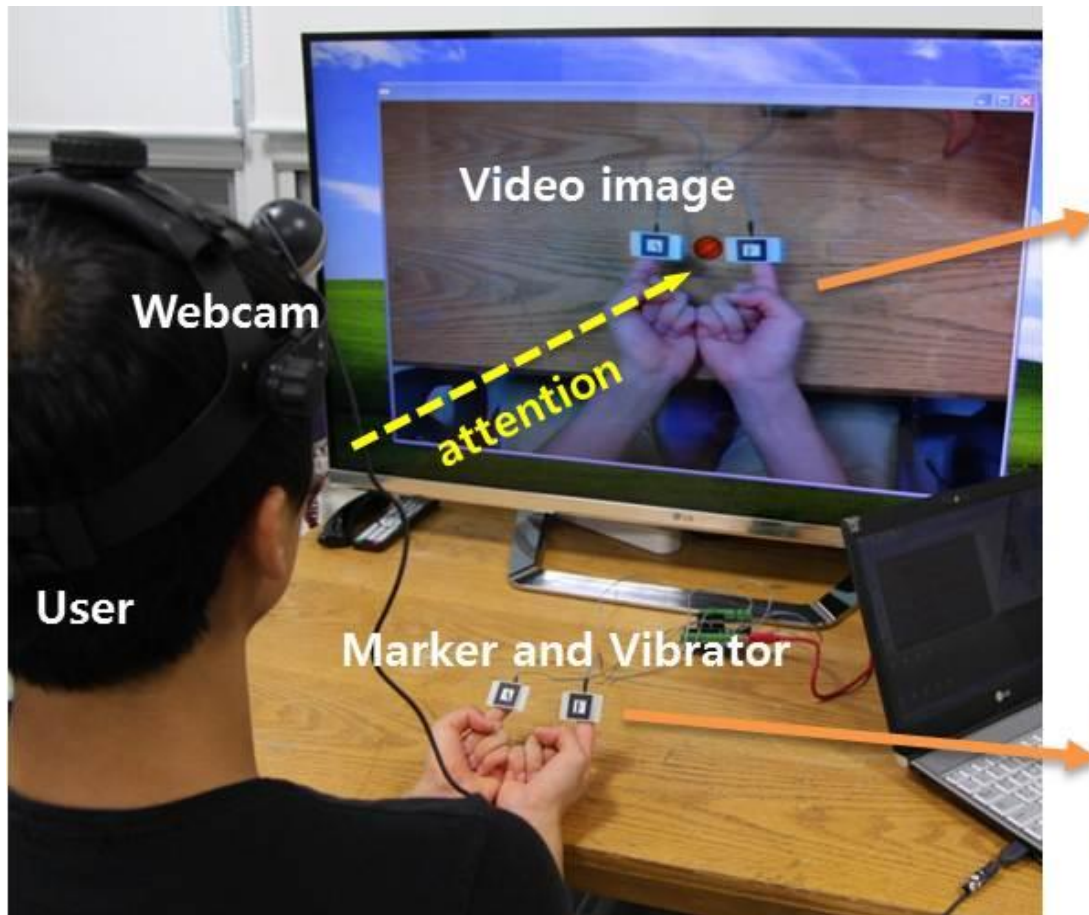
The Cutaneous Rabbit: A Perceptual Illusion.  
*Science*, (Geldard, 1972)

