

Mobility-First Mutual Telepresence



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Agenda

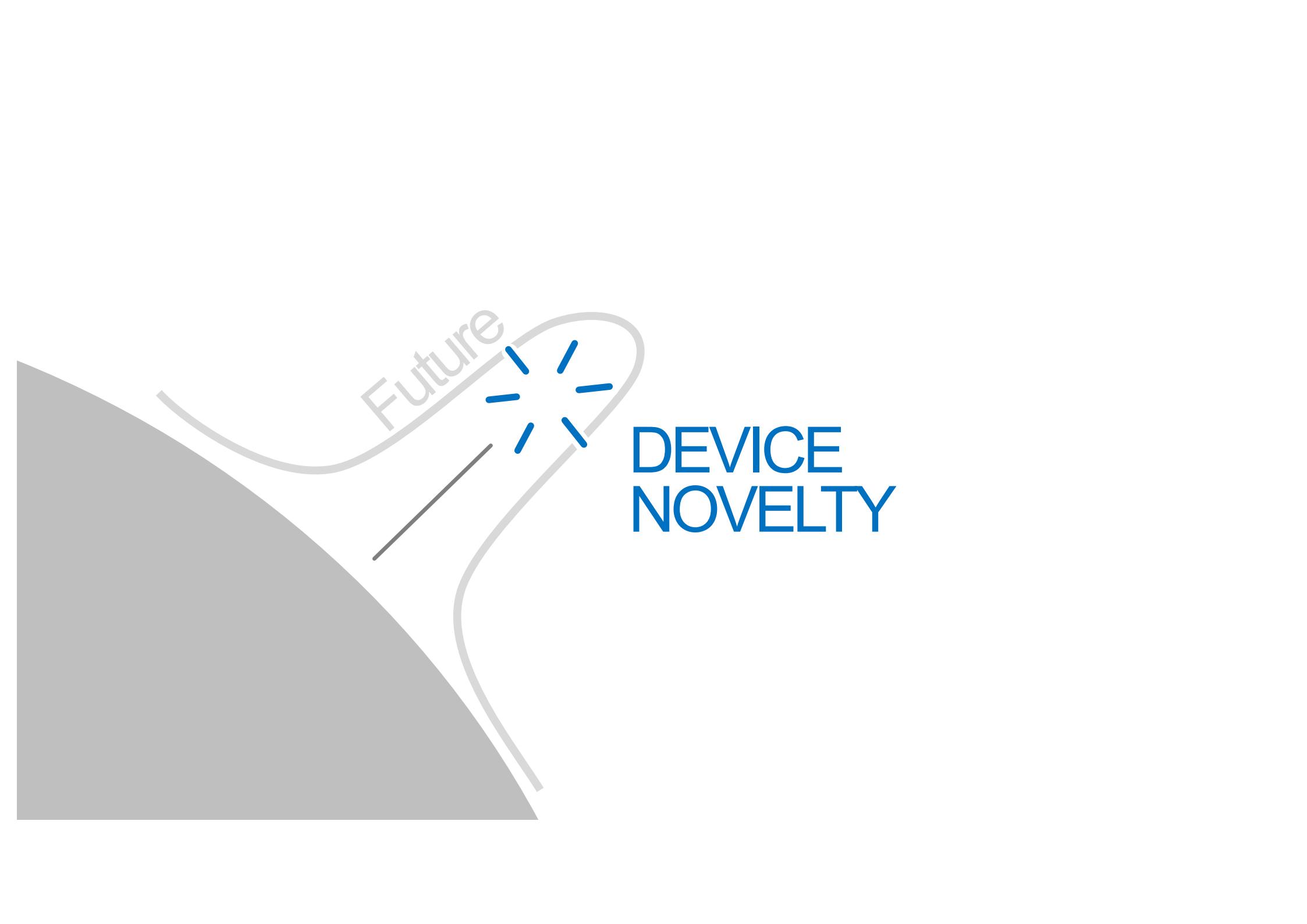
- Intro – my method in hci
- Ecological HMDs
- Mobility-first telepresence

HCl

Technical HCI **NOVEL** Interaction



DEVICE
NOVELTY



Future

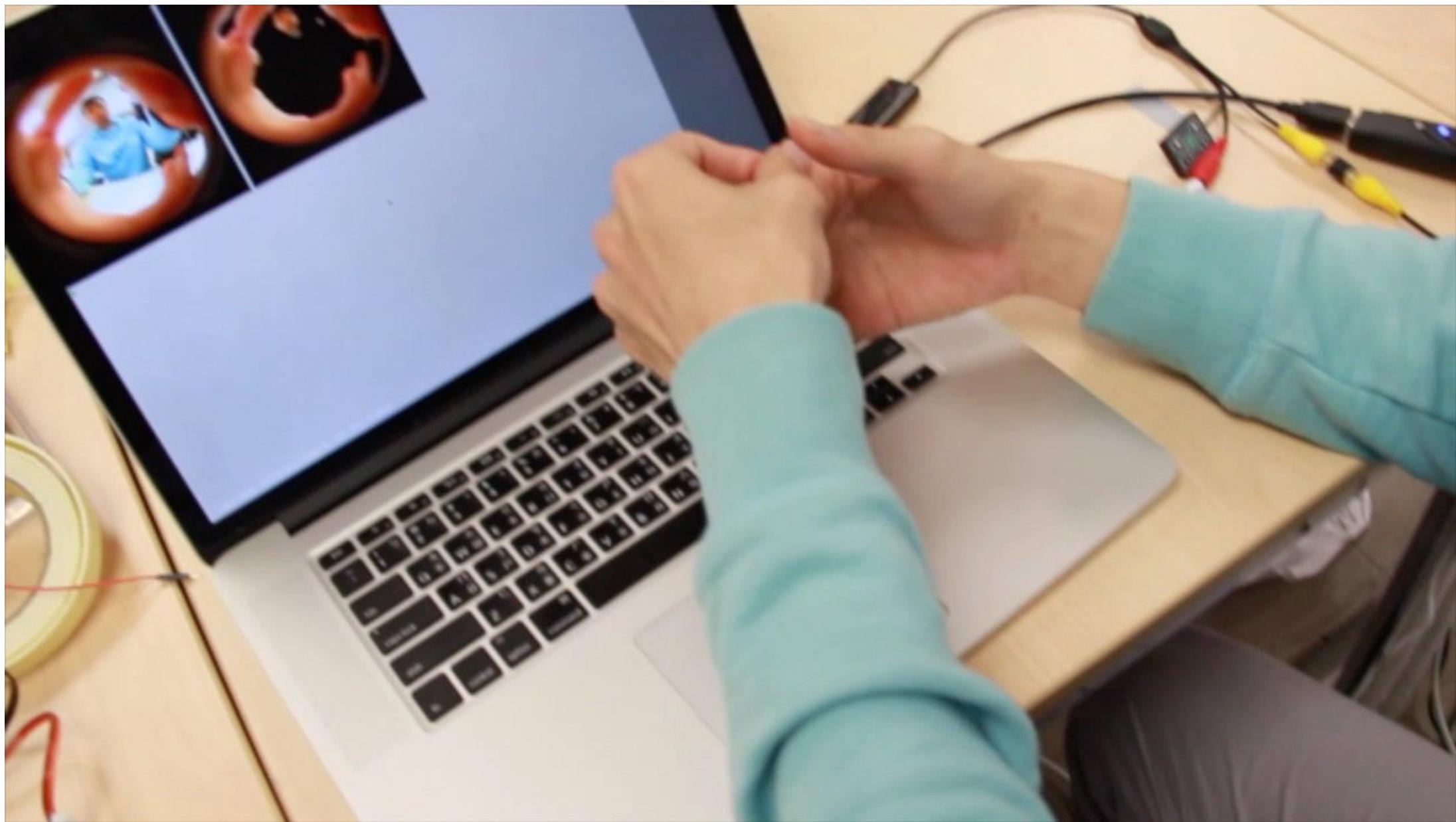
DEVICE NOVELTY



CyclopsRing

CHI '15





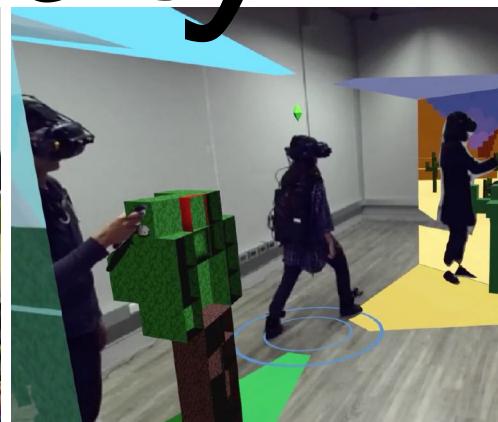
Virtual Reality



MobileHCI '17



UIST '18



UIST '20



UIST '20

make
Virtual Reality (HMD)
an ecological device

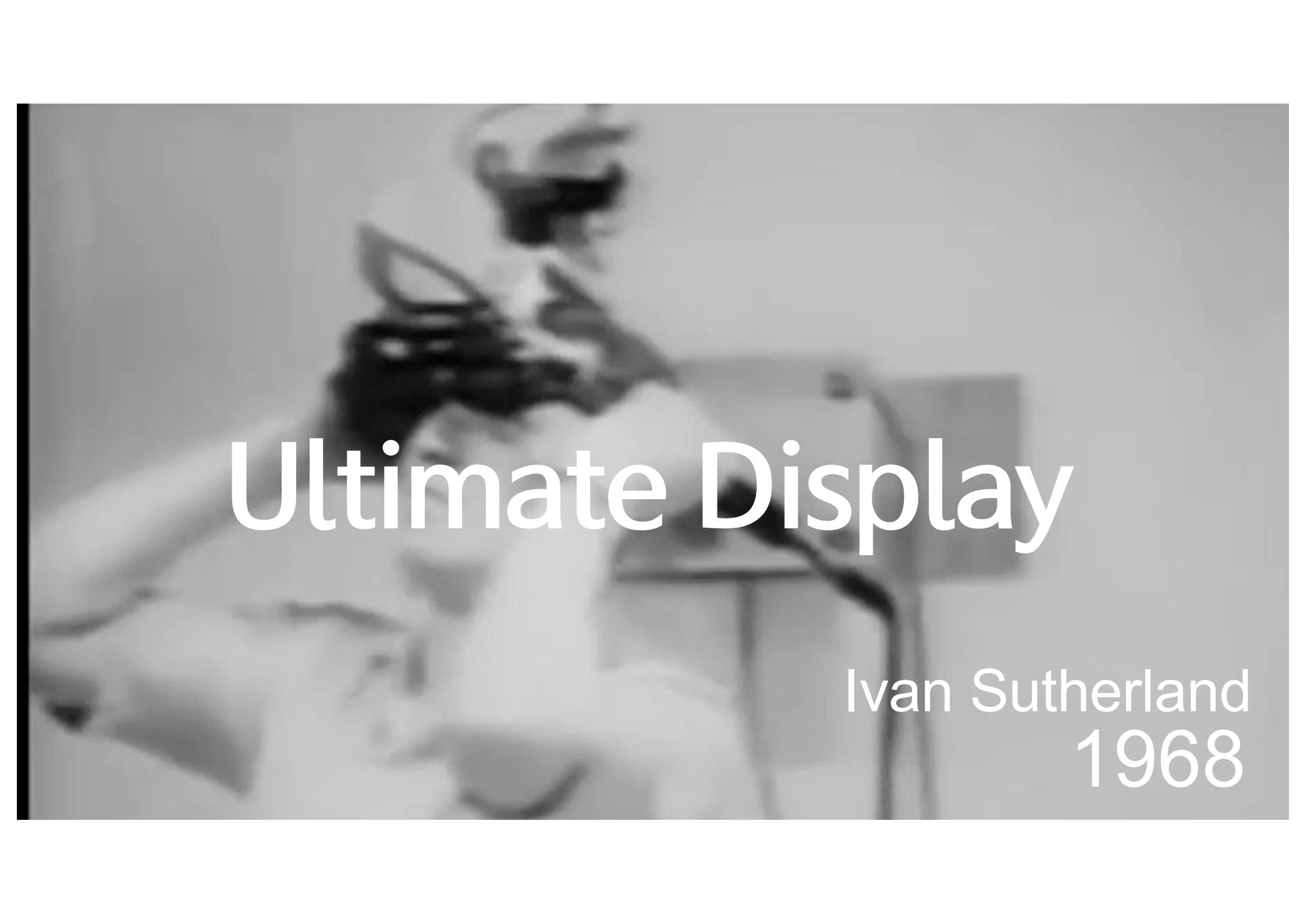
make
Virtual Reality (HMD)
an ecological device

that cares the surroundings (e.g., the externals).

background

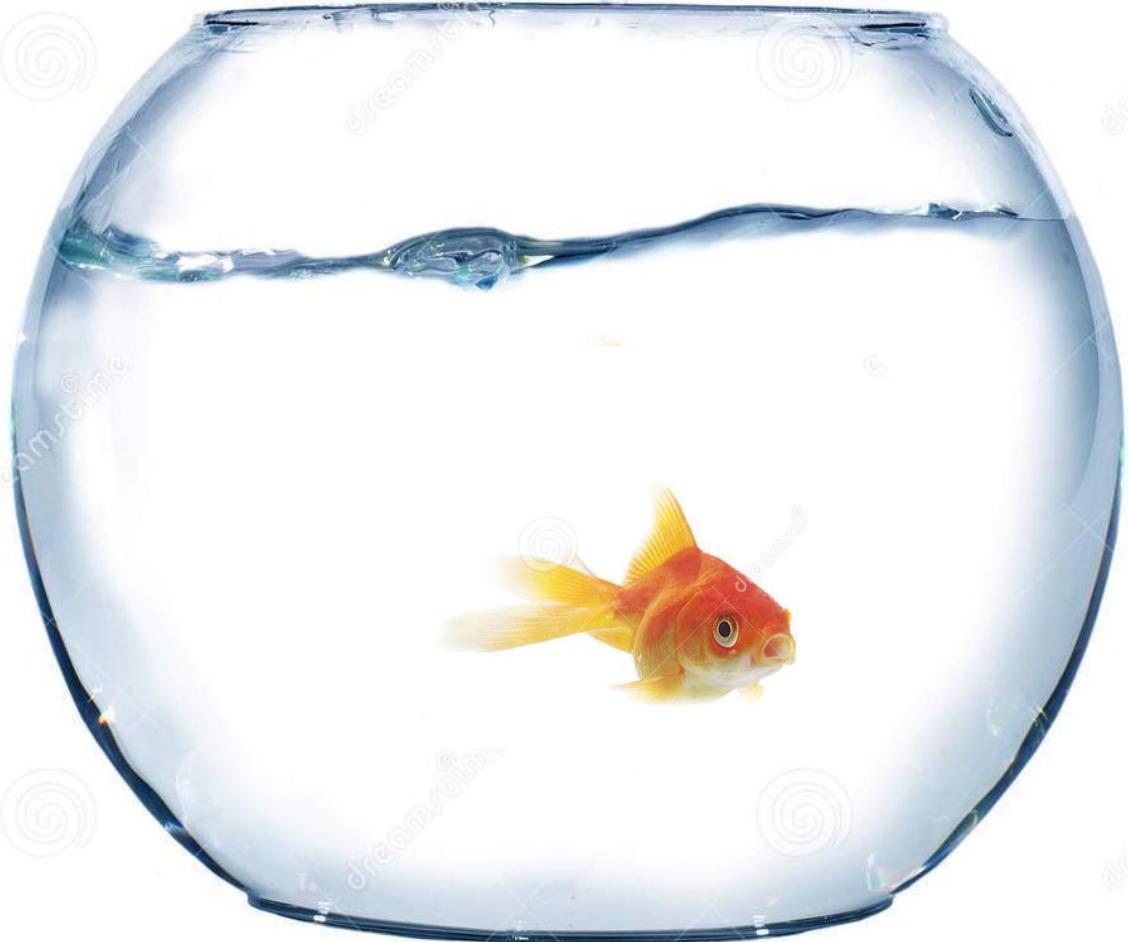
Virtual Reality

an immersion device



Ultimate Display

Ivan Sutherland
1968

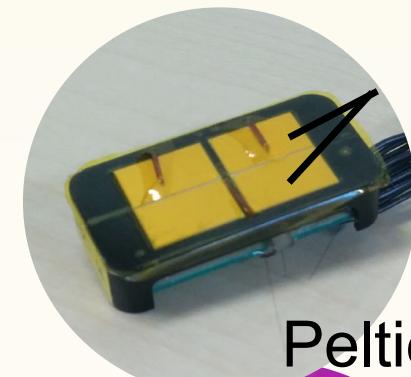




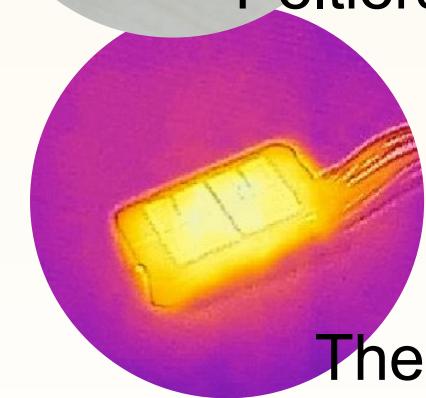
immersion
involves being or feeling surrounded by something.
an expression of how deeply one is submerged
into a body of fluid







Peltiers



Thermal
Vision

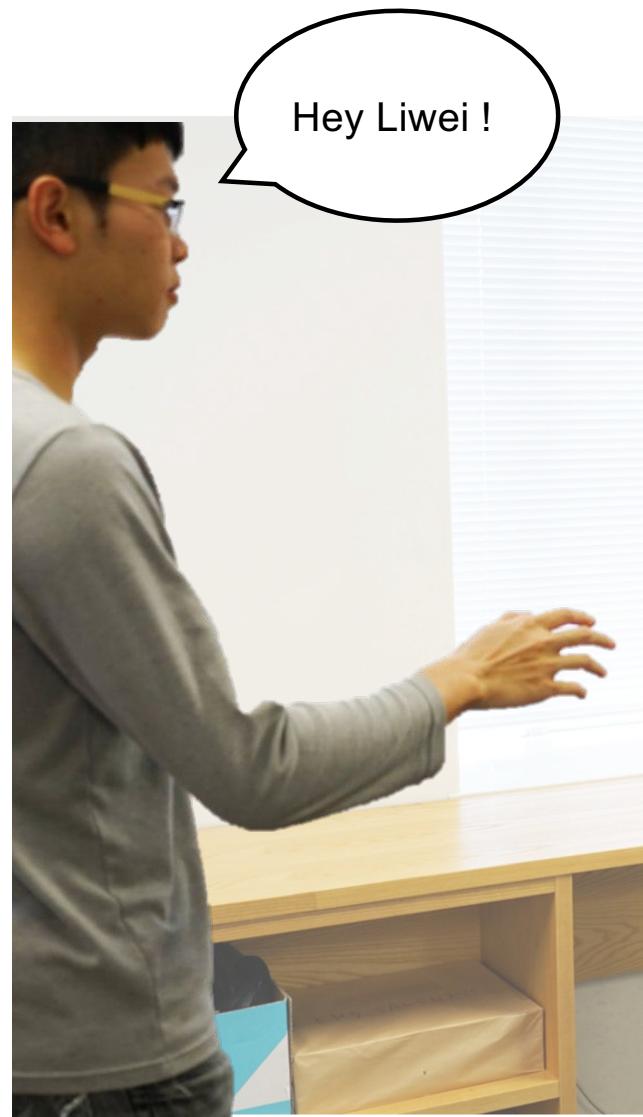
atsunari Sato and Takashi Maeno: Presentation of Rapid Temperature Change using Spatially Divided Hot and Cold Stimuli, Journal of Robotics and Mechatronics, Vol.25, No.3, pp.497-505

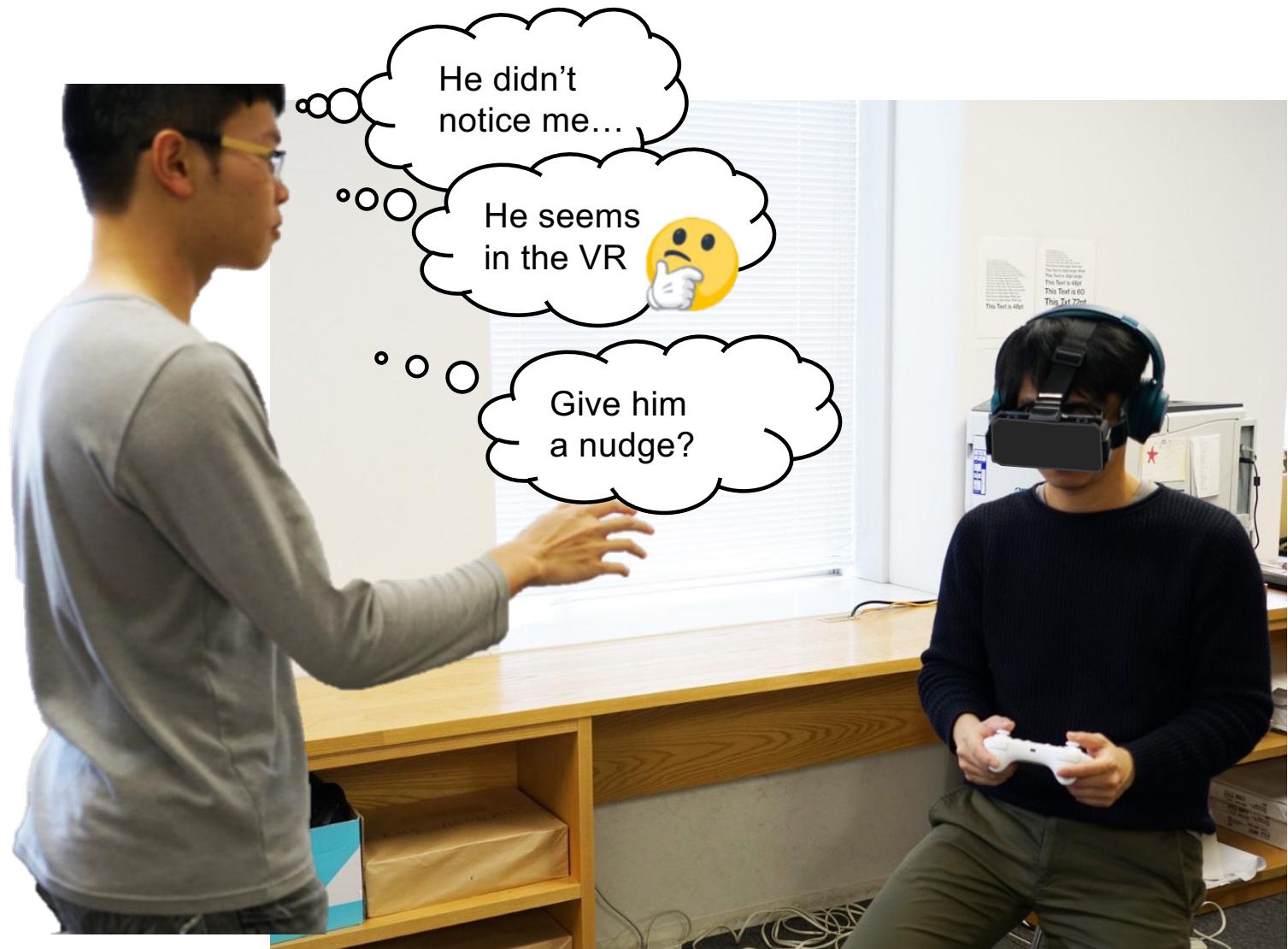
**Immersive VR causes troubles
to the surroundings**