# Out of the Body Illusion

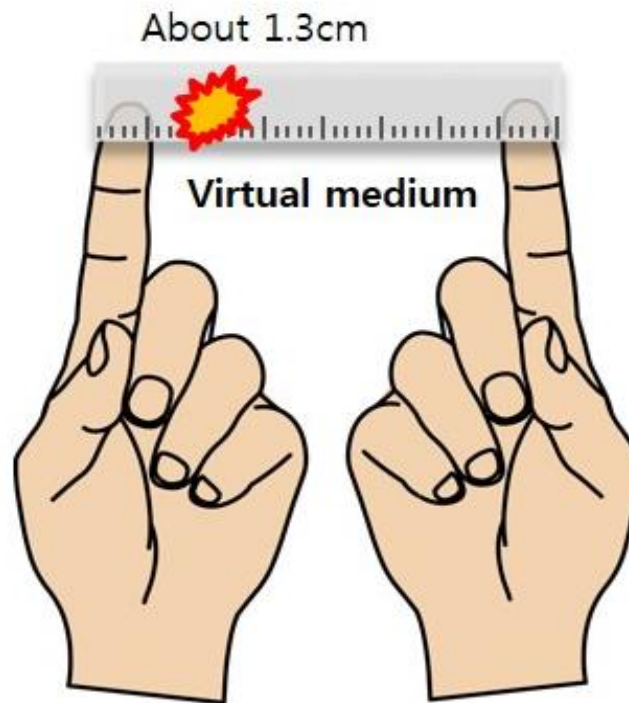




# Experiment

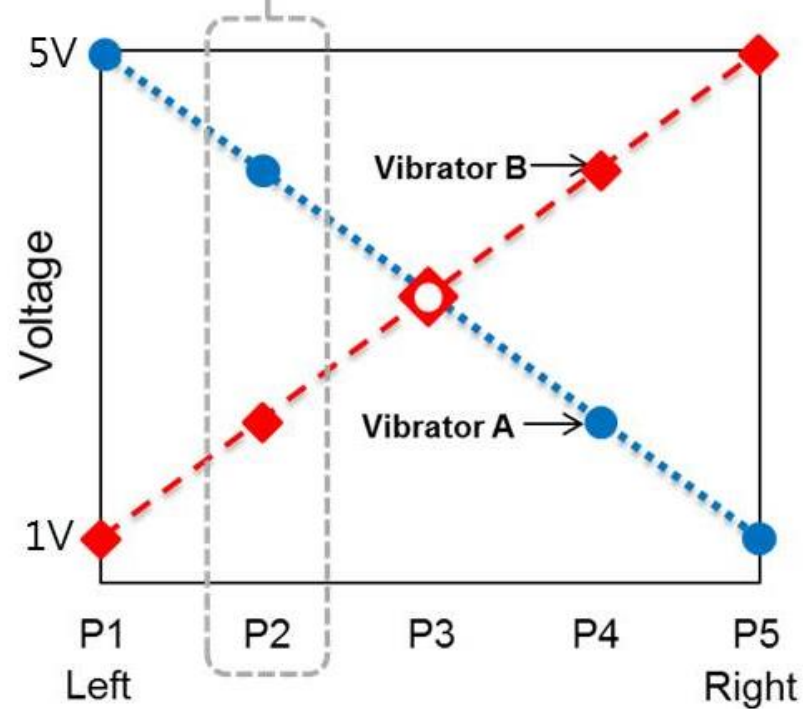
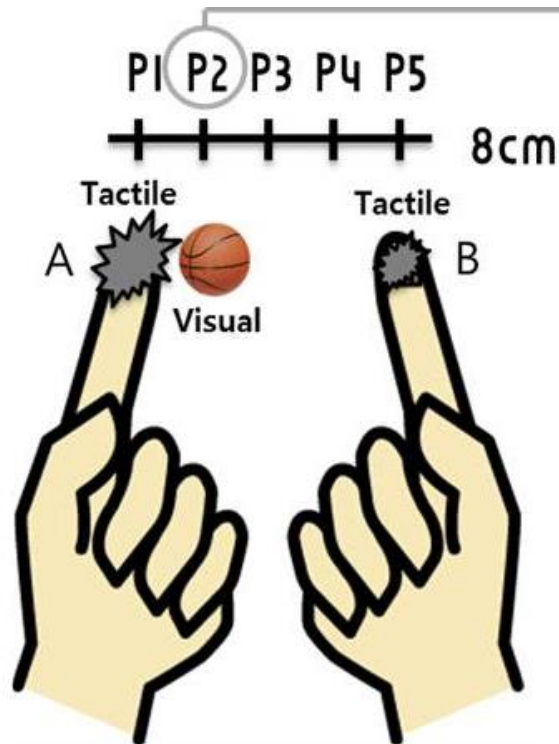