2017

FrontFace









FrontFace:

*Facilitating Communication Between HMD Users
and Outsiders Using Front-Facing-Screen HMDs*





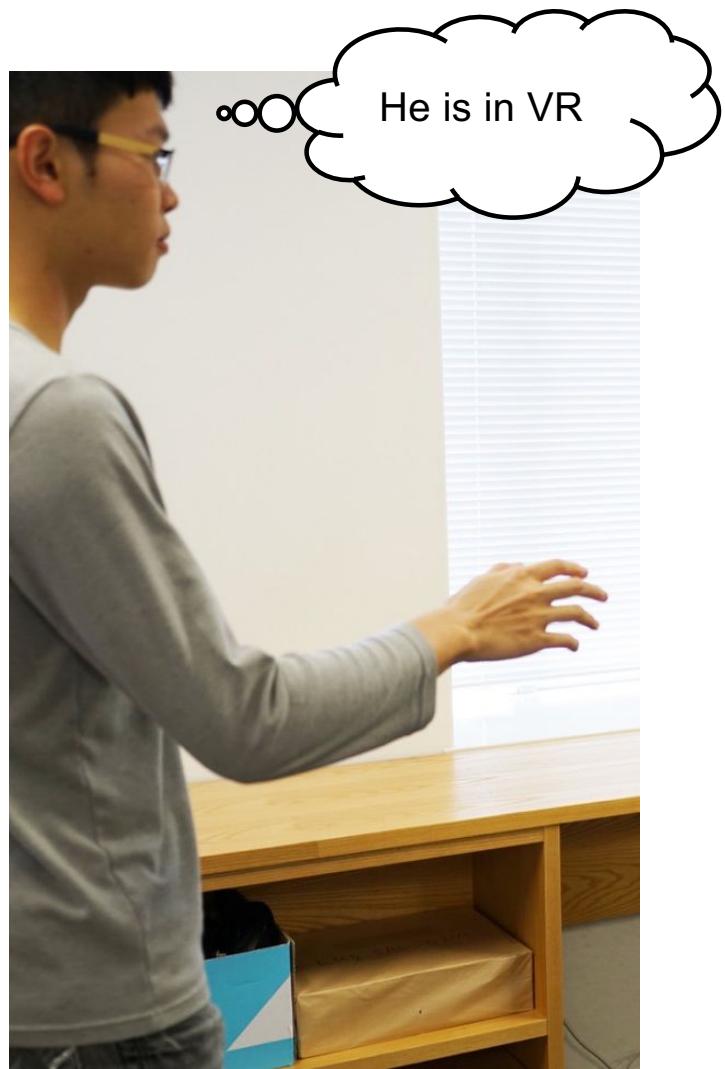
Use this face screen to communicate user state

Reality



Virtual
Reality



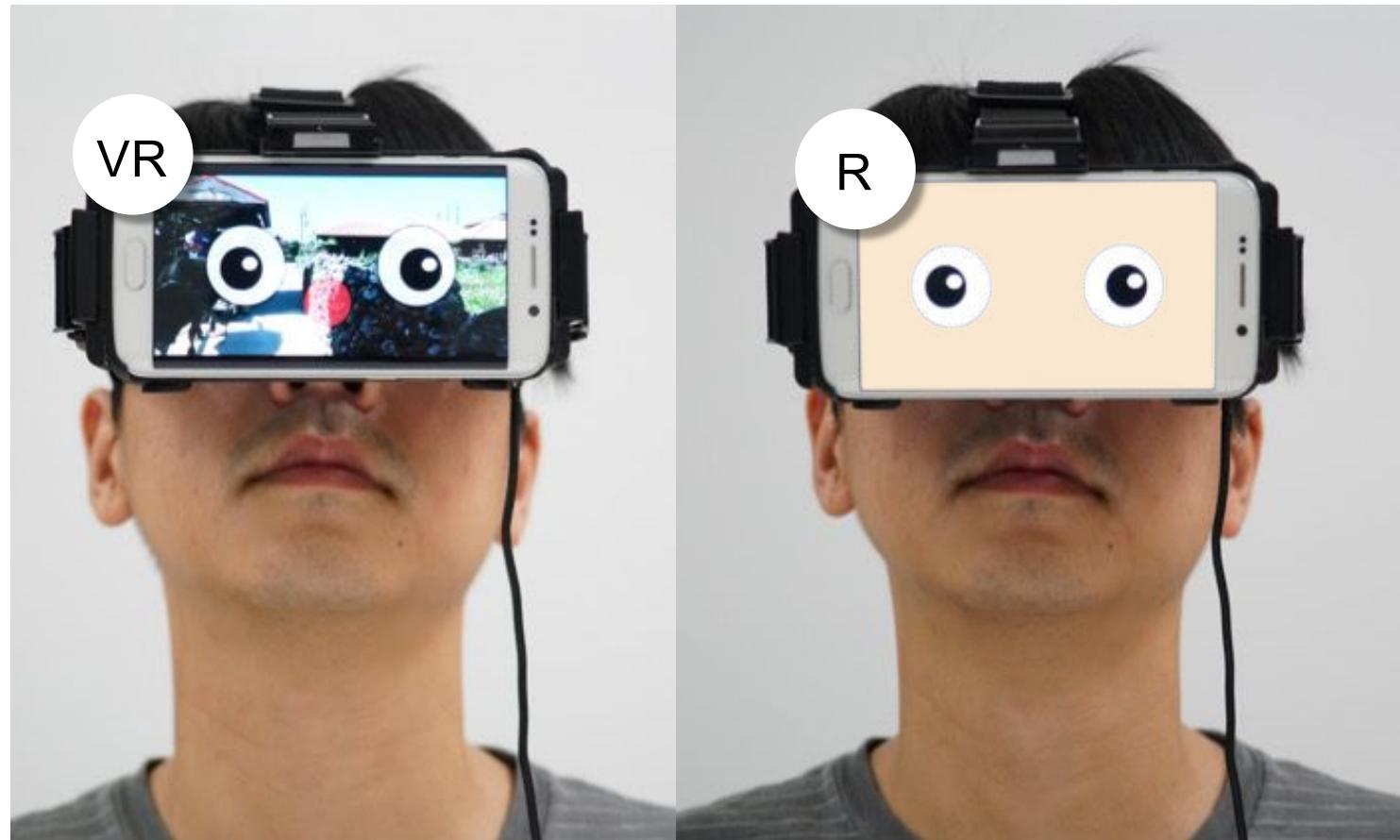




Proof-of-Concept Implementation



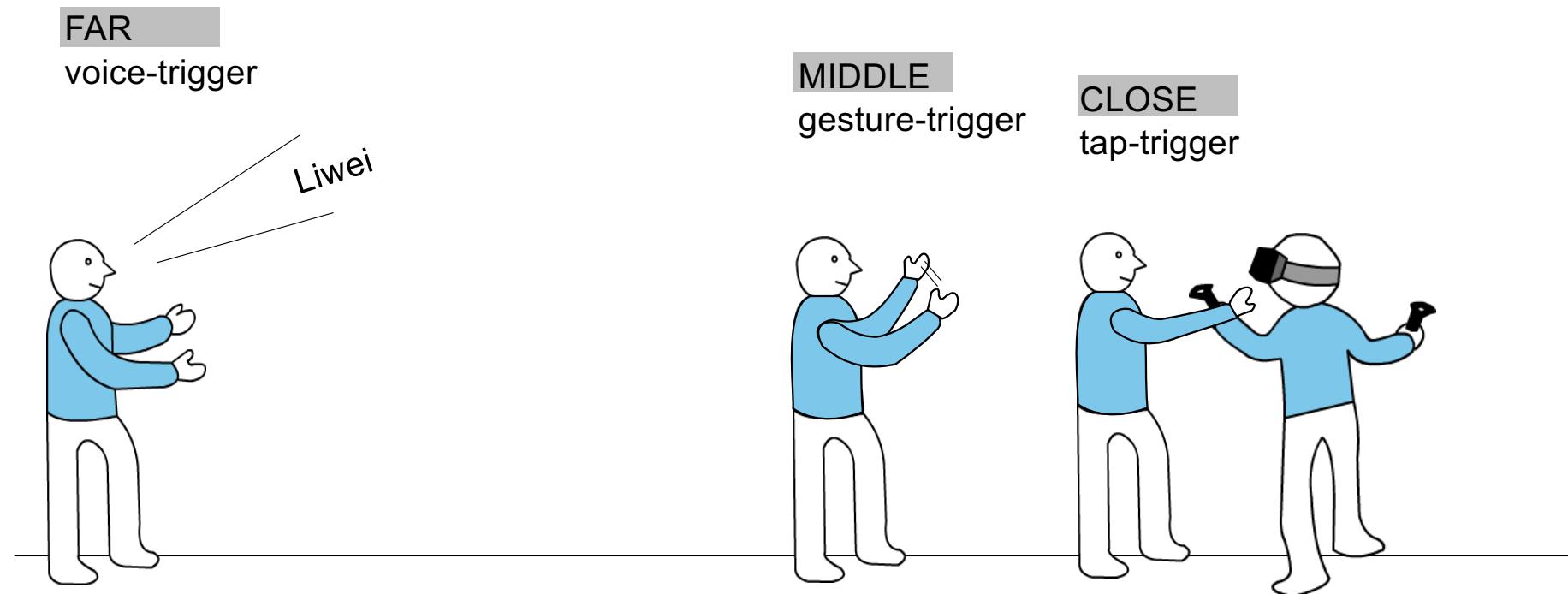
User Presence (2017)



Apple Vision Pro (2023)

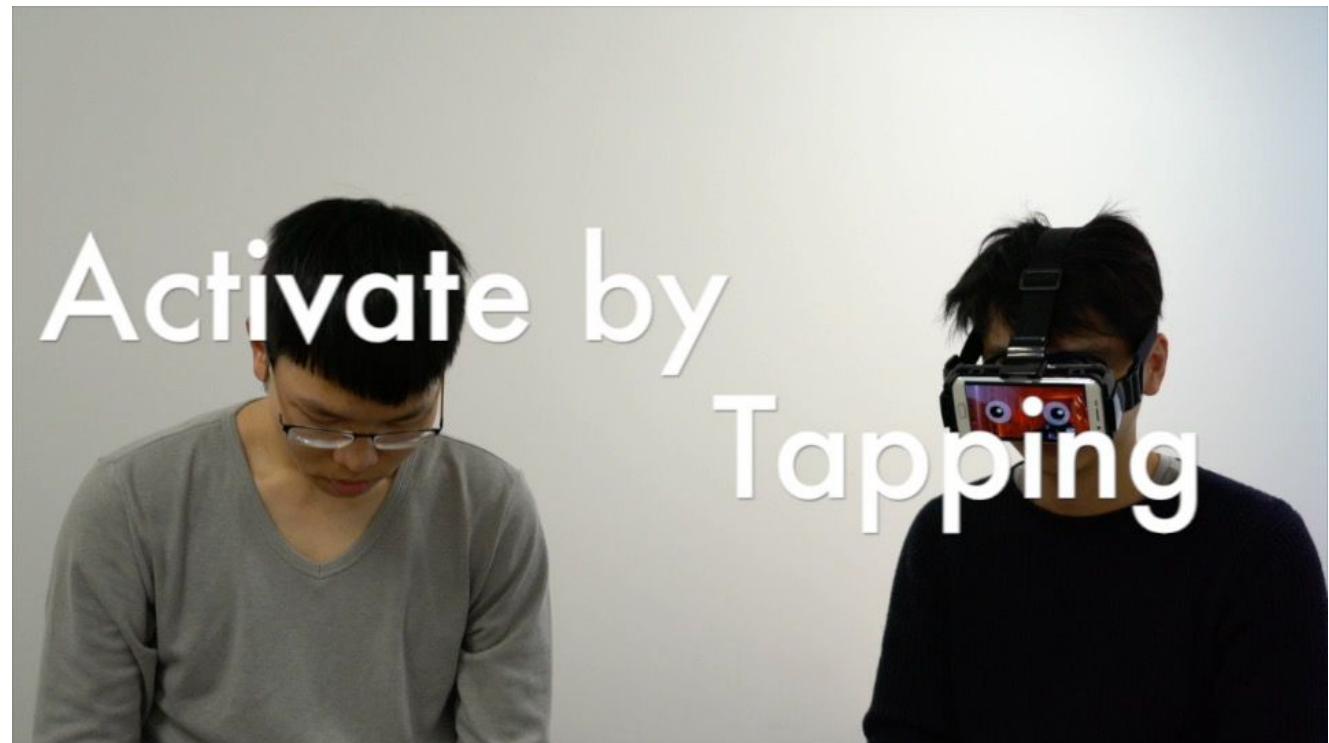


Outsider-Initiated Communication

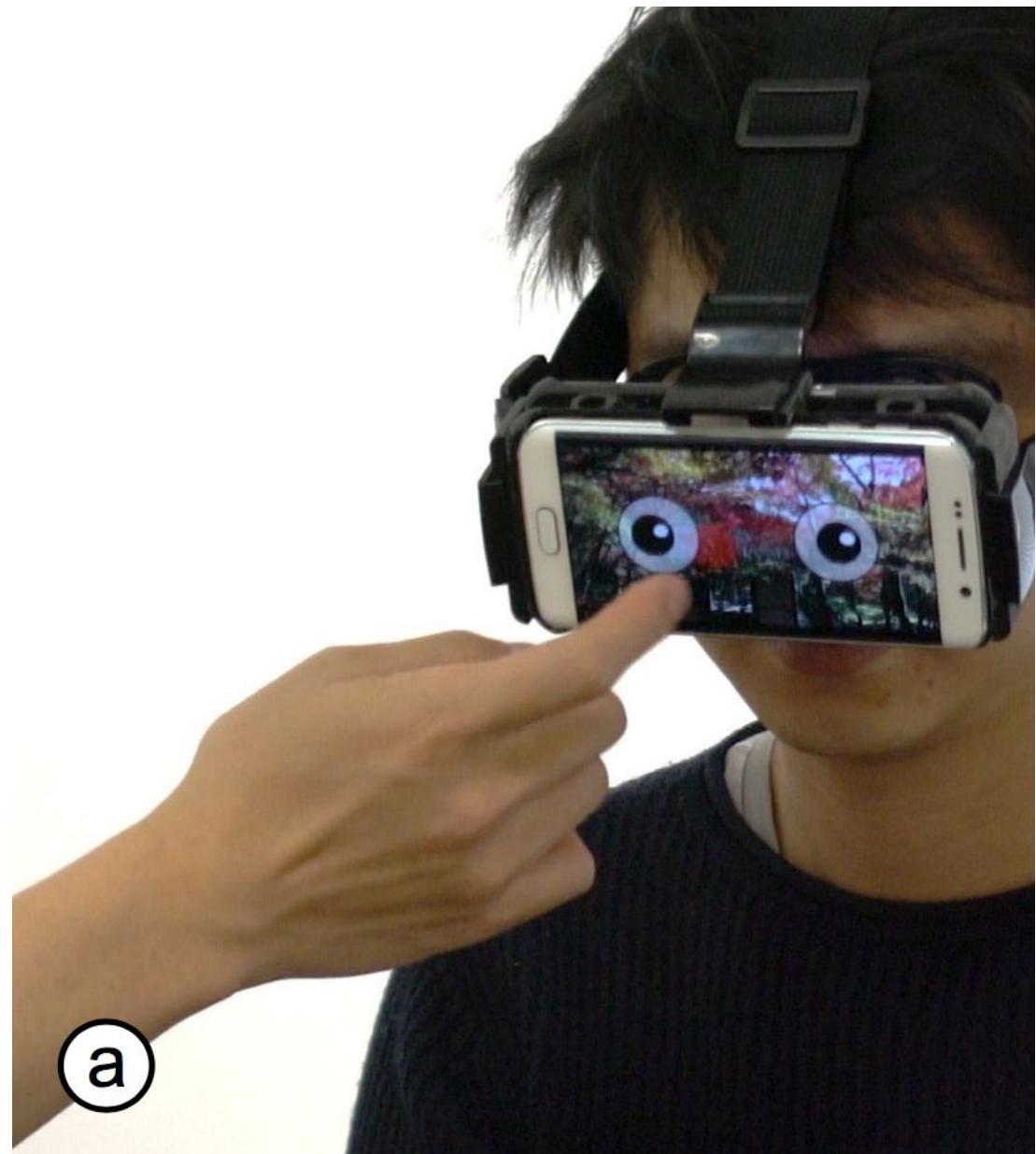
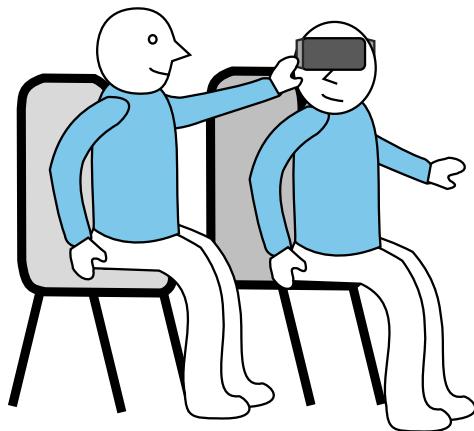


Outsider-Initiated Communication

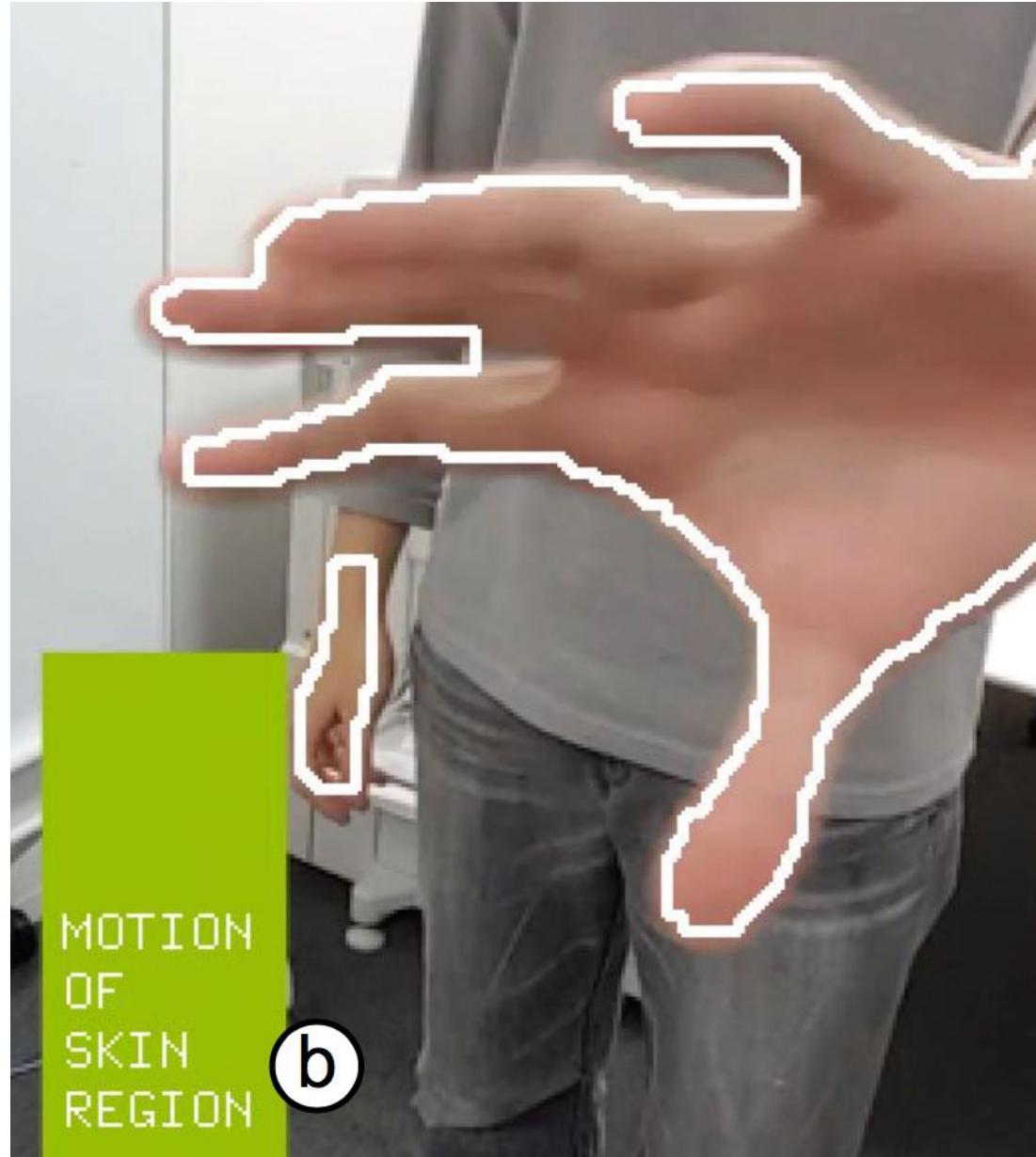
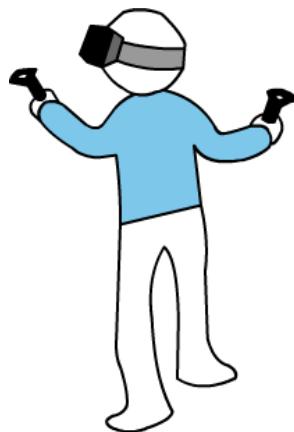
- Tap-Trigger
- Gesture-Trigger
- Voice-Trigger