# Out of the Body on the Virtual



# Out of the Body: without Body Extension

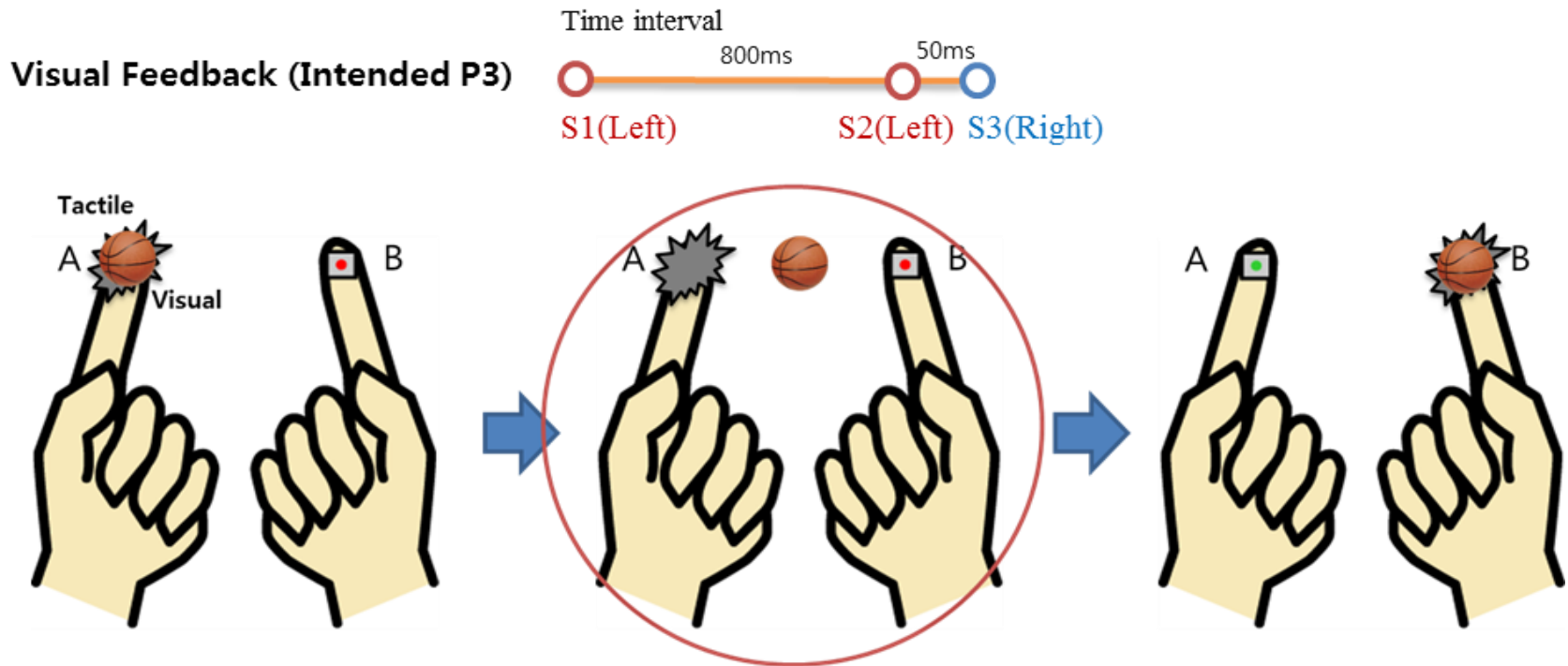
## Funneling





# Out of the Body: without Body Extension

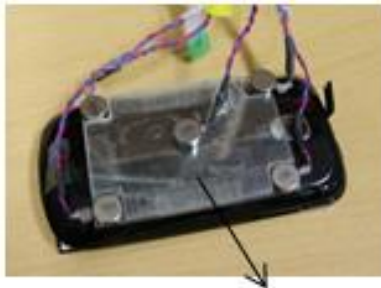
## Saltation



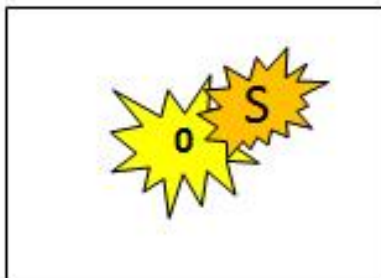
# Extending to 2D



Single



Used

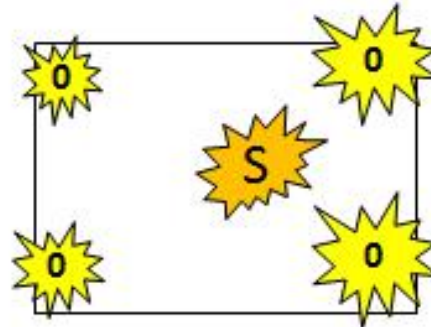


Stimulation at the middle  
Location of sensation not  
controllable

Funneling



Not used

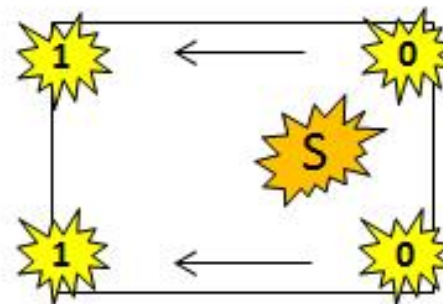


Simultaneous stimulation  
at 3 corners  
Location of sensation  
controlled with relative  
amplitudes

Saltation

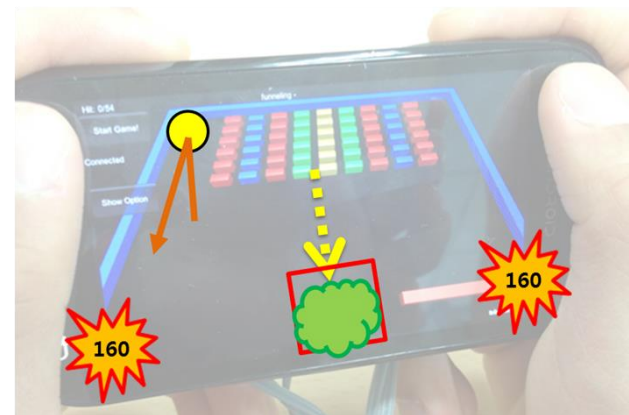
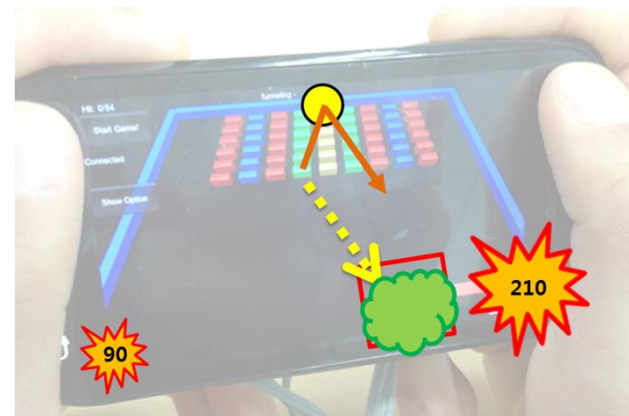
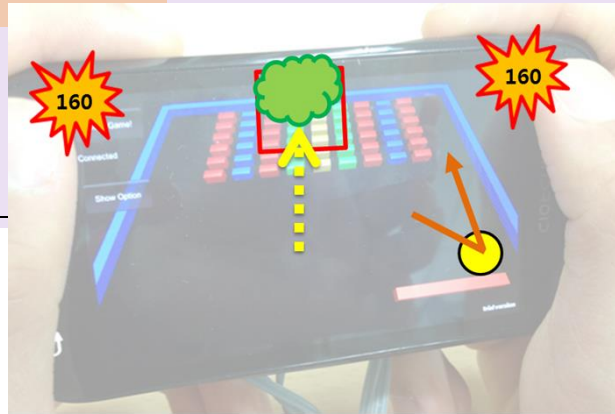