CLOSE
tap-trigger



MIDDLE
gesture-trigger



FAR

voice-trigger

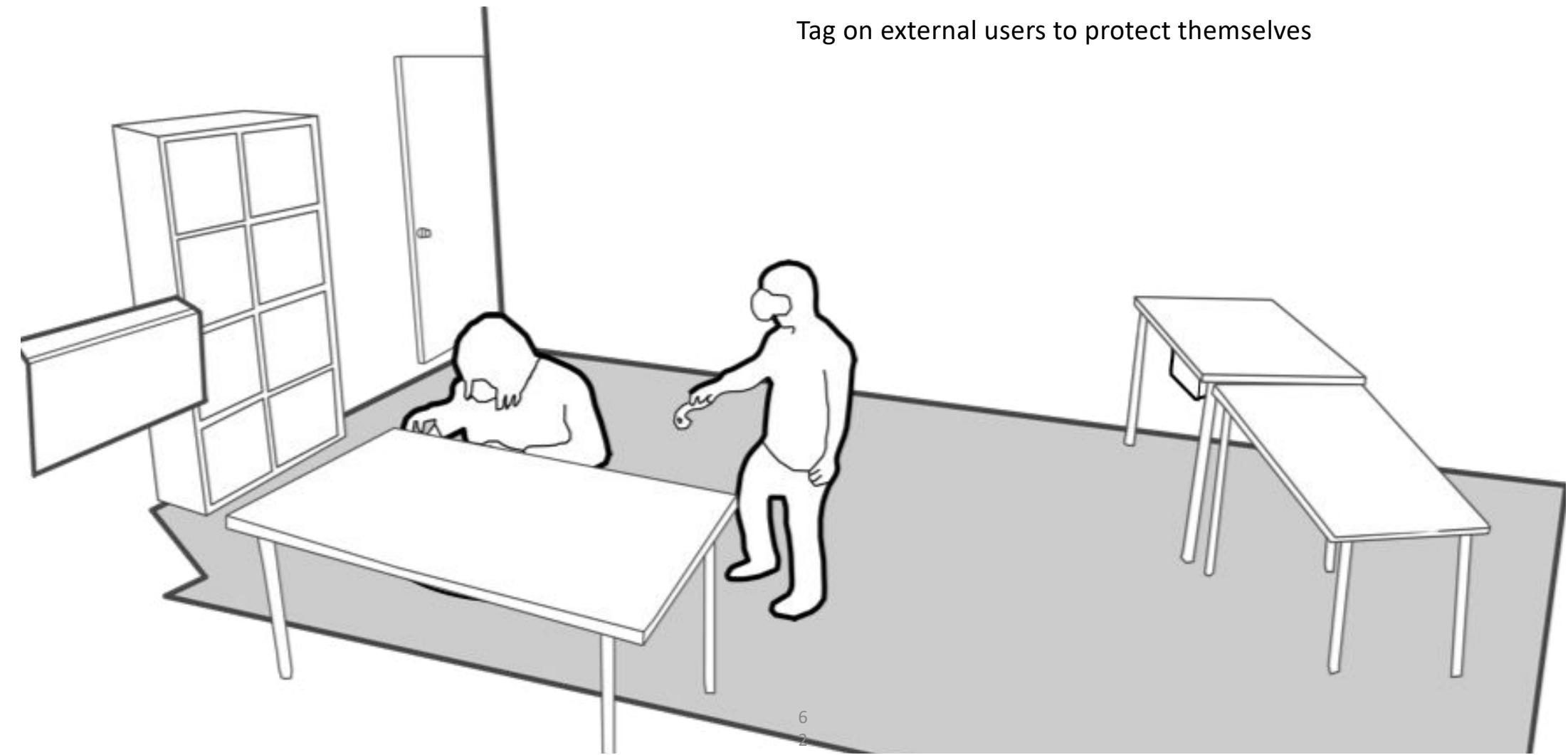


ShareSpace

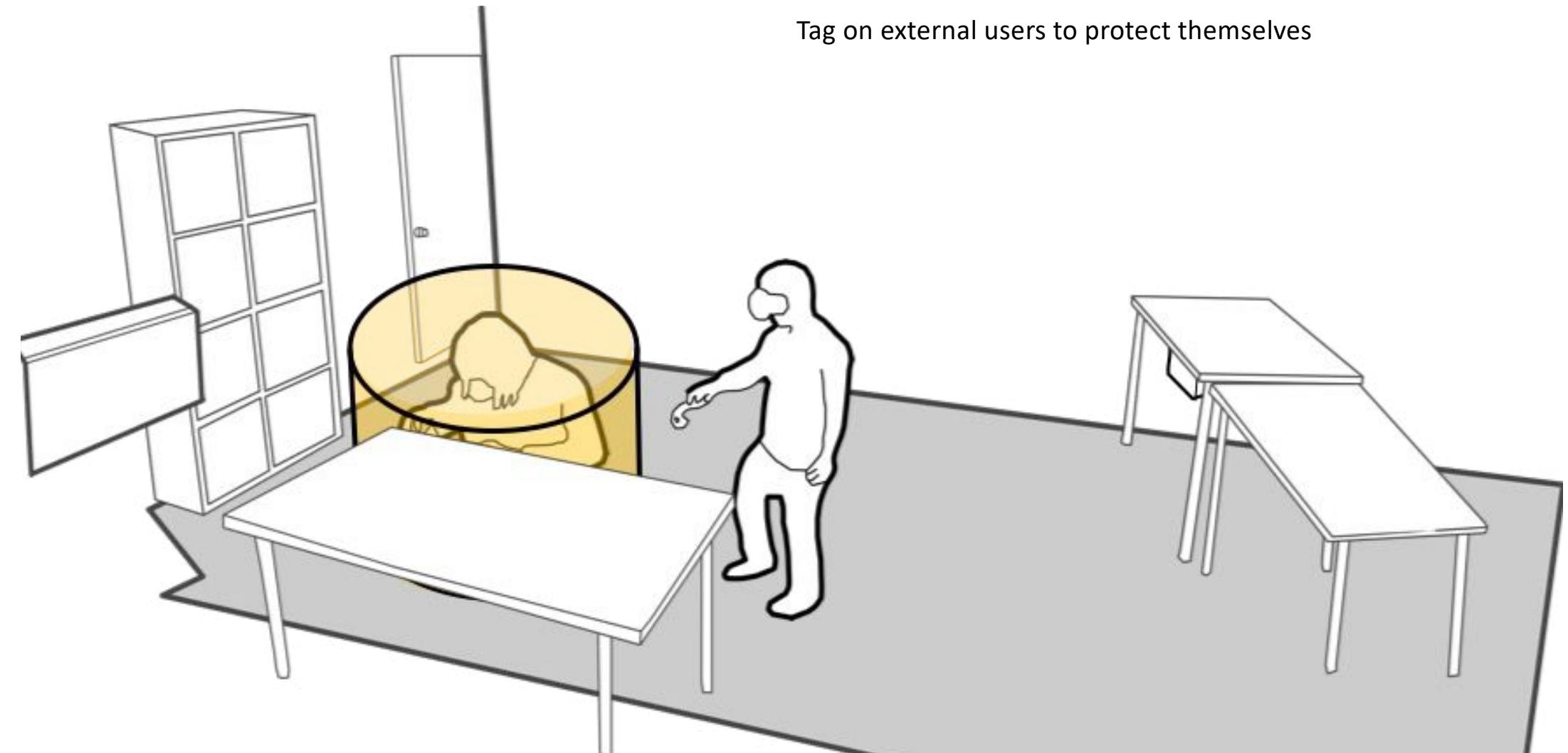




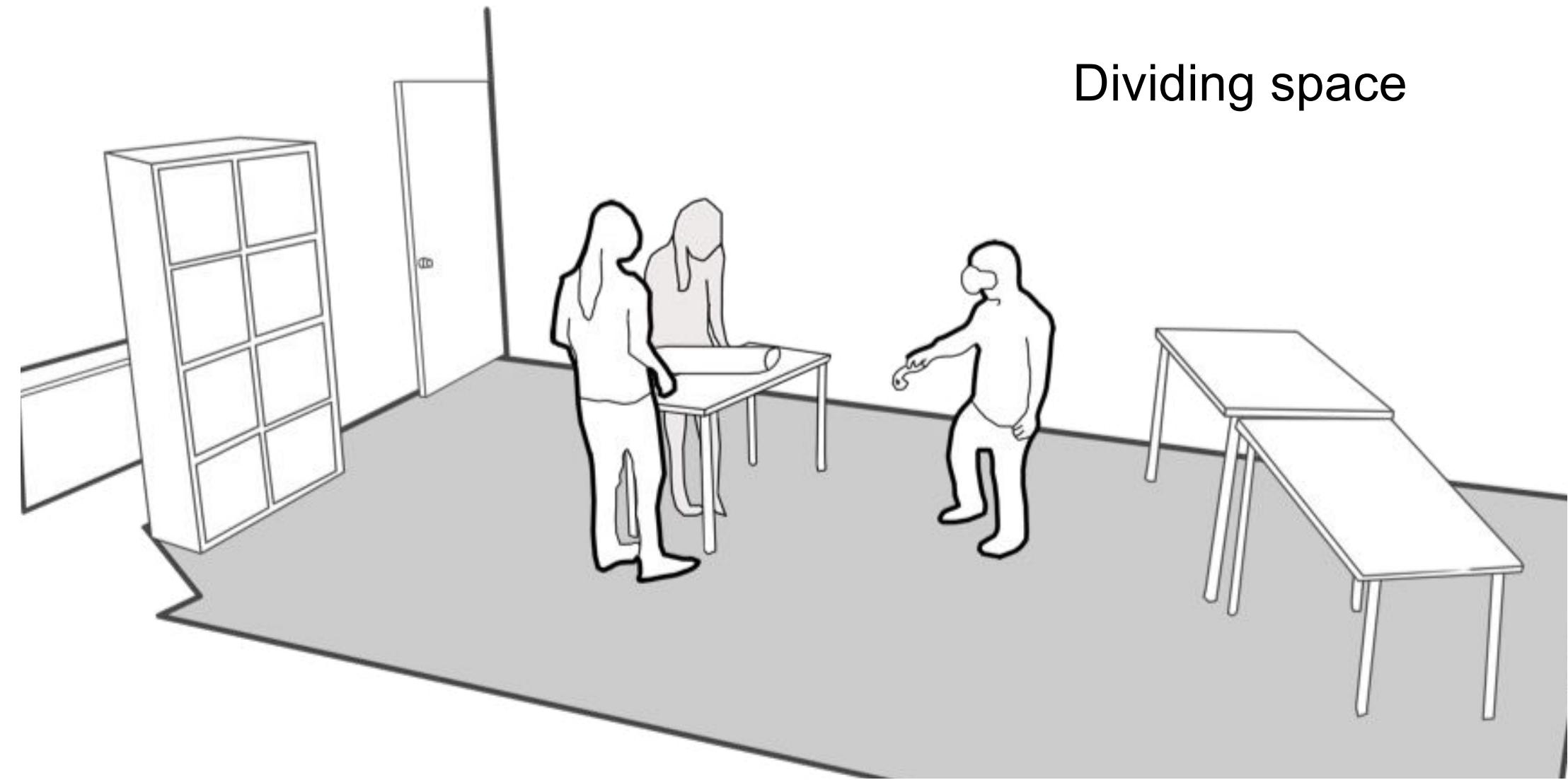
Tag on external users to protect themselves



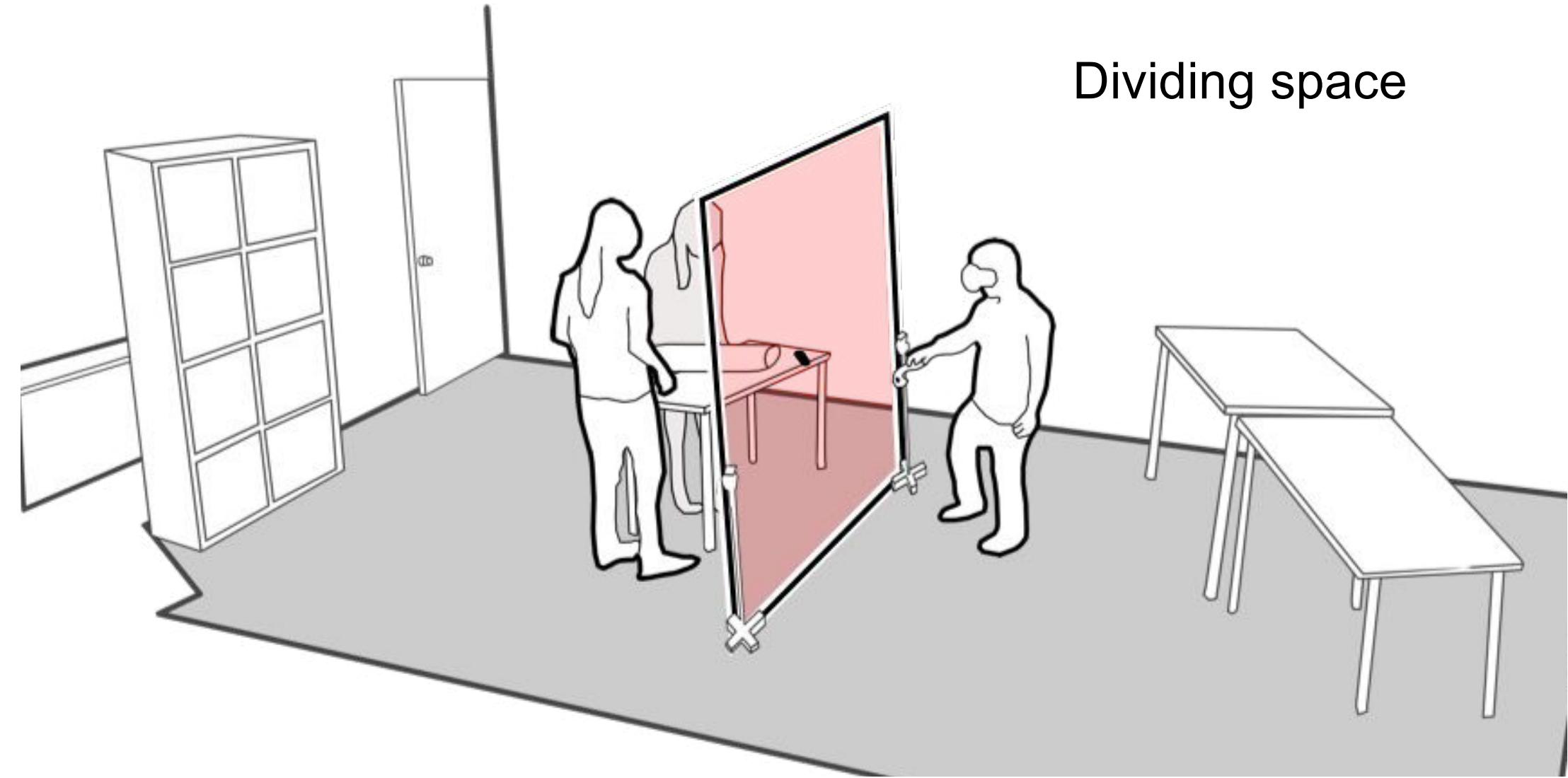
Tag on external users to protect themselves



Dividing space



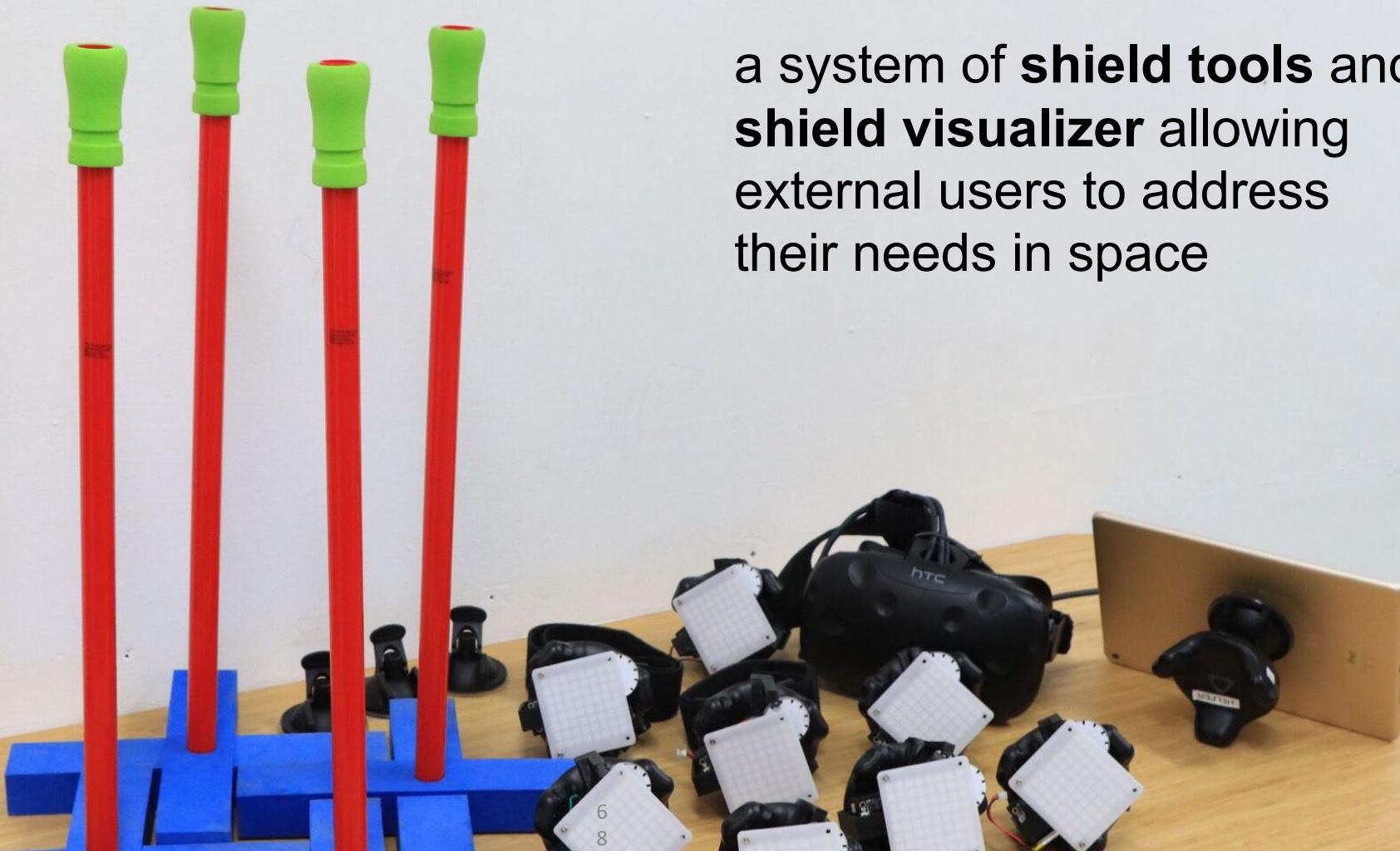
Dividing space





ShareSpace

a system of **shield tools** and
shield visualizer allowing
external users to address
their needs in space