Not used

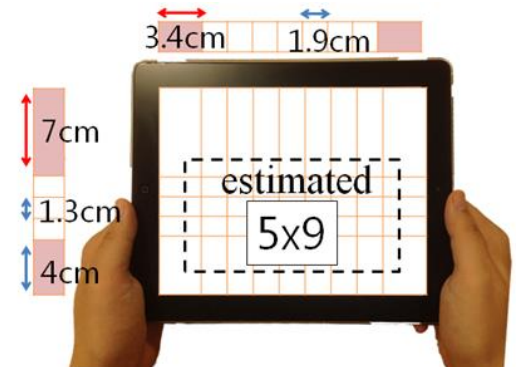
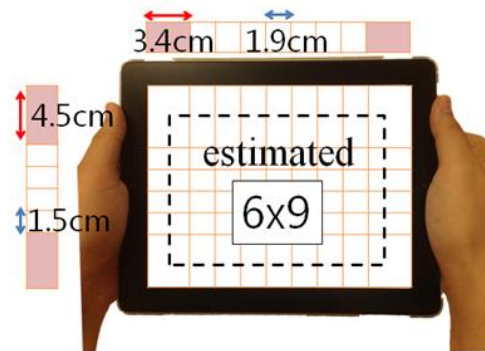
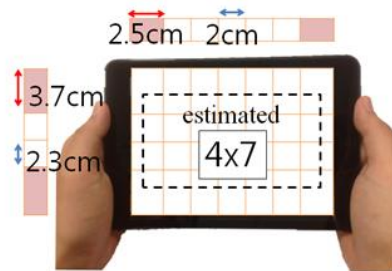
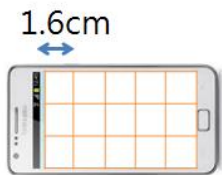


Timed stimulation  
at 4 corners  
Location of sensation  
controlled with ISI's

# Arkanoid

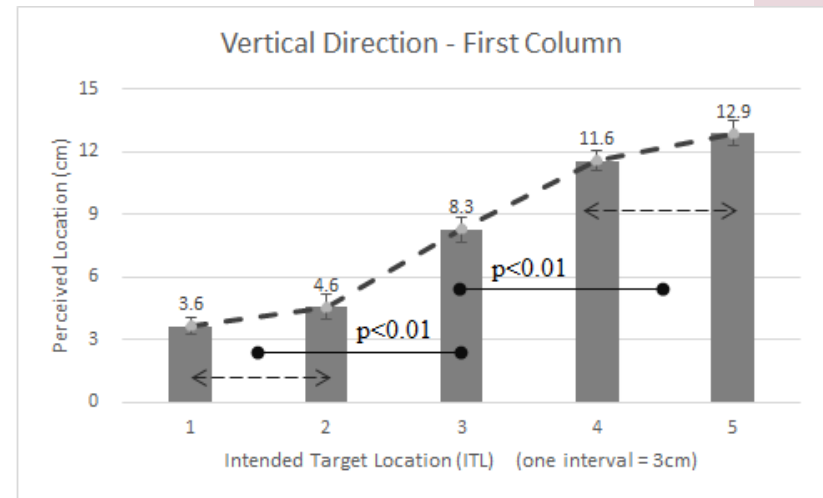
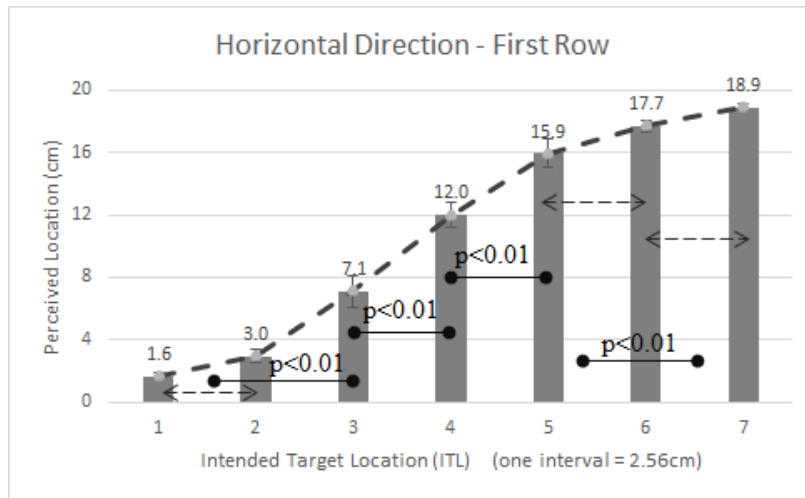


# To a larger sized device? (like an i-Pad)



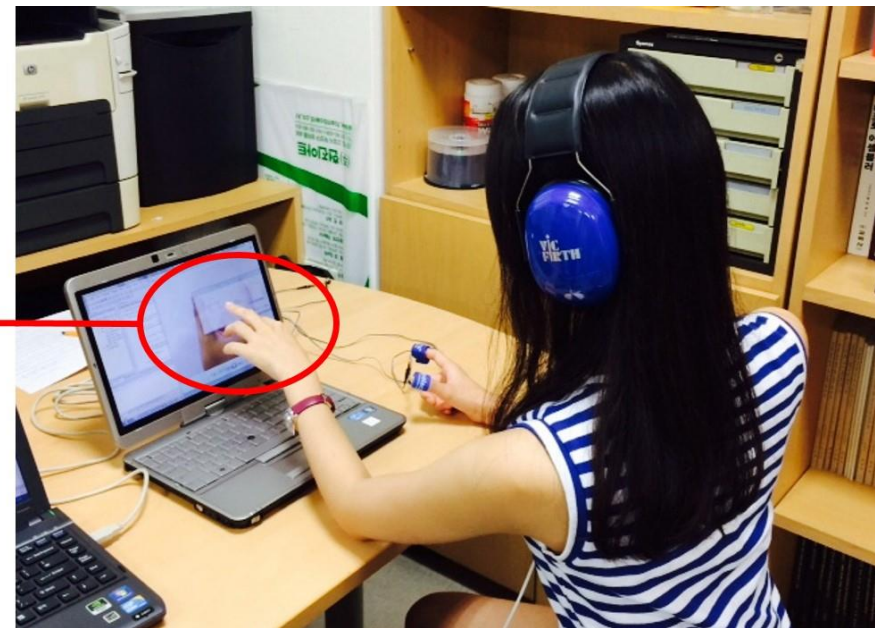
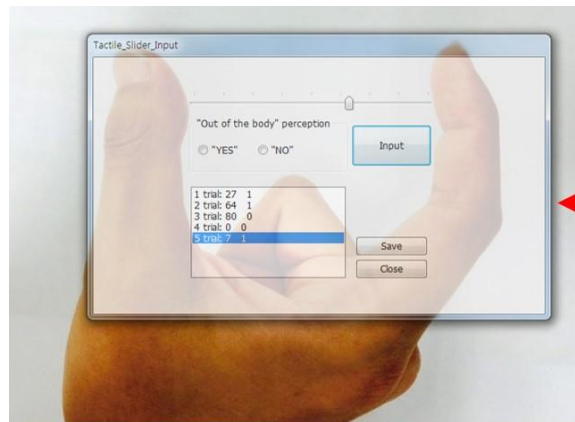
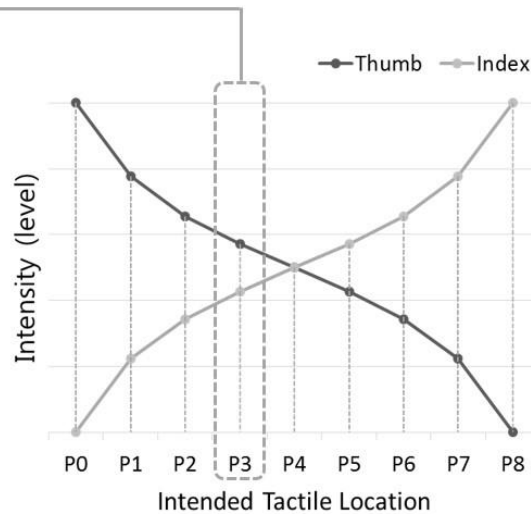
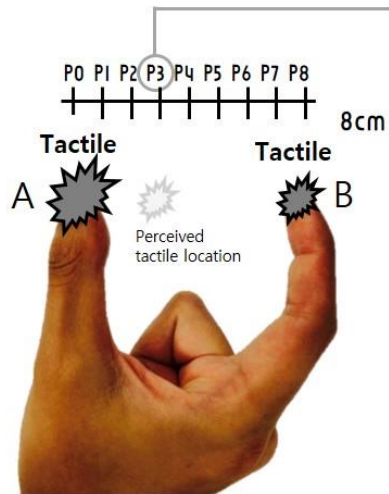