Attachment method

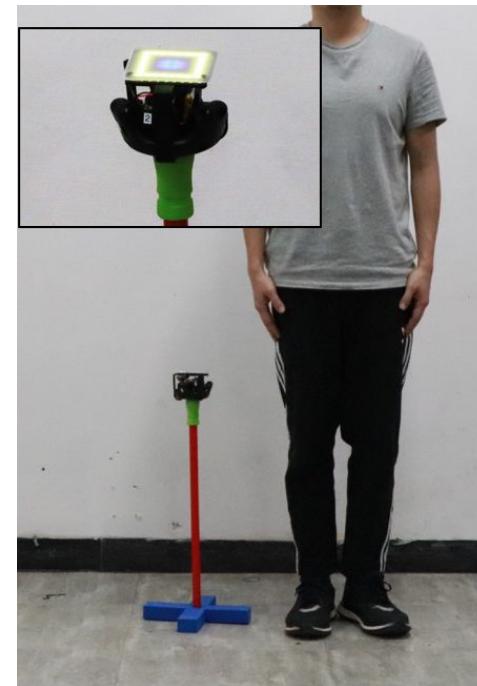
surface-sucker

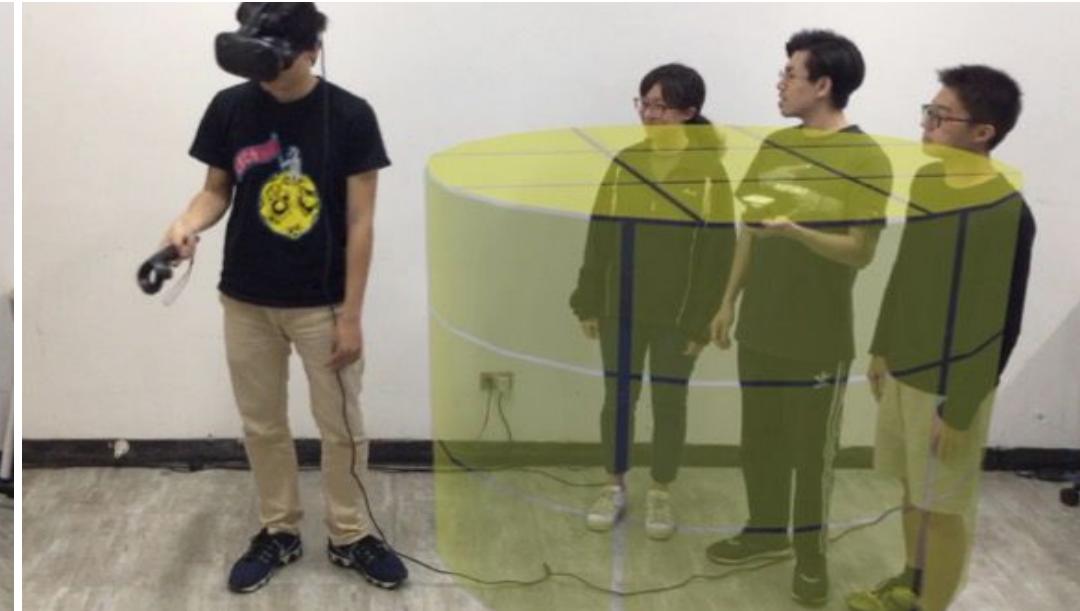


arm-belt



stand



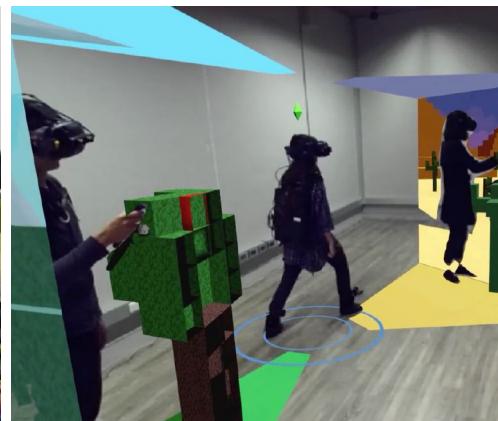


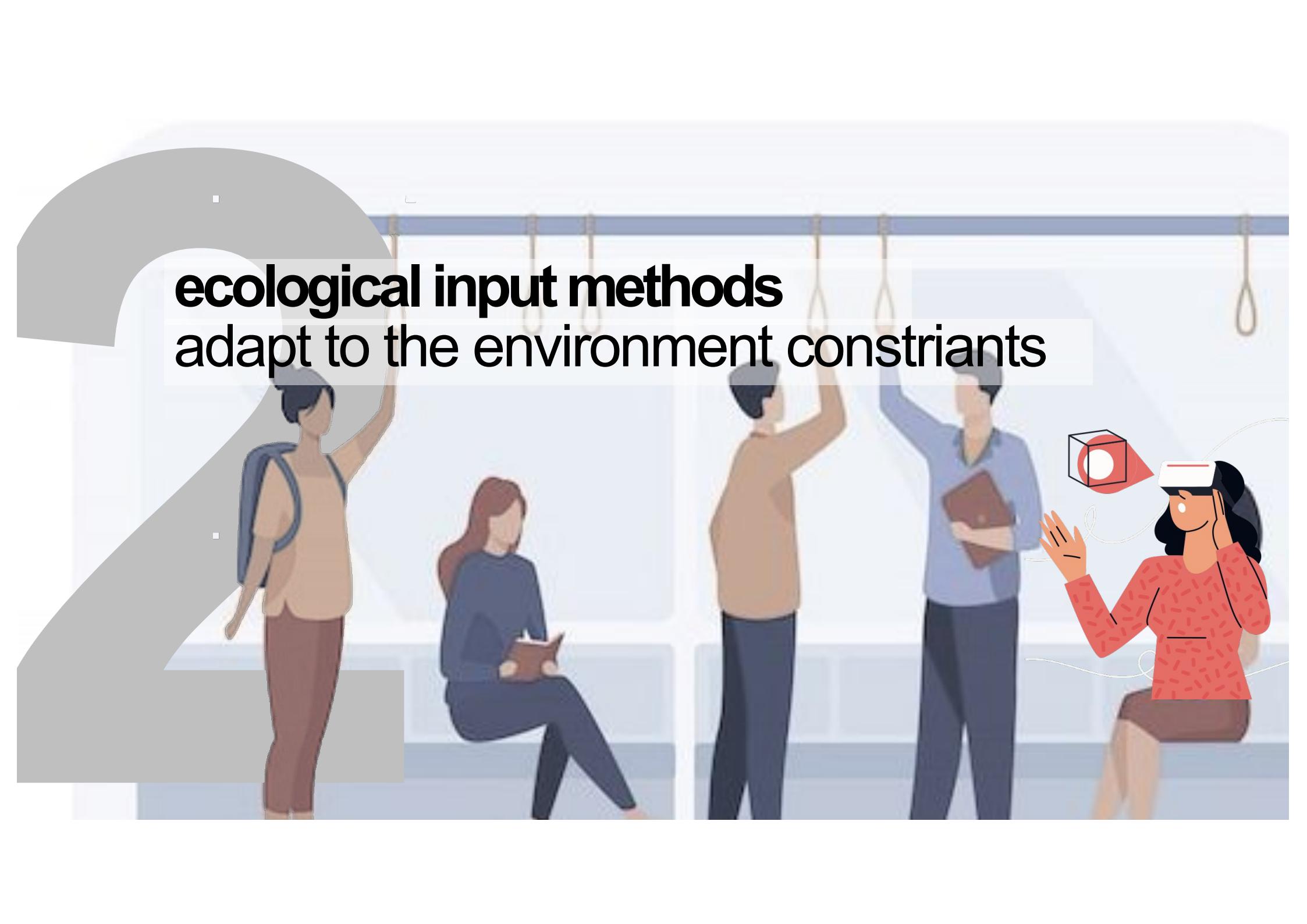


Let Us Talk Face-to-Face



HMD as an ecological device is accessible to the surroundings



A background illustration depicting a modern office environment. On the left, a person in a tan shirt and brown pants stands with their arms raised, wearing a blue backpack. In the center, a person in a dark blue sweater is seated, looking down at a book. To the right, two more individuals stand; one in an orange shirt has their arm raised, while the other in a light blue shirt holds a brown folder. On the far right, a person in a red patterned shirt uses a VR headset, with a red cube floating above their hand.

ecological input methods
adapt to the environment constraints

2024

Seated-WIP

*Enabling Walking-in-Place
Locomotion on Stationary
Chairs for Highly
Constrained Spaces*

Liwei Chan, Tzu-Wei Mi, Zung-Hao Hsueh,
Yi-Ci Huang, Ming-Yun Hsu

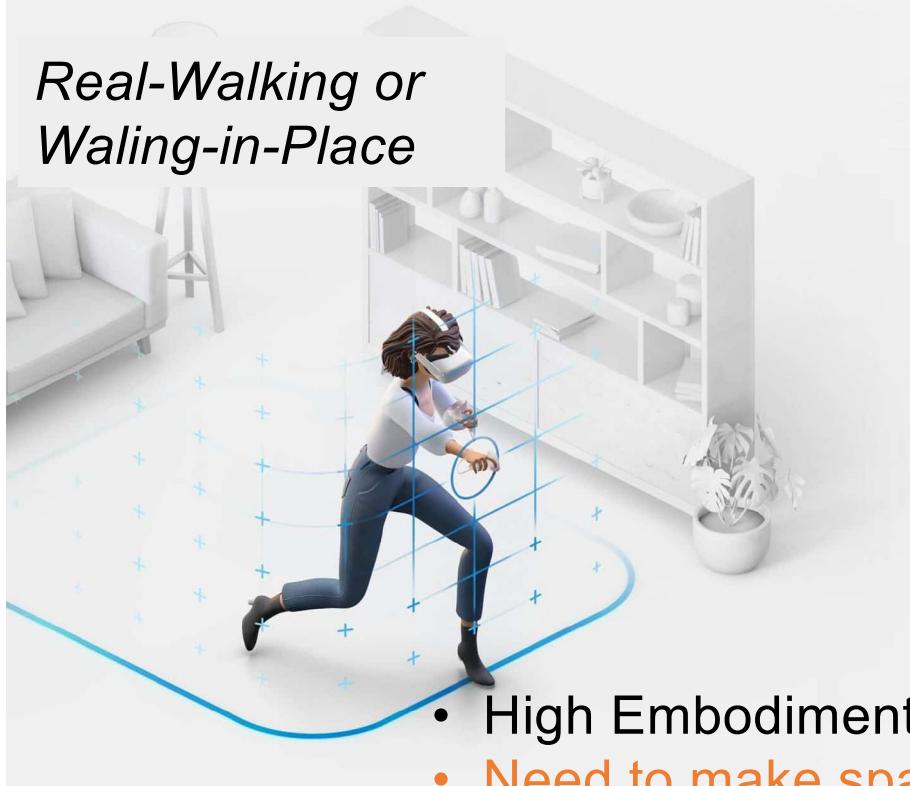






VR Locomotion

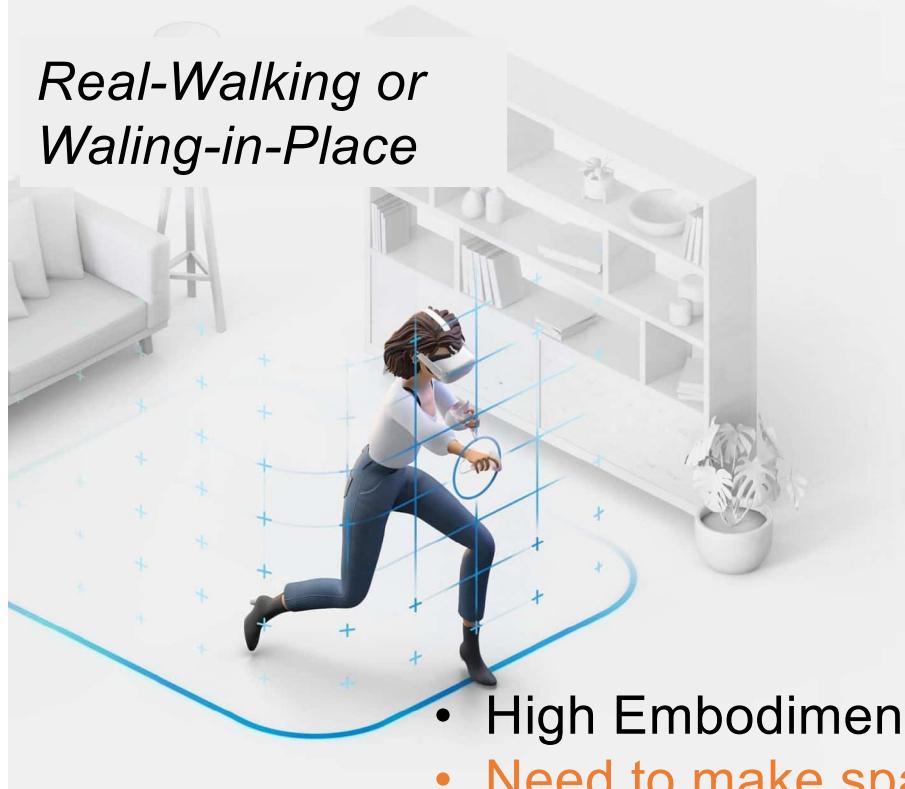
*Real-Walking or
Walking-in-Place*



- High Embodiment
- Need to make space
- Not for prolonged use

VR Locomotion

*Real-Walking or
Walking-in-Place*



- High Embodiment
- Need to make space
- Not for prolonged use

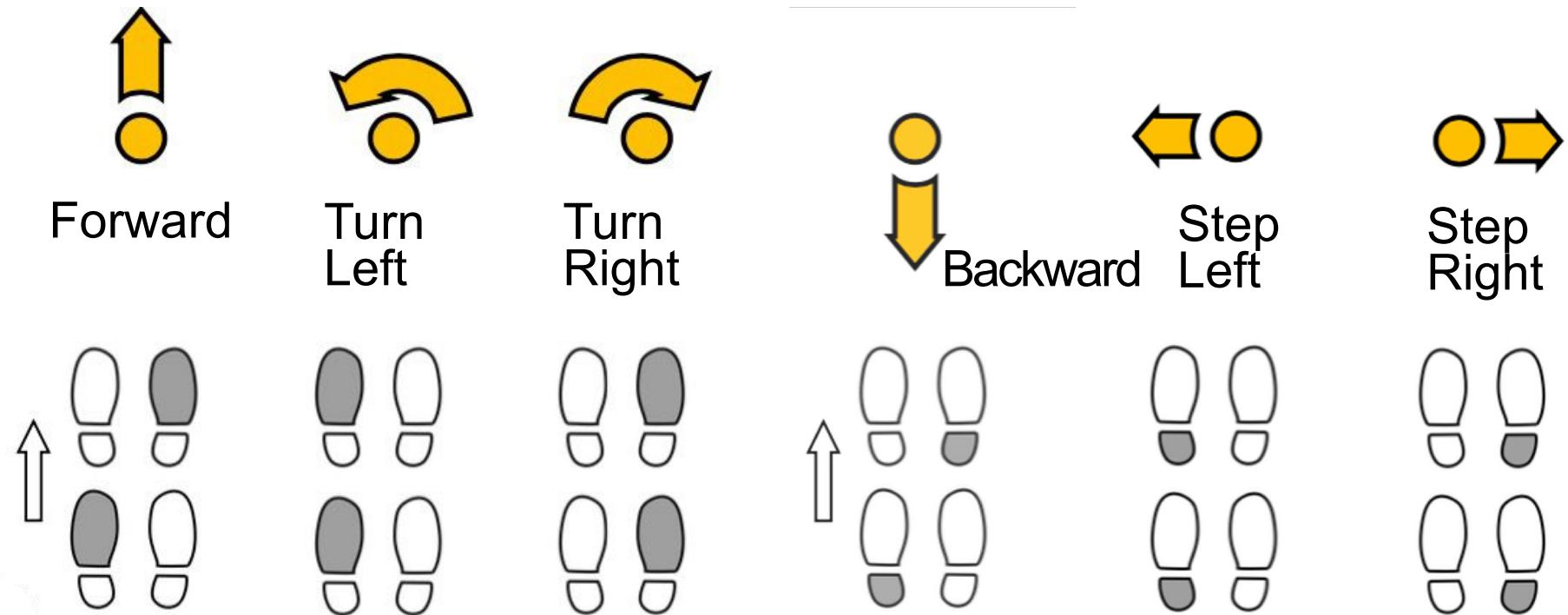


- Medium Embodiment
- Anywhere can sit
- Prolonged use

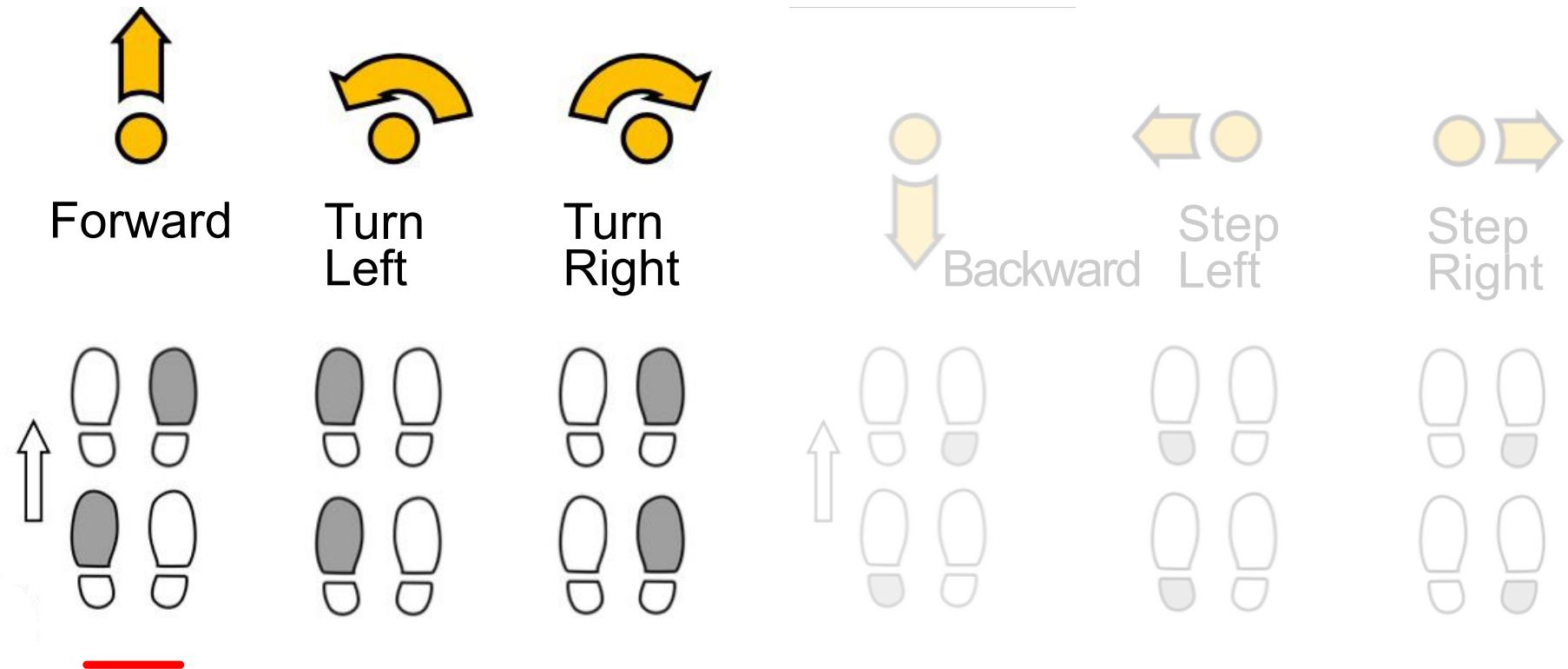




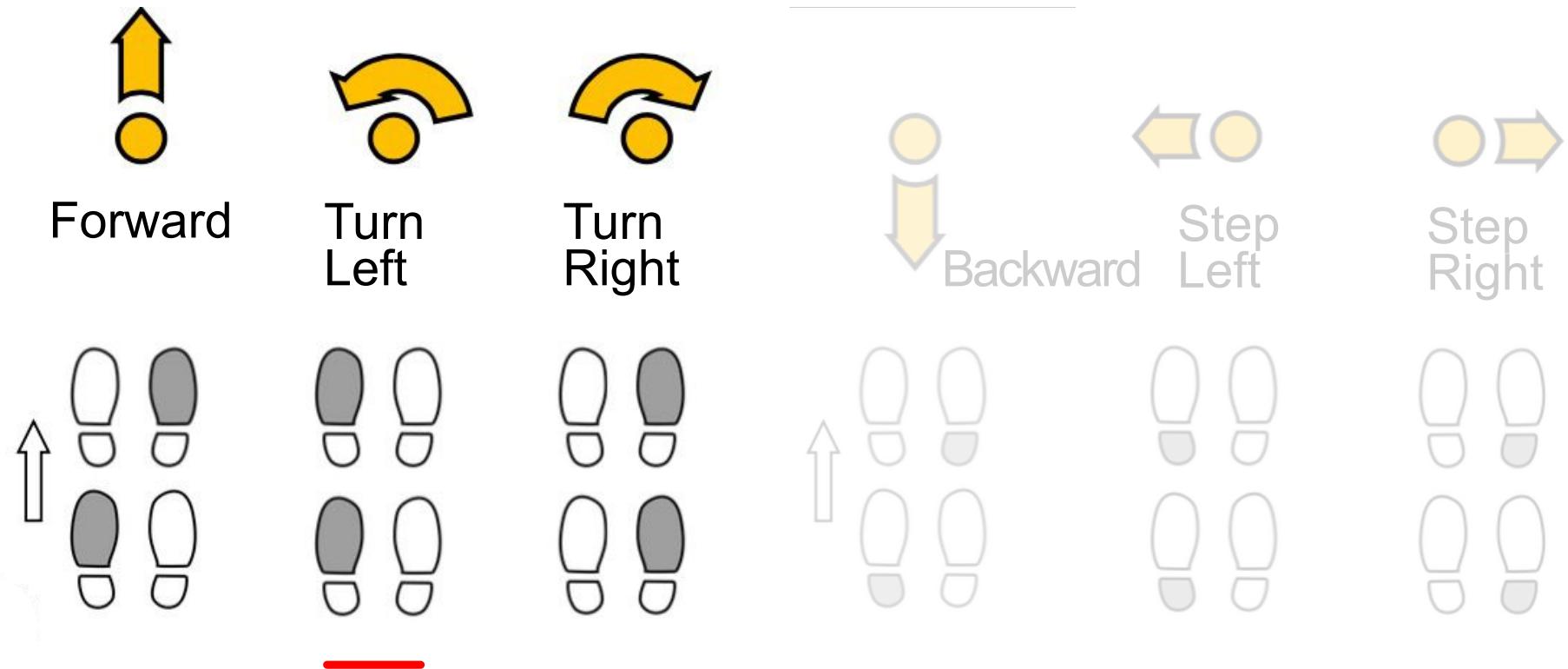
Interaction Design



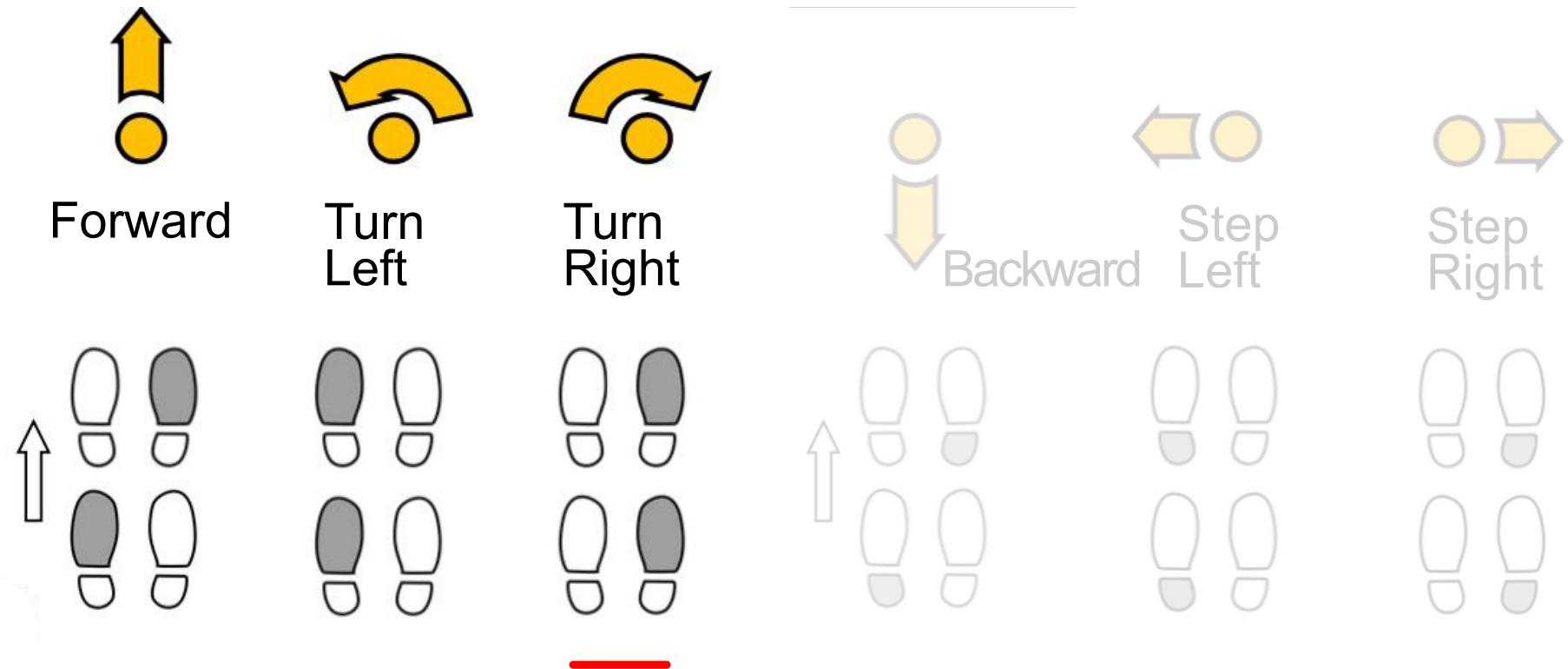
Interaction Design



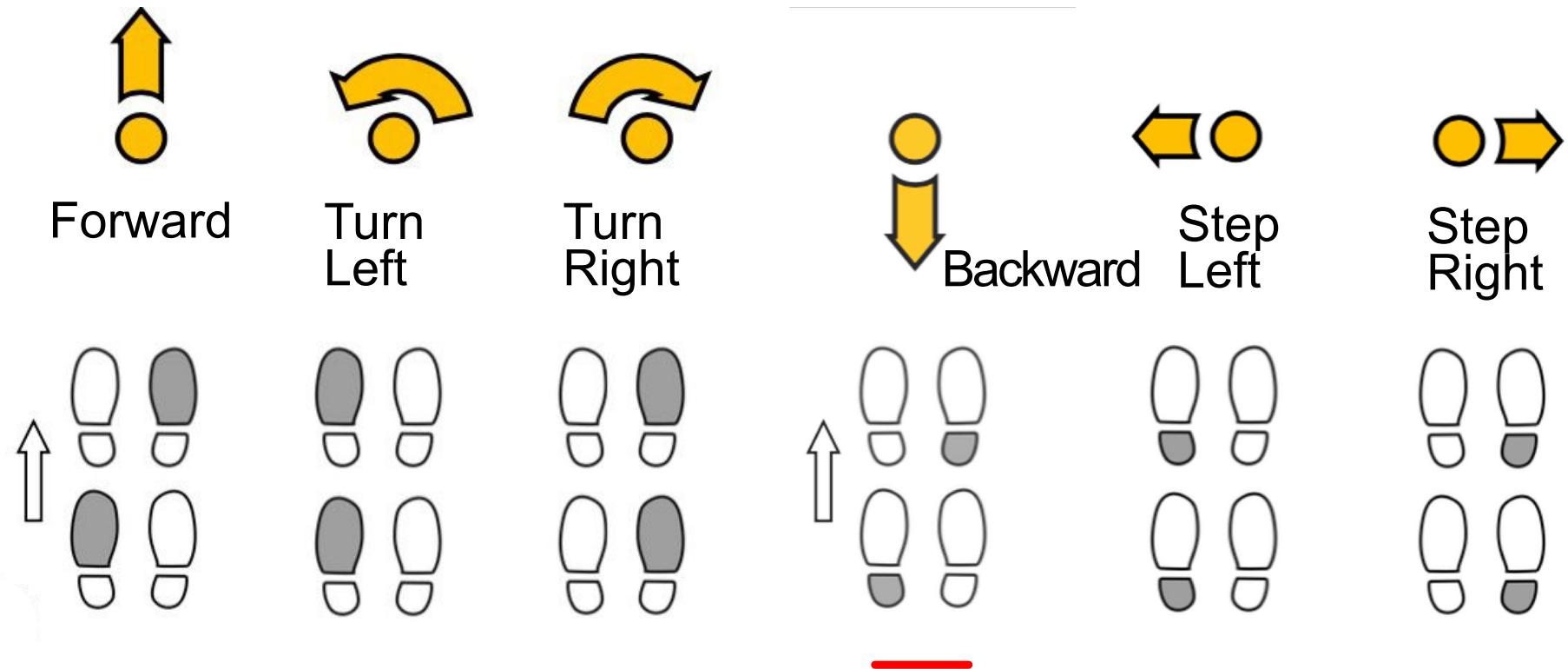
Interaction Design



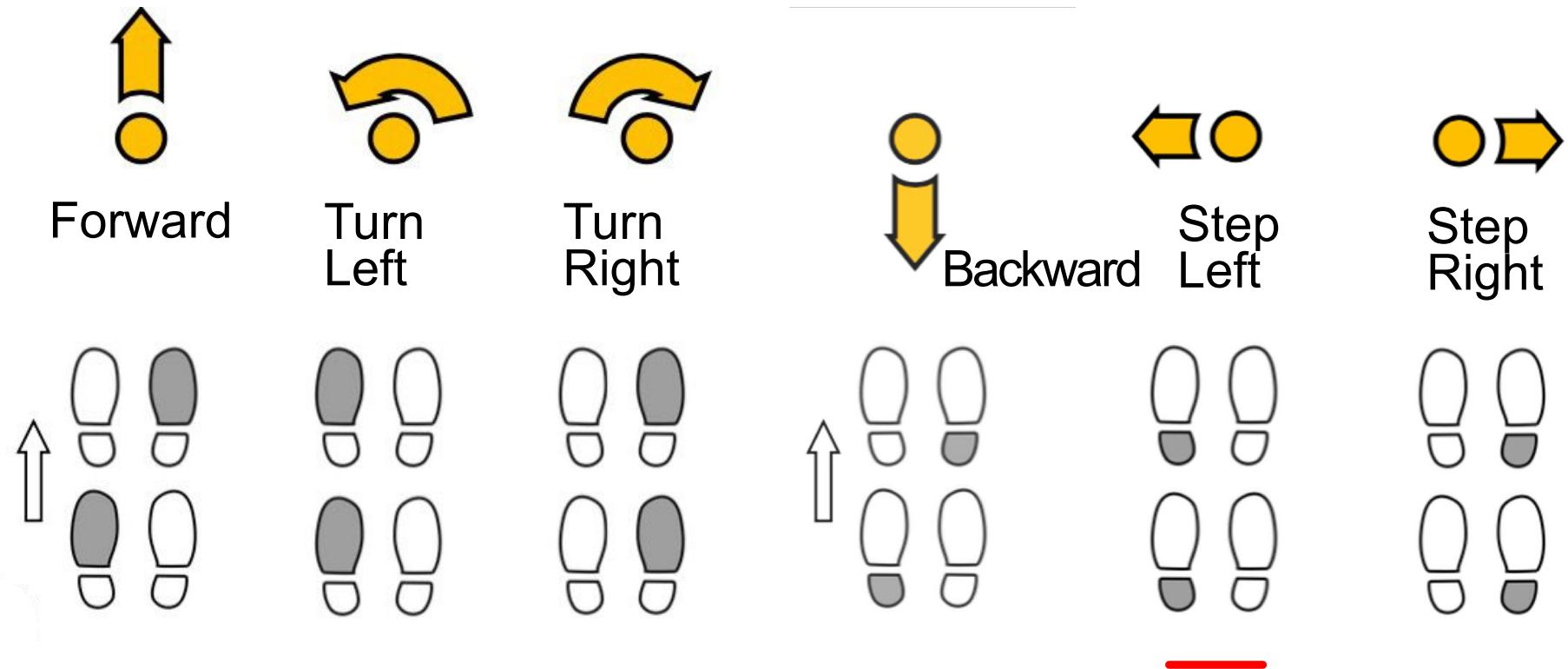
Interaction Design



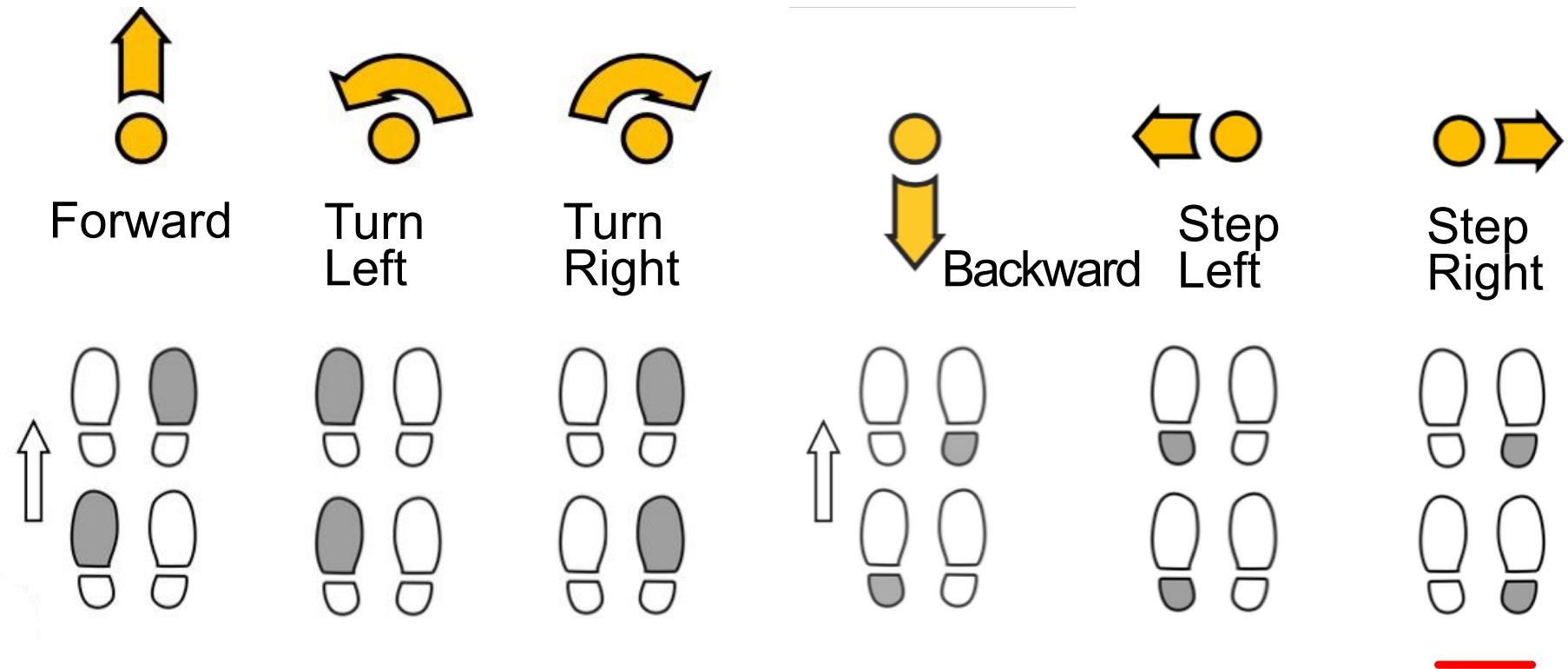
Interaction Design



Interaction Design



Interaction Design



Prototype

Photo-Reflective
Sensors

Wifi Arduino
(Adafruit M0)
with a lithium battery



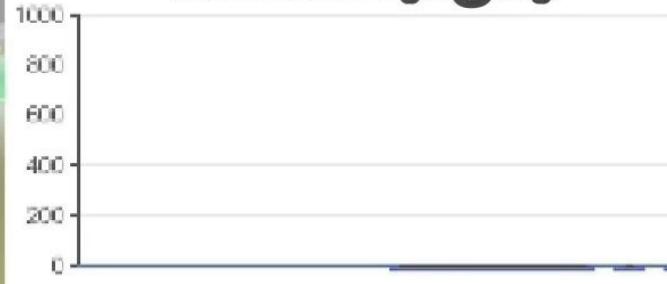
Forefoot (Right)



Forefoot (Left)



Rearfoot (Right)



Rearfoot (Left)



Thumbstick



Leaning



FootSteps



Thumbstick



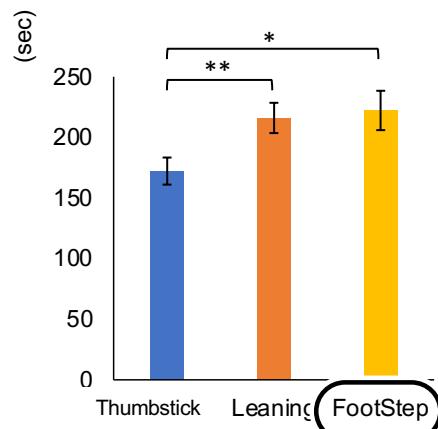
Leaning



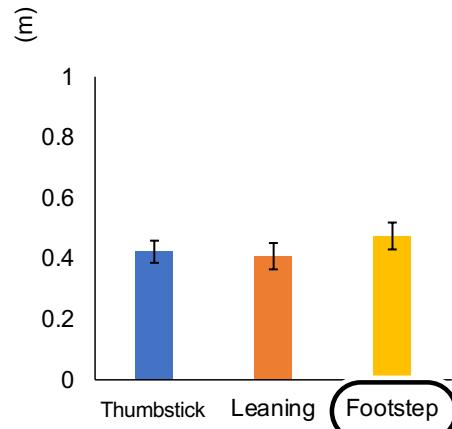
FootSteps



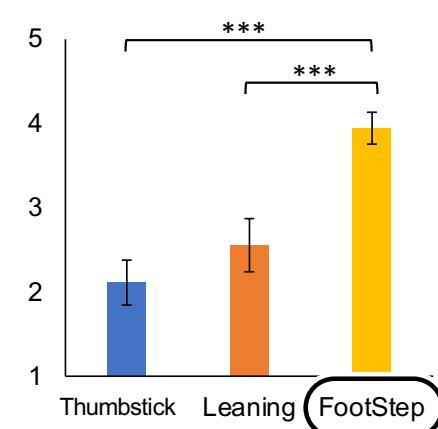
Completion Time



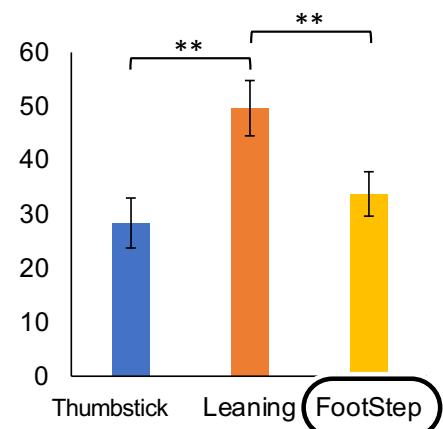
Drift Error



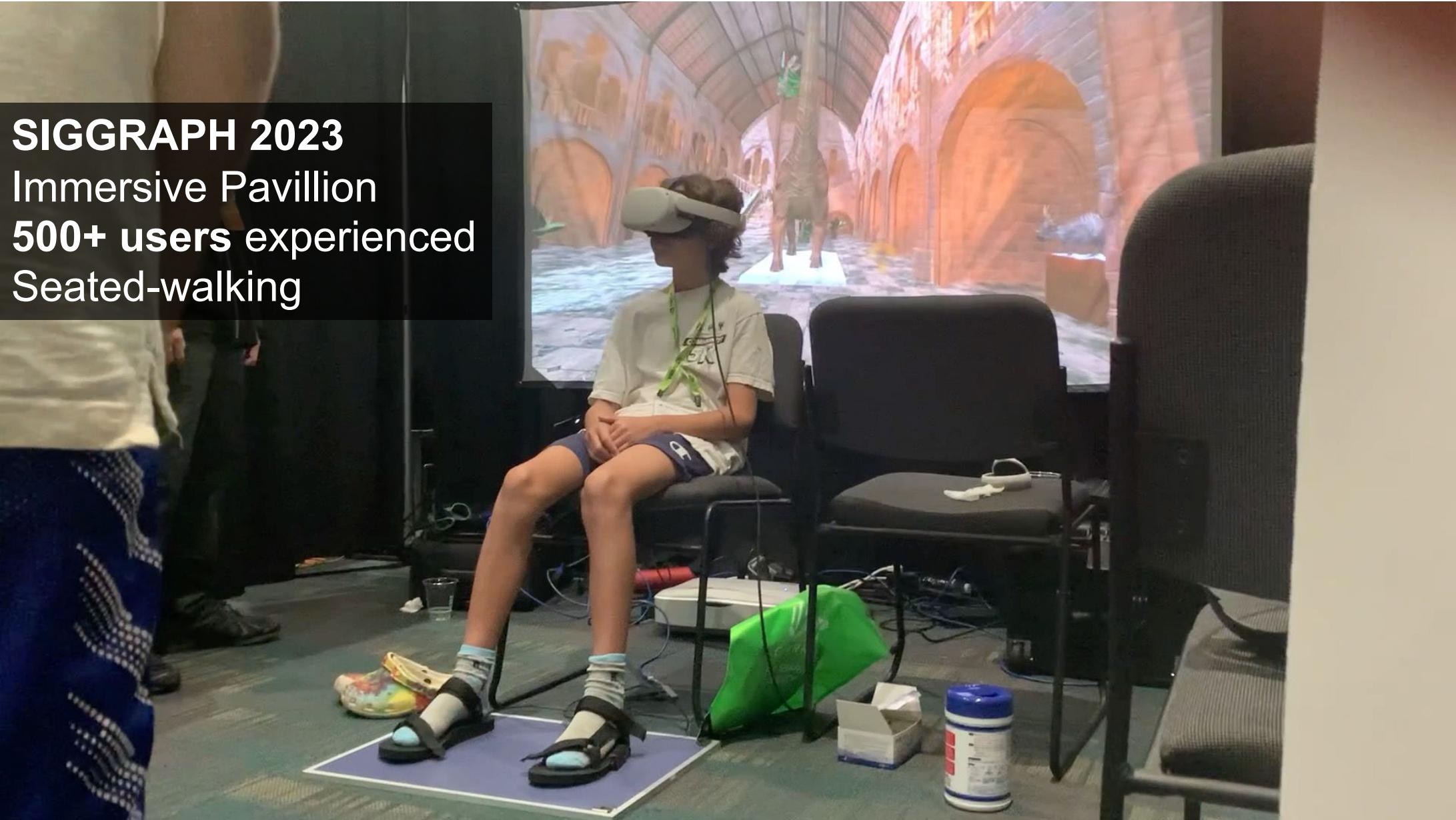
Embodiment



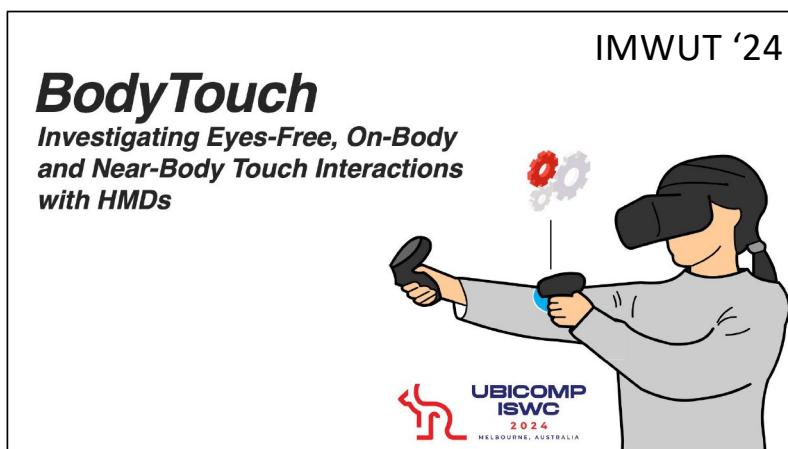
NASA-TLX



SIGGRAPH 2023
Immersive Pavillion
500+ users experienced
Seated-walking



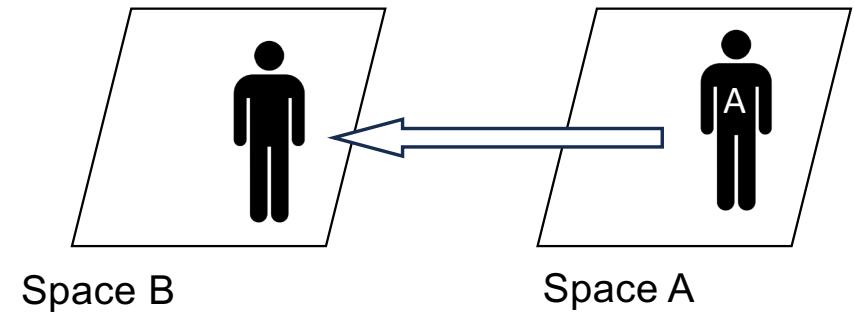




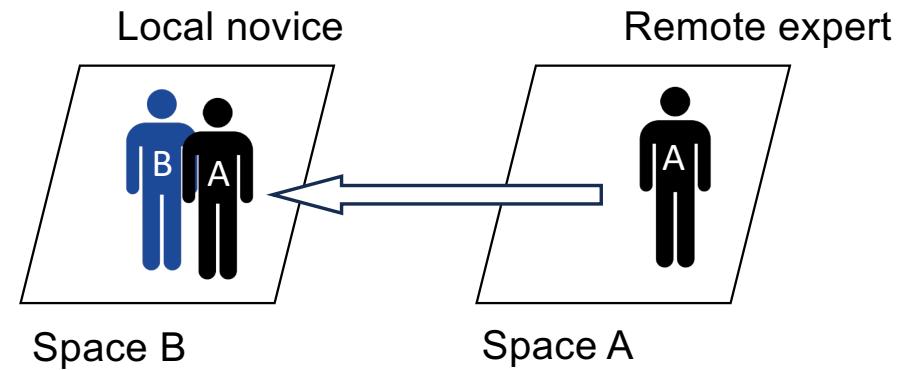
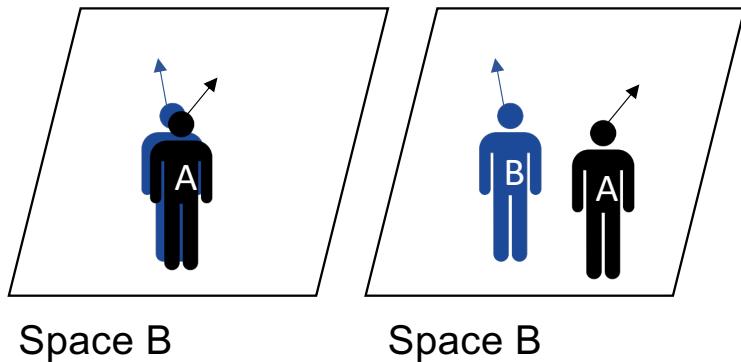
Mobility-First Mutual Telepresence