# To a larger sized device? (like an i-Pad)

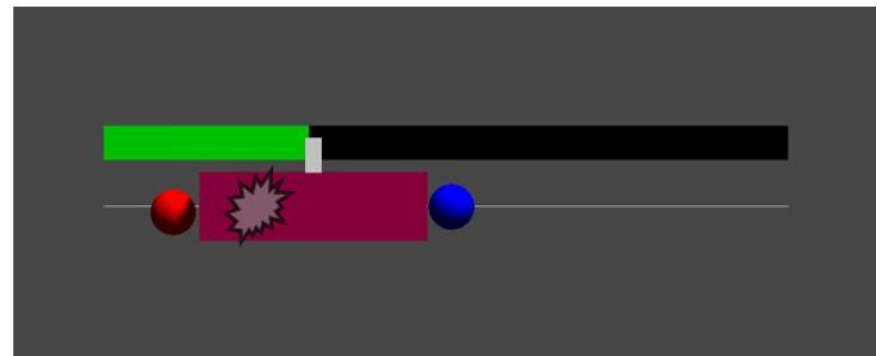
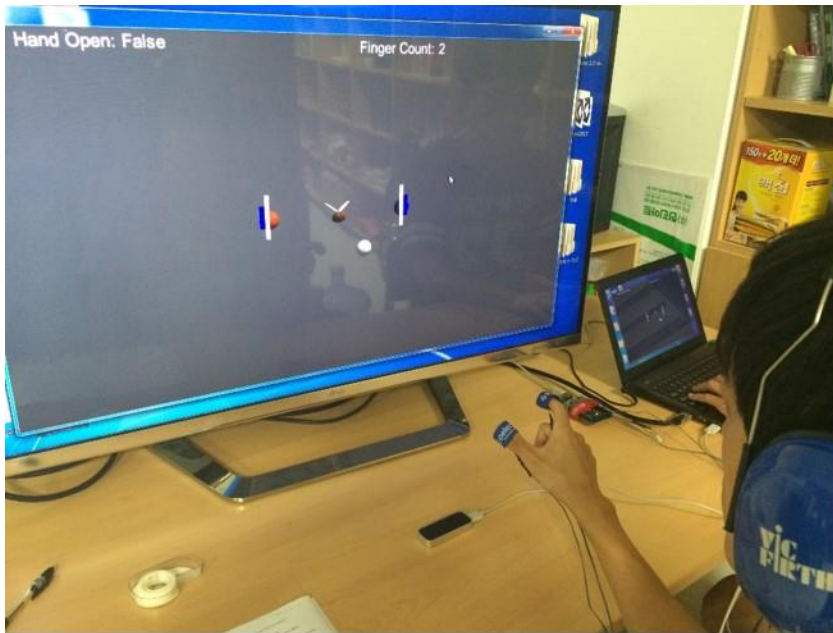


73.9	65.2	56.5	60.8	52.1	82.6	86.9
78.2	91.3	65.2	69.5	78.2	73.9	78.2
86.9	86.3	78.2	86.9	91.3	73.9	91.3
95.6	91.3	56.5	69.5	73.9	95.6	91.3
91.3	73.9	73.9	52.1	73.9	69.5	73.9