Telepresence

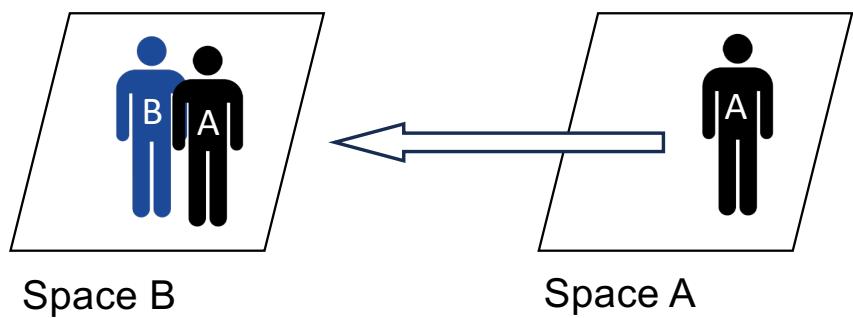


Asymmetric Telepresence - collaboration



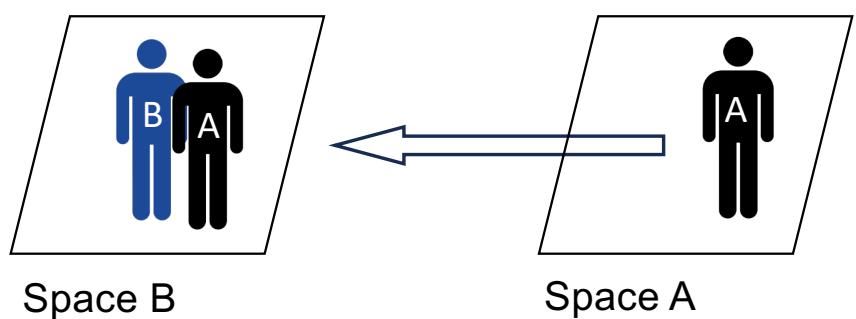
Holoportation, UIST '16

Asymmetric Telepresence - collaboration



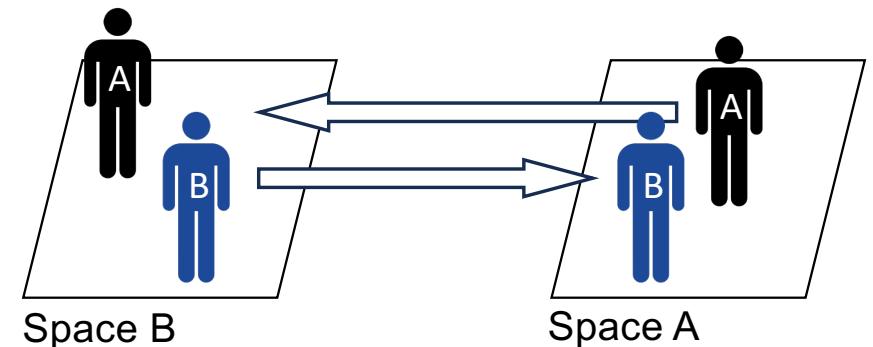
A's environment presence
moved to Space B

Asymmetric Telepresence - collaboration



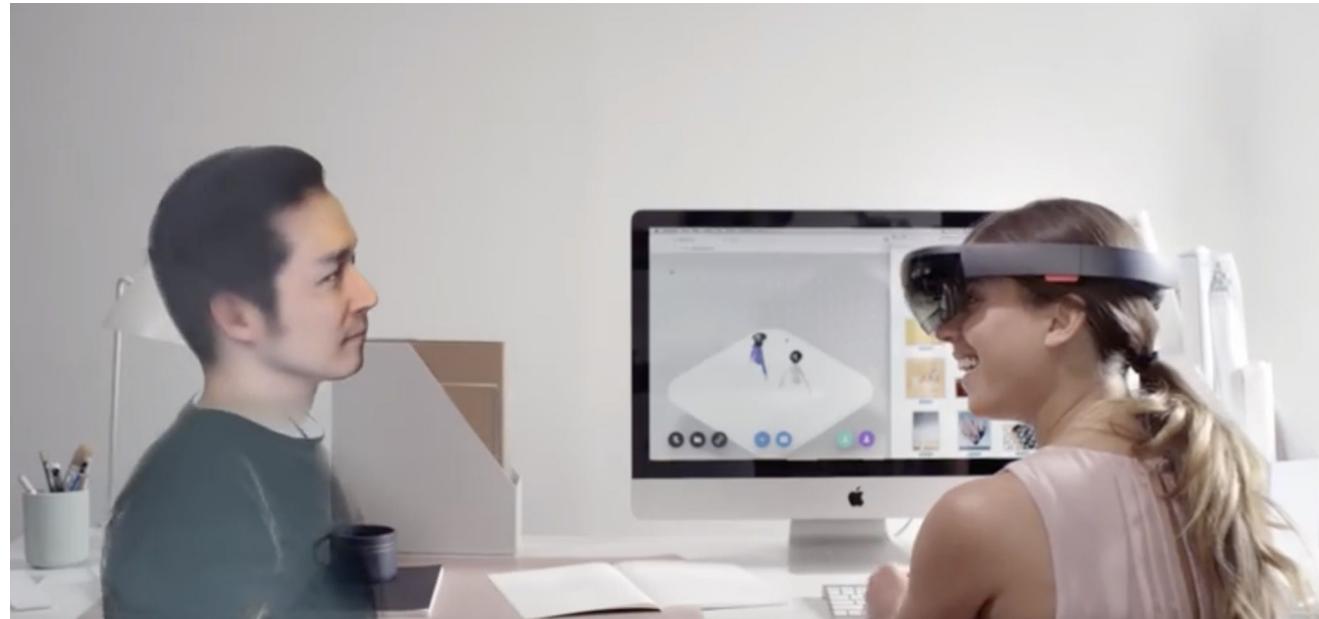
A's environment presence
moved to Space B

Symmetric Telepresence **(Mutual Telepresence)**

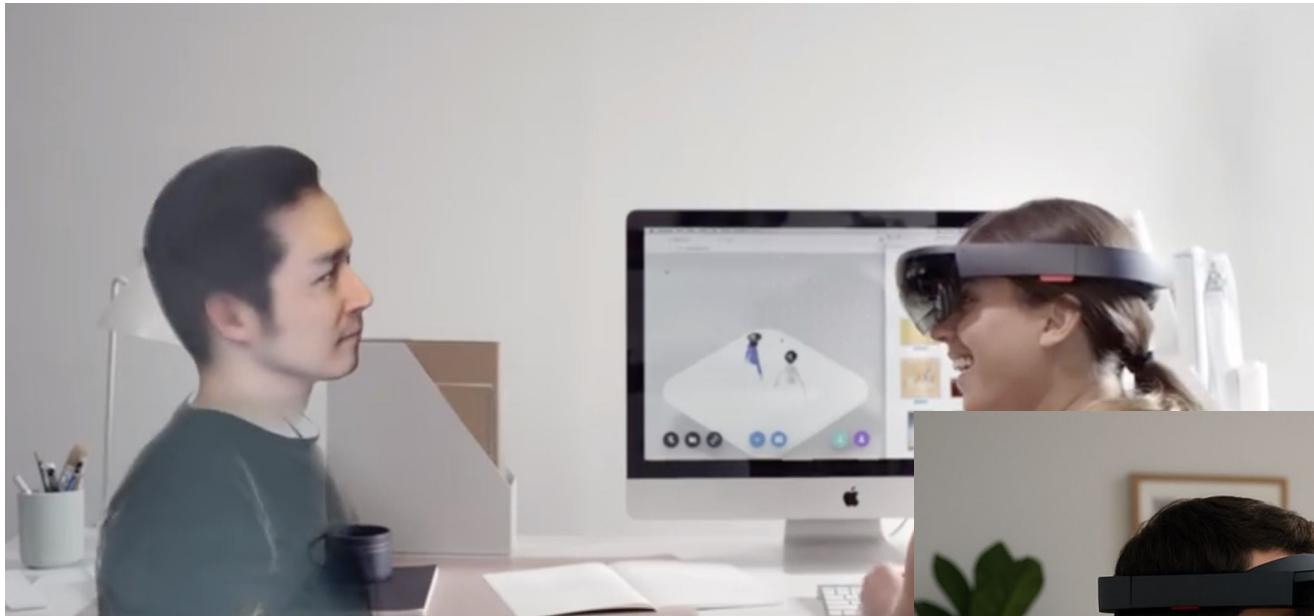


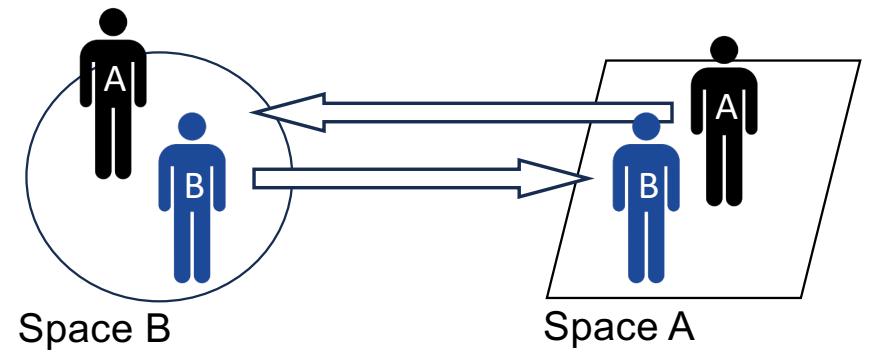
Both A and B's environment presence
remain unchanged

Telepresence

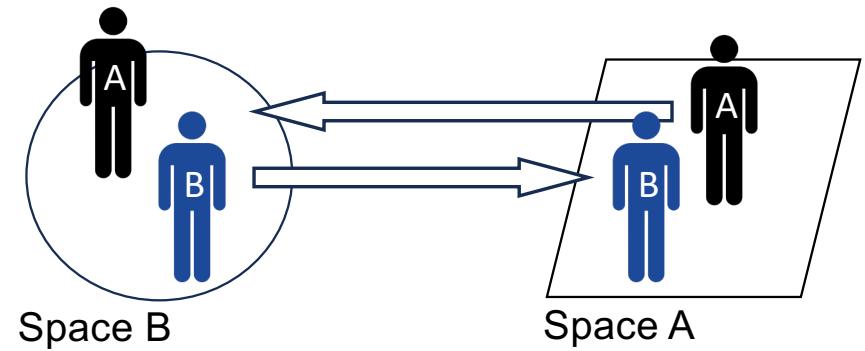


Symmetric Telepresence



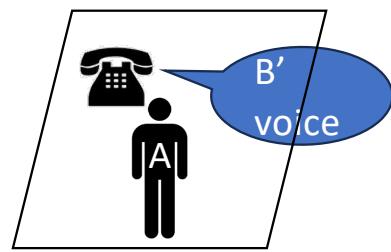
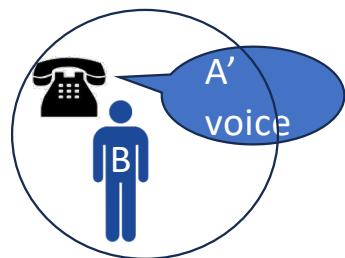


symmetric telepresence



why symmetric telepresence matters?

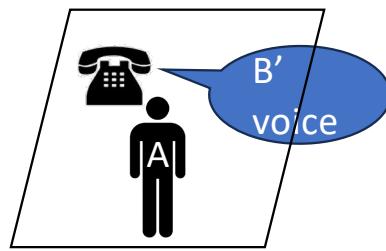
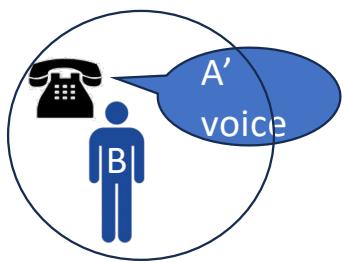
Telephone



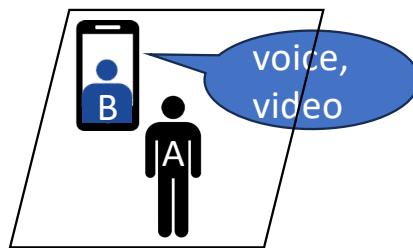
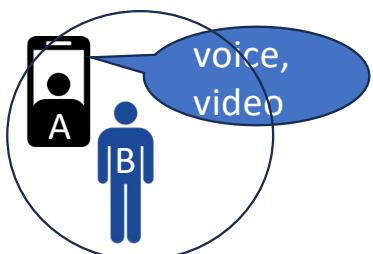
Voice + Video

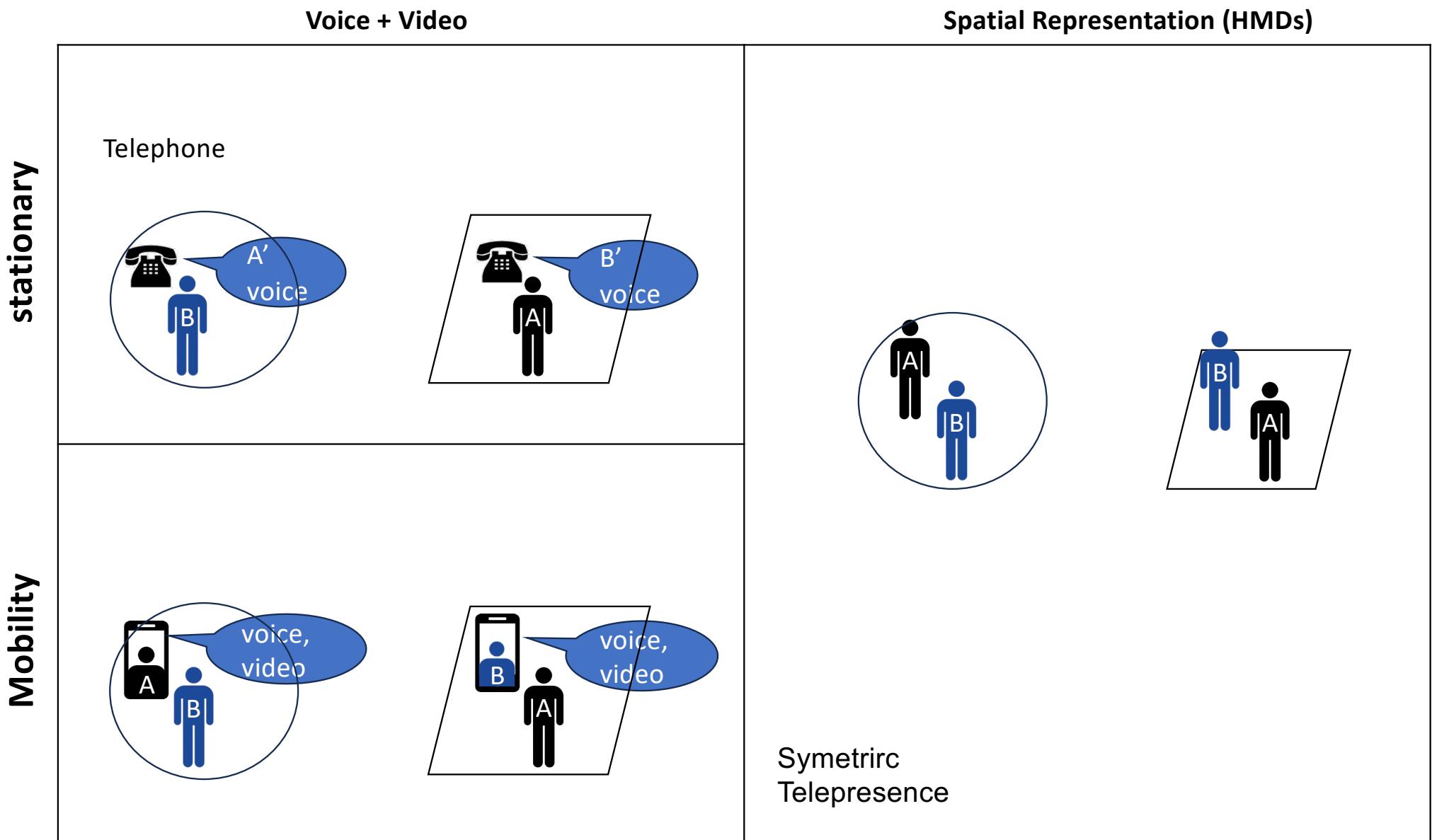
stationary

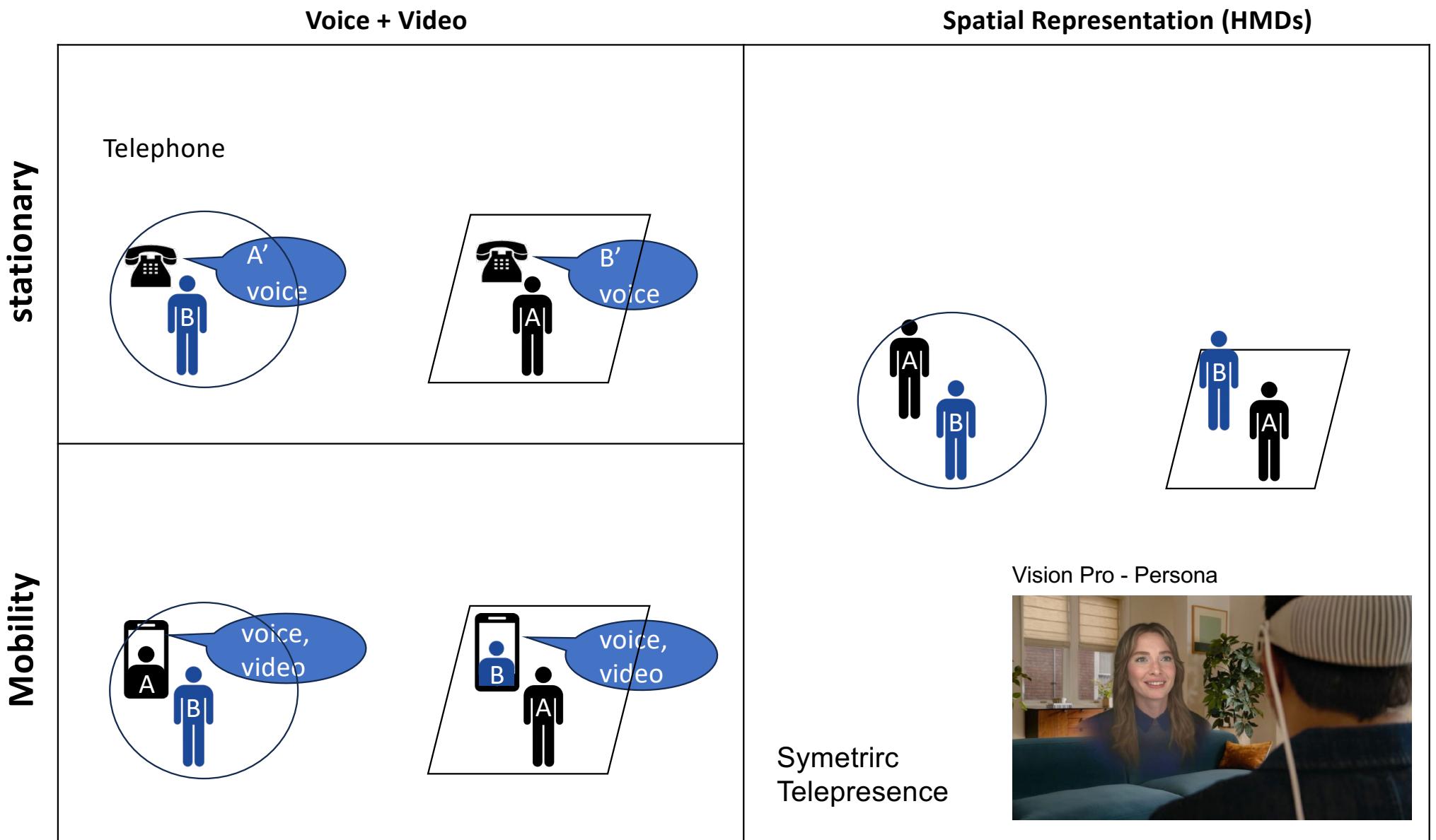
Telephone

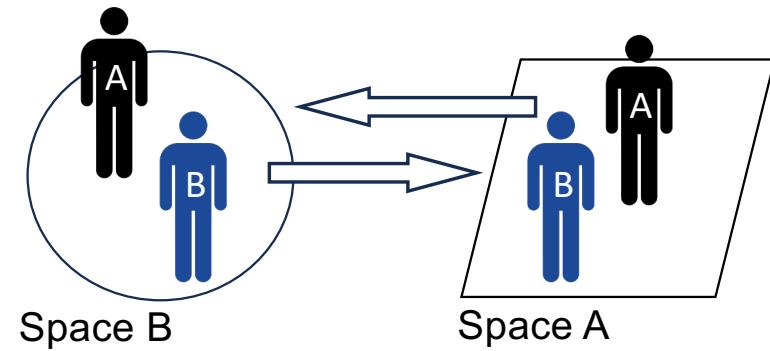


Mobility





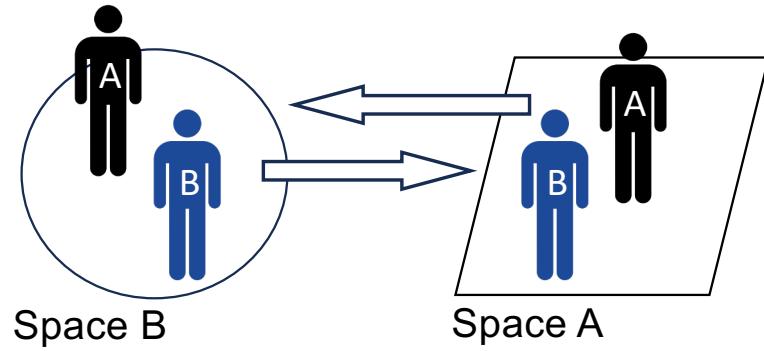




Symmetric Telepresence

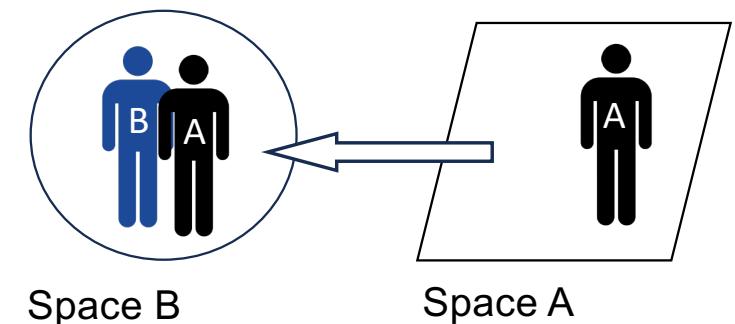
- Conversation-centric
- Virtual task

Making
a call



Symmetric Telepresence

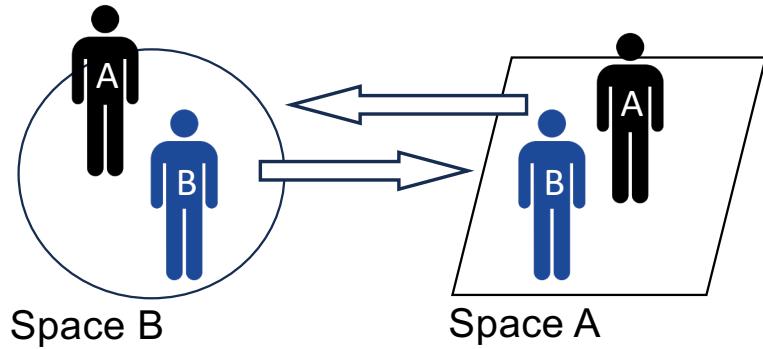
- Conversation-centric
- Virtual task



Asymmetric Telepresence

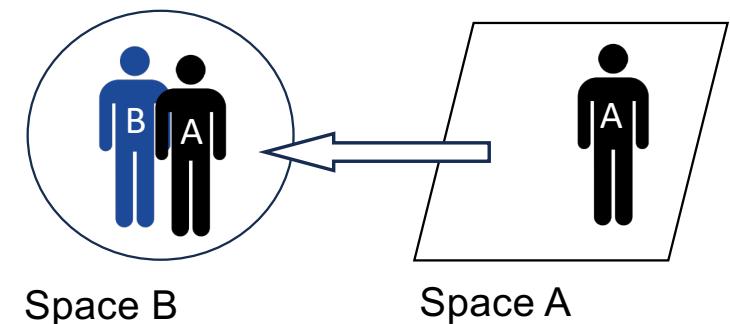
- When at the same space is essential for the conversation

Making
a call



Symmetric Telepresence

- Conversation-centric
- Virtual task

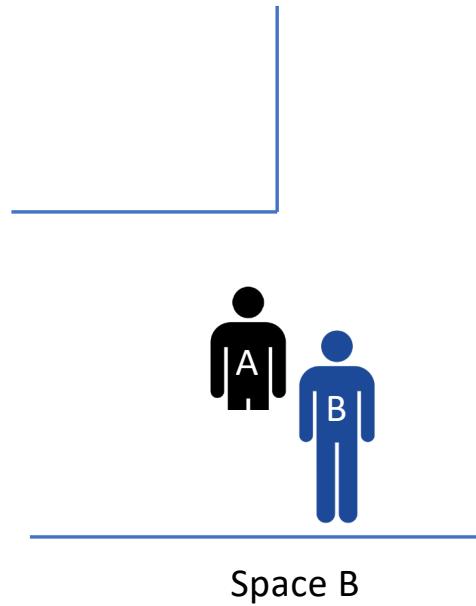


Asymmetric Telepresence

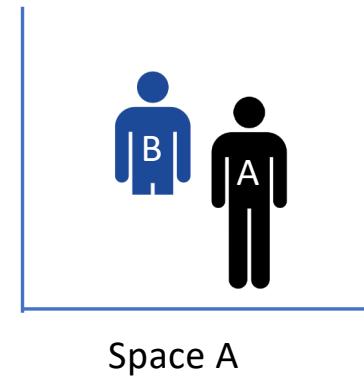
- When at the same space is essential for the conversation

Making
a call

Symmetric Telepresence in Mobility

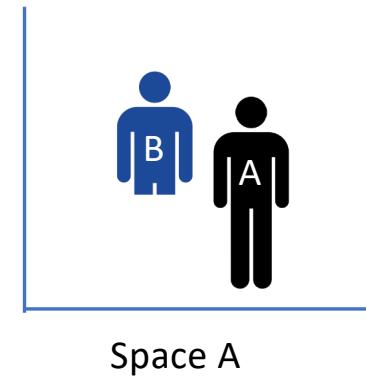
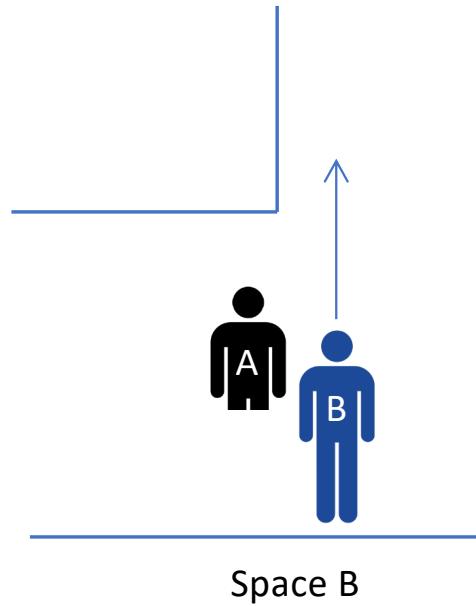


Space B

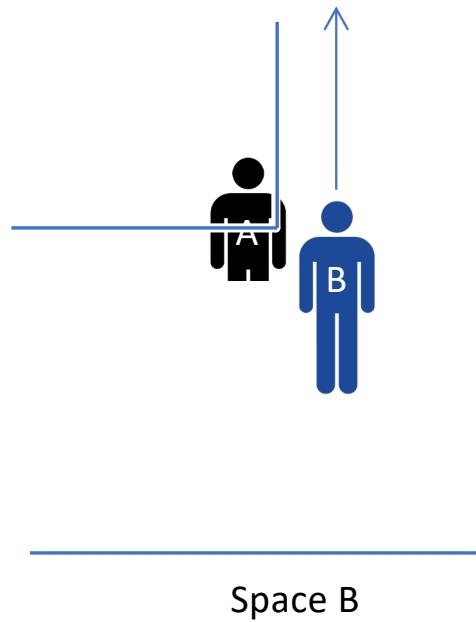


Space A

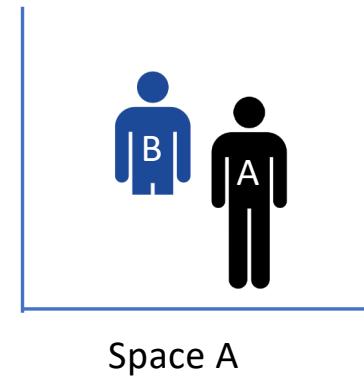
Symmetric Telepresence in Mobility



Symmetric Telepresence in Mobility



>> Adaptation kicks in



Mutual Telepresence Call





Miranda
making a “MR call”



Home

Office

Miranda's Home



Miranda's Home



Amy's Office



Surrogate Avatar

system that continuously adapts the remote avatar to the local user's environment based on the current context



Formation Study

Explore desired avatar placement users expect in different environments and in station and walking conditions



Results: Five Adaptation Goal

- Avatar Visibility
- Task Visibility
- Social Presence
- Physical Affordance
- Continuity

Results: Five Adaptation Goal

- **Avatar Visibility**
 - Avoid occlusion with the environmental
 - Consider field of view and facing toward user
- Task Visibility
- Social Presence
- Physical Affordance
- Continuity



Results: Five Adaptation Goal

- Avatar Visibility
- **Task Visibility**
- Social Presence
- Physical Affordance
- Continuity
 - Avoid obstructing primary task
 - Avoid obstructing navigating path



Results: Five Adaptation Goal

- Avatar Visibility
 - Task Visibility
 - **Social Presence**
 - Physical Affordance
 - Continuity
- Close and facing them -> communication together
 - Nearby chair -> seated together
 - Similar eye-level -> mutual respect



Results: Five Adaptation Goal

- Avatar Visibility
 - Task Visibility
 - Social Presence
 - **Physical Affordance**
 - Continuity
- Position on nearby chair
 - Prevent from levitation



Results: Five Adaptation Goal

- Avatar Visibility
- Task Visibility
- Social Presence
- Physical Affordance
- **Continuity**
 - Preserve consistent placement
 - Avoid unnecessary adjustment



Adaptation Framework

AUIT – the Adaptive User Interfaces Toolkit for Designing XR Applications

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Mathias N. Lystbæk
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Peter Kán
Vienna University of Technology
Austria