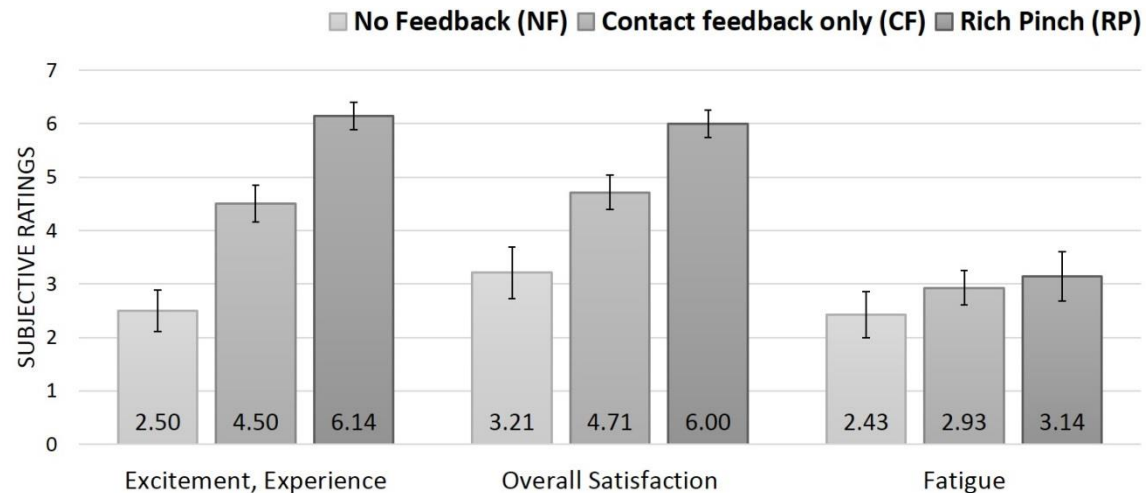
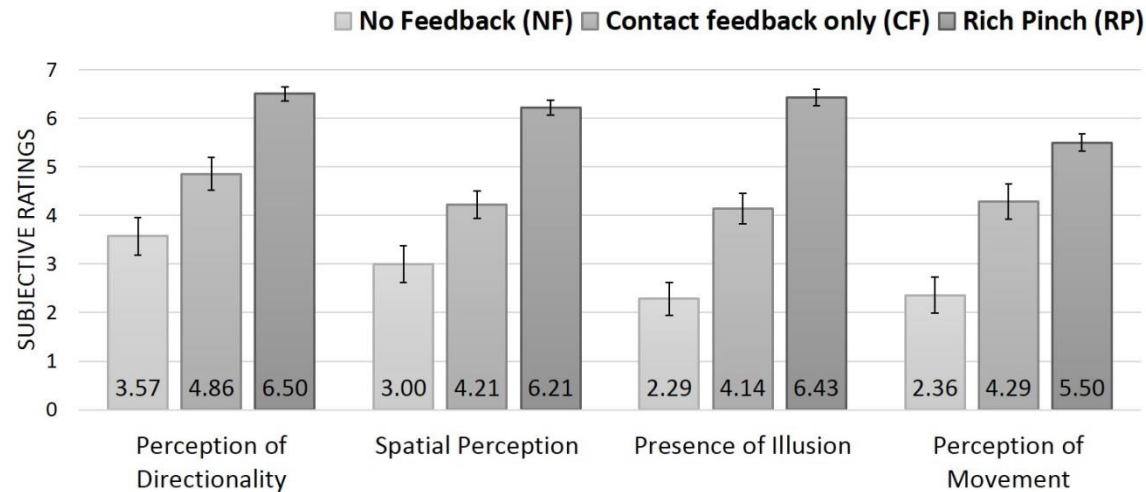
# More direct application to HCI: Rich Pinch



# More direct application to HCI: Rich Pinch



# More direct application to HCI: Rich Pinch





# Conclusion

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- ▶ 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