Kaj Grønbæk
Aarhus University
Denmark

Anna Maria Feit
Saarland University, Saarland
Informatics Campus
Germany

Antti Oulasvirta
Aalto University
Finland

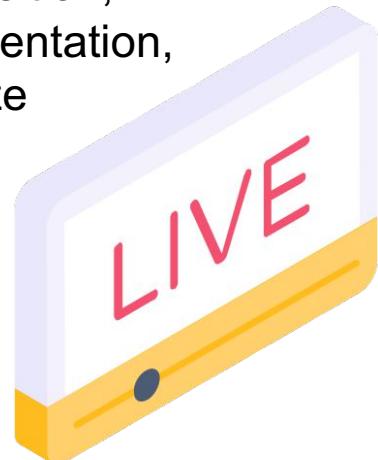


Multi-Objectives Adaptation Adaptive UI

Adaptation Framework

Solution Space

Position,
Orientation,
Size

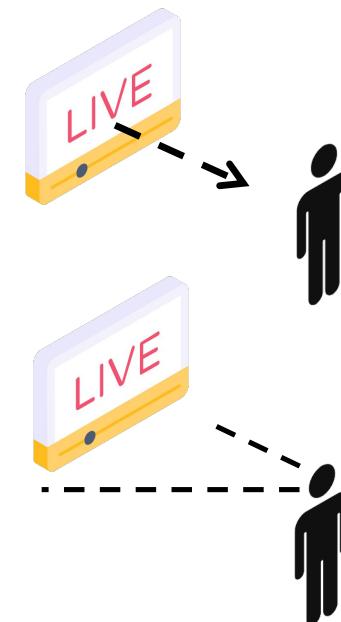


Objectives

Face-to-User

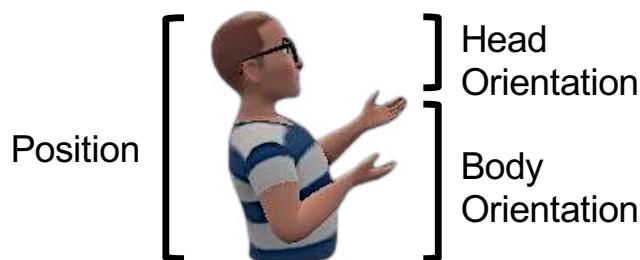
User Field of View

•
•
•

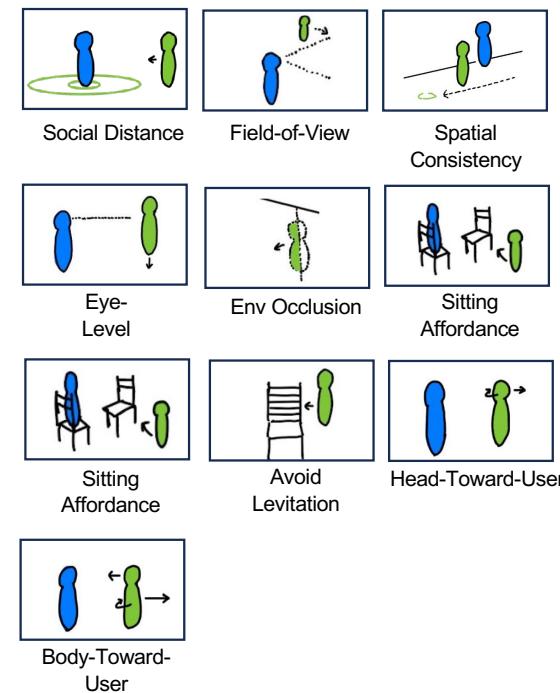


Adaptation Framework

Solution Space



Objectives

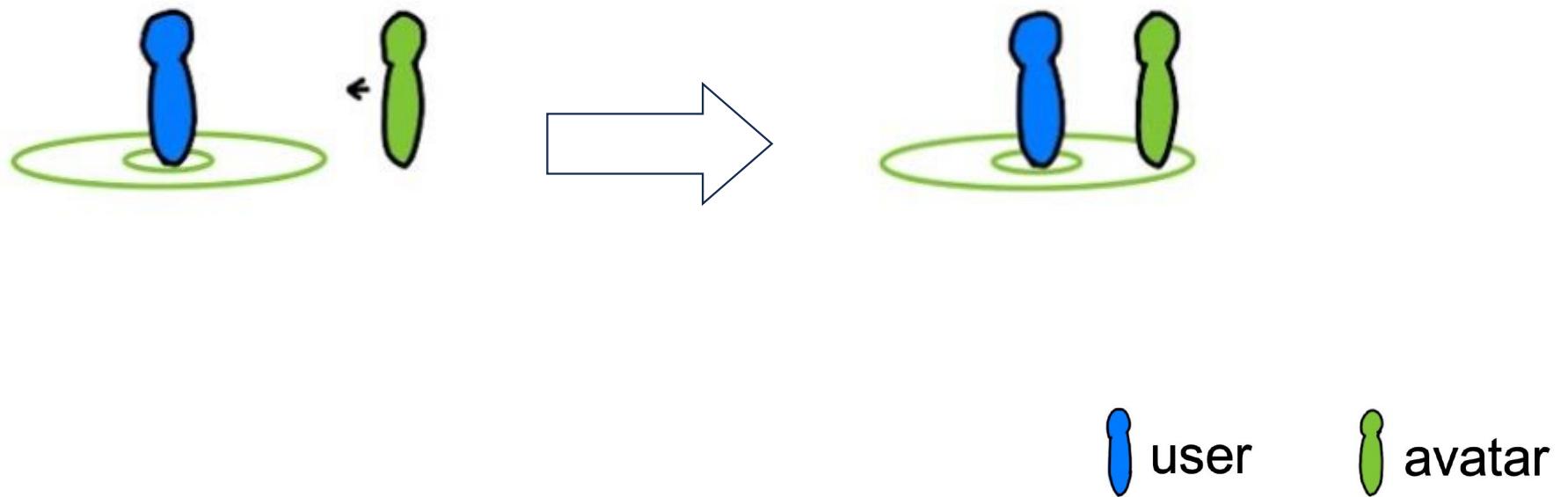


Context Objects



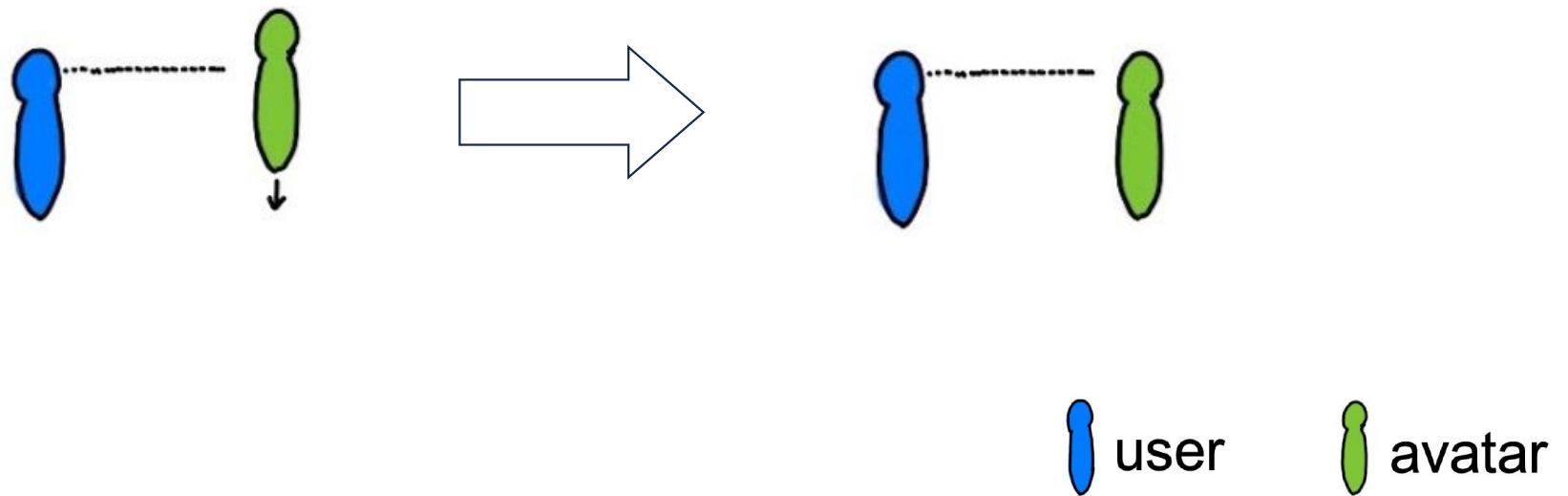
Social Distance Objective

Position the avatar at a comfortable social distance



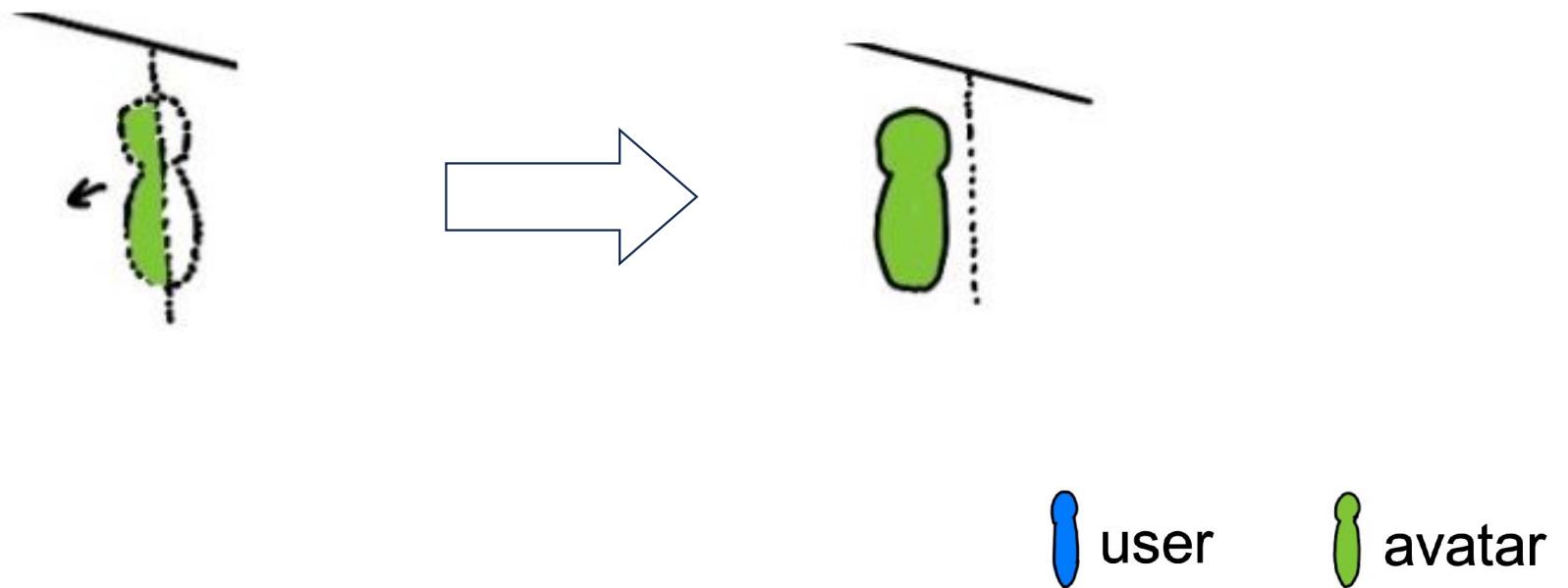
Eye-Level Objective

Align the avatar's eye level with the user



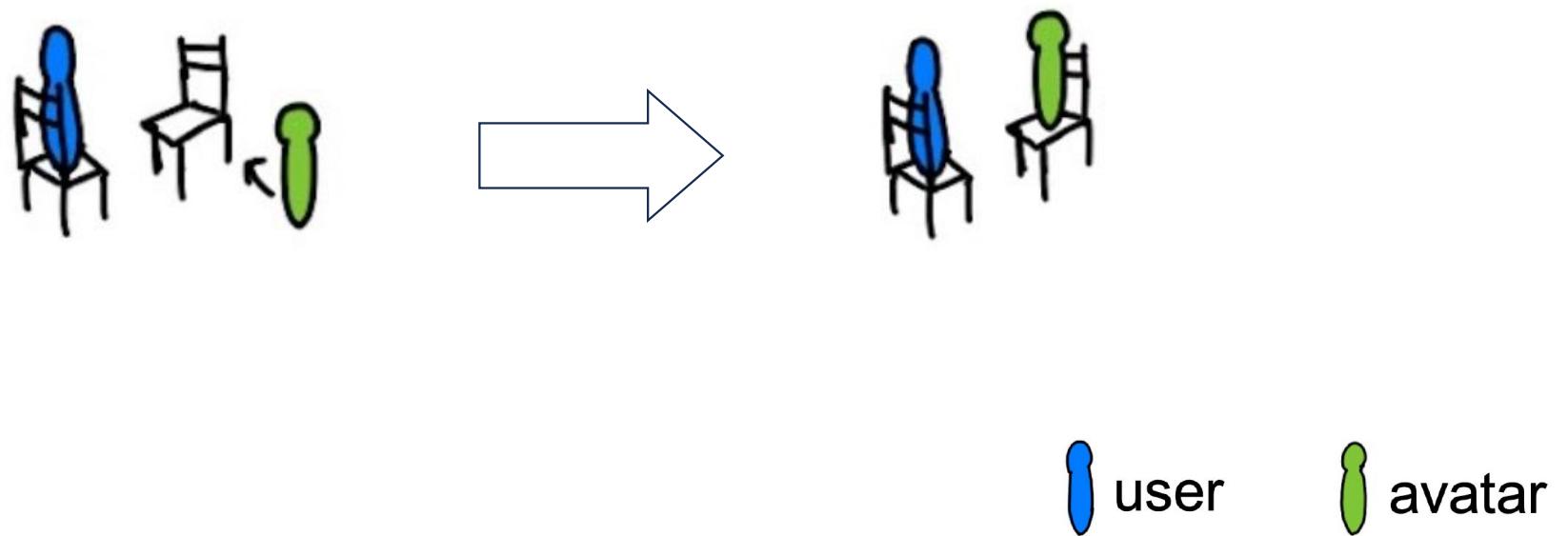
Environmental Occlusion Objective

Prevent avatar merging with the environment



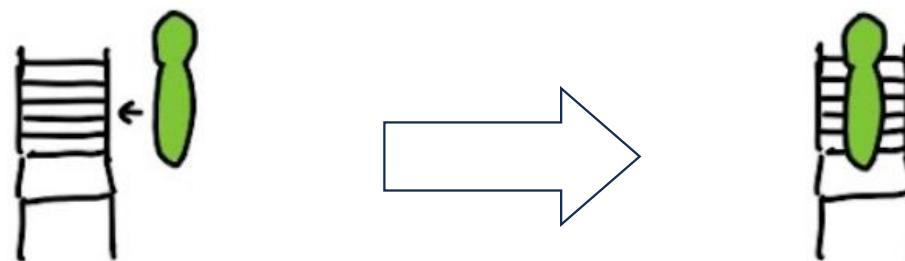
Sitting Affordance Objective

Ensure the avatar sits on a nearby chair



Avoid Levitation Objective

Ensure the avatar stays grounded

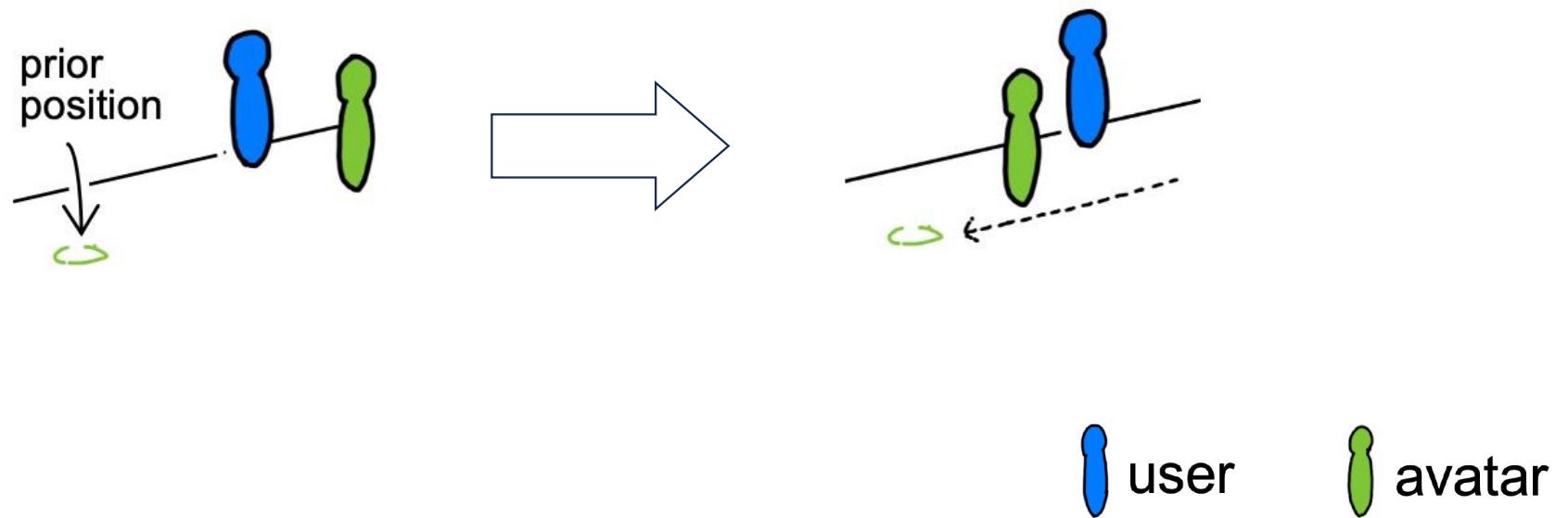


user

avatar

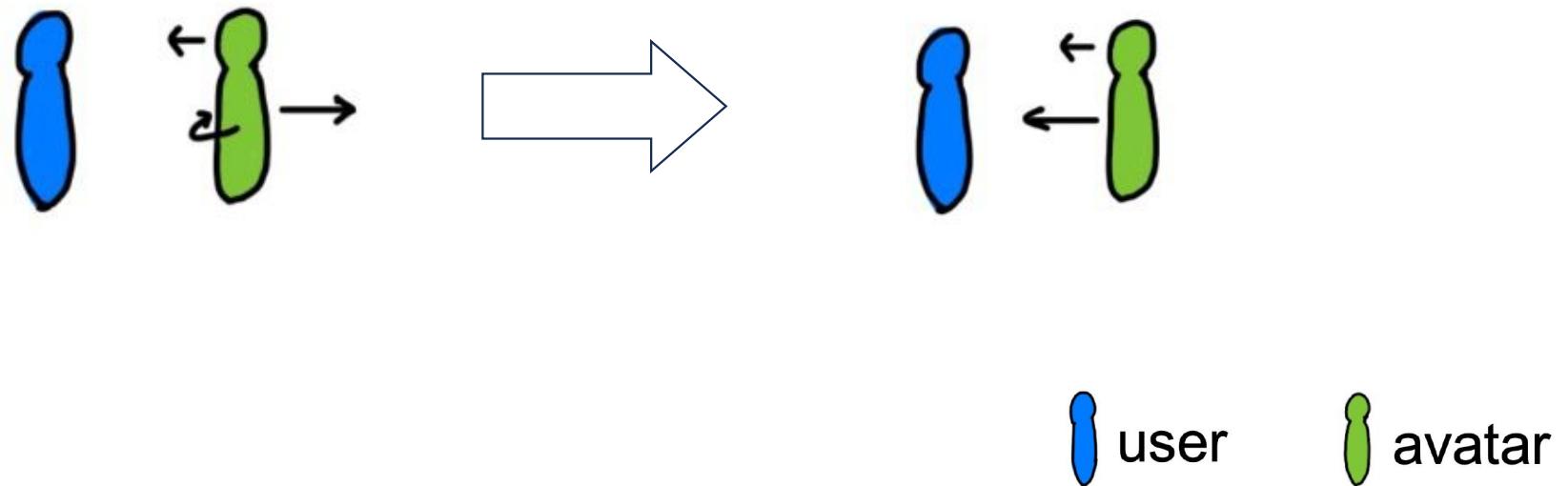
Spatial Consistency Objective

Ensure the avatar's position without abrupt changes from its previous location



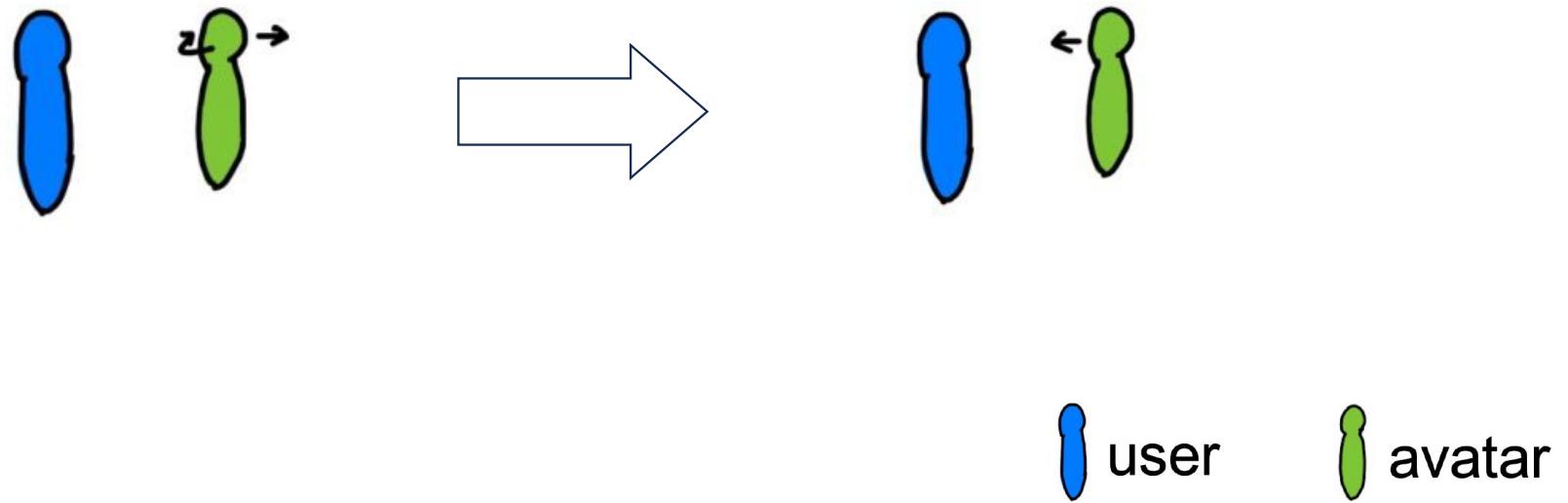
Body-Toward-User Objective

Orient the avatar's body toward the direction of the user head



Head-Toward-User Objective

Orient the avatar's head towards the user





User Study

Study Design

Two conditions: stationary and nomadic conditions.

- A within-subject study with 9 pairs of participant
- Switch room after experience first condition

Task

- Discussion
- Locomotion

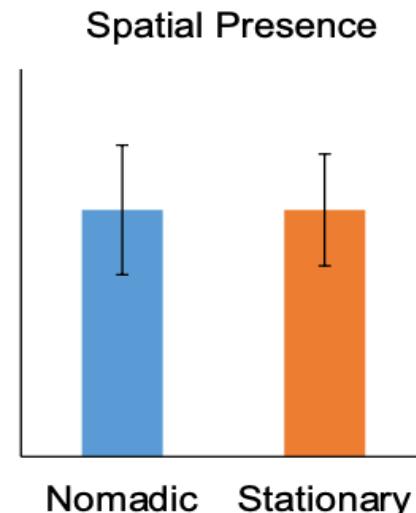
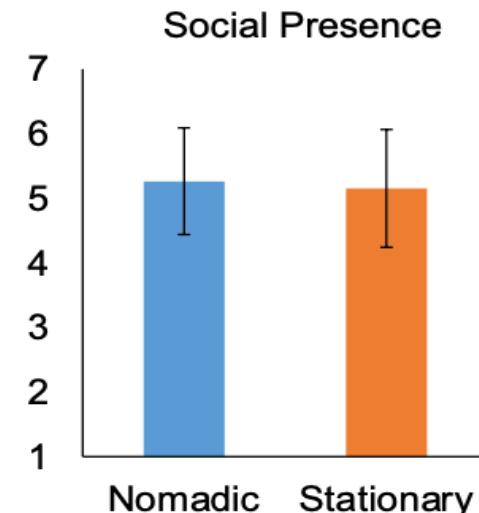
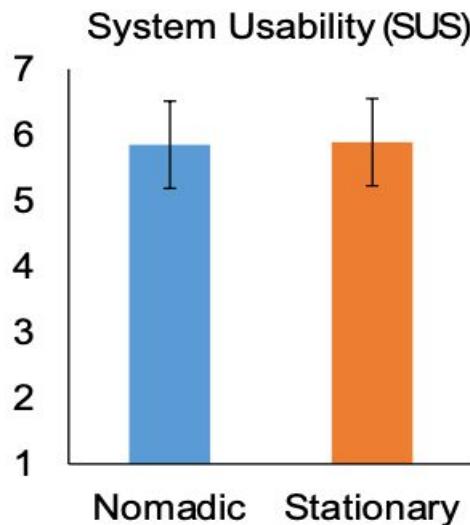


Hypothesis:
participant pairs—one stationary, one dynamic—
during the conversation will report similar experiences.



Standard Questions

Stationary Participants vs. Nomadic Participants



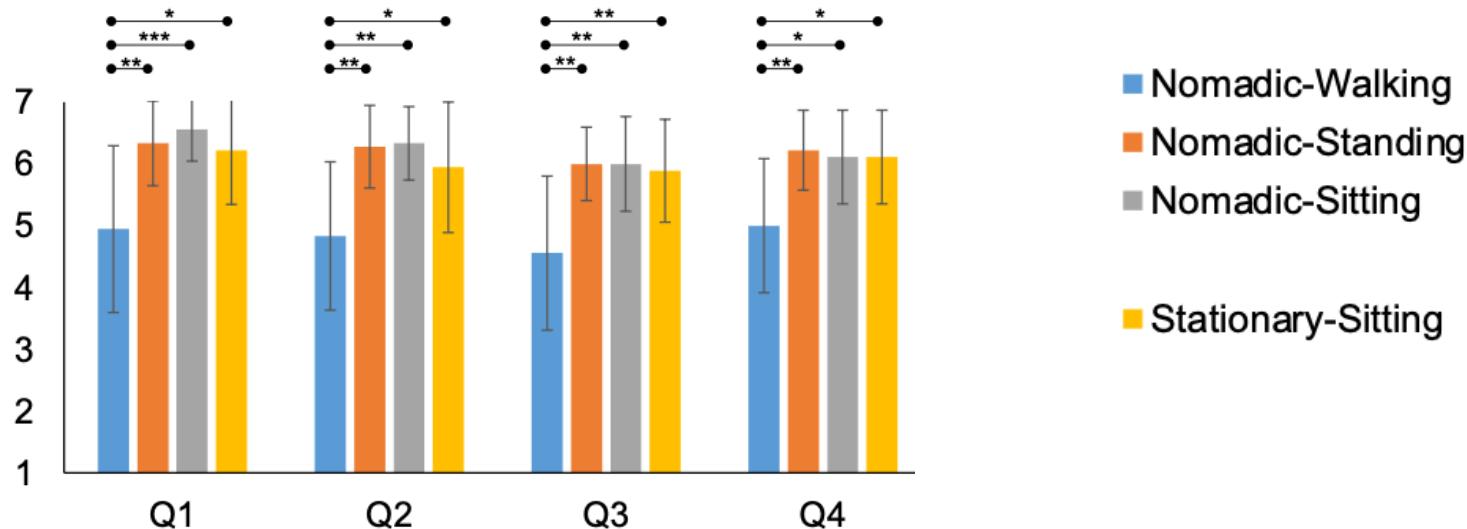
Custom Questions

Q1: Verbal Flow: Was it easy to keep the conversation going?

Q2: Smoothness: Did the conversation feel smooth?

Q3: Awareness: Did your partner seem aware of their surroundings?

Q4: Adaptation Fit: Did the system's timing and positioning feel right to you?



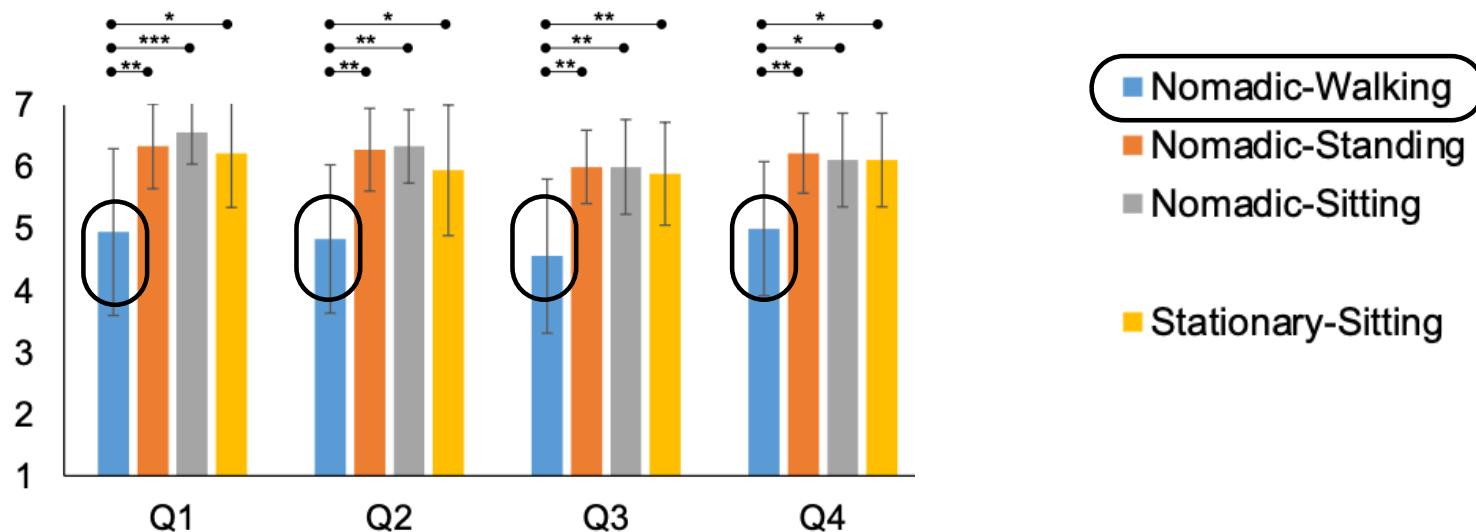
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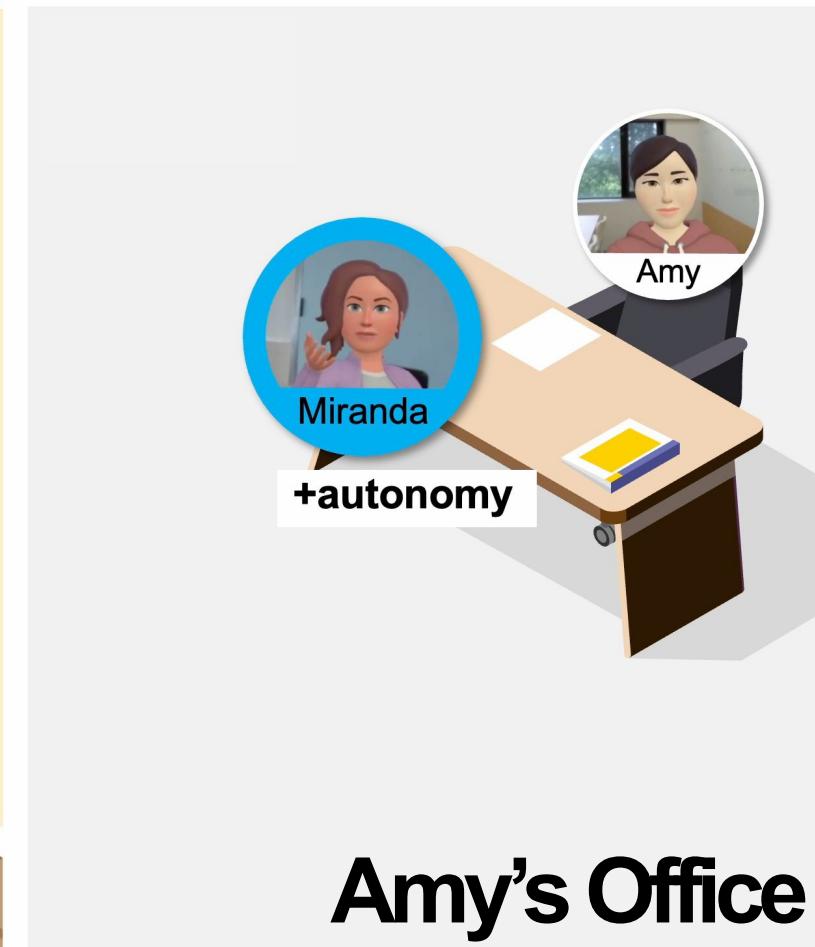
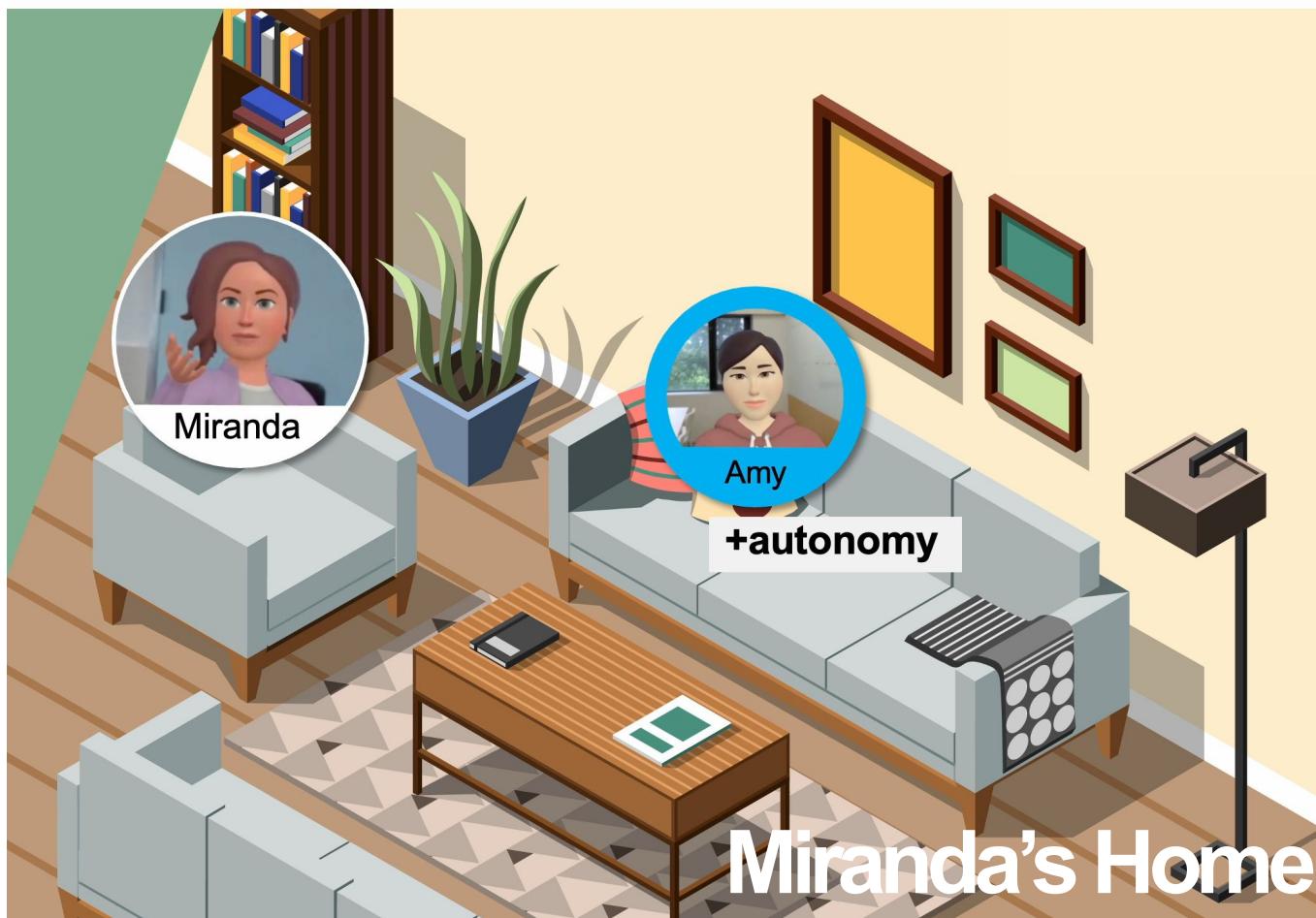
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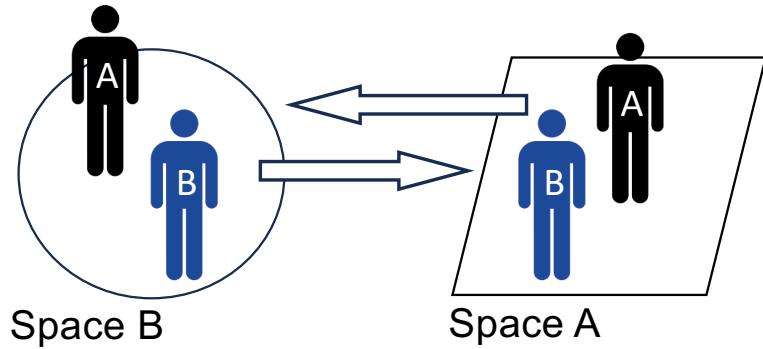
- “*The avatar took a bit longer to react when I started walking, which broke the flow of interaction.*” (P3)
- “*While I was walking, the avatar appeared in my view, obscuring my navigation to the chairs.*” (P13)
- *Participant perceived higher sense of avatar environmental awareness in sitting and standing*
- “*When I am sitting, the avatar naturally occupies the opposite chair, creating a realistic face-to-face discussion setting.*” (P5)

Mutual Telepresence Call





recap



Symmetric Telepresence

- Conversation-centric
- Virtual task



Asymmetric Telepresence

- When at the same space is essential for the conversation

Vision Pro
Persona

Making
a call



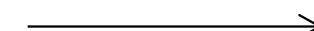
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Reality →

Augmented Reality
(Mixed Reality)



Virtual
Reality

