Ubiquitous Computing
Tangible User Interfaces
Proxemic Interaction

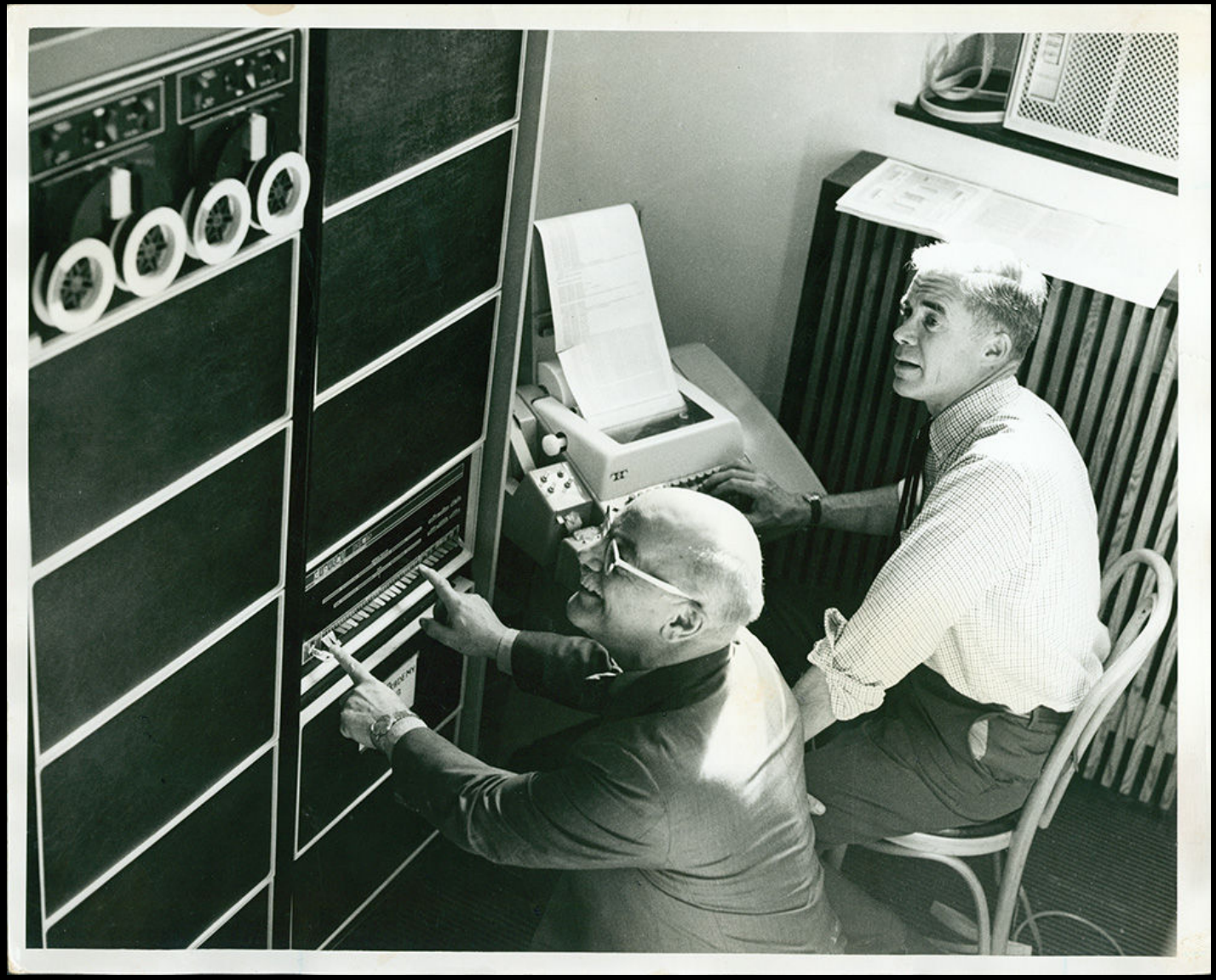
M.Sc. Rafael Veras

Outline

- Brief history of ubicomp
- Basic ubicomp principles
- Present and future of TUIs
- Principles of Proxemic Interaction
- Lots of videos

Studying Ubicomp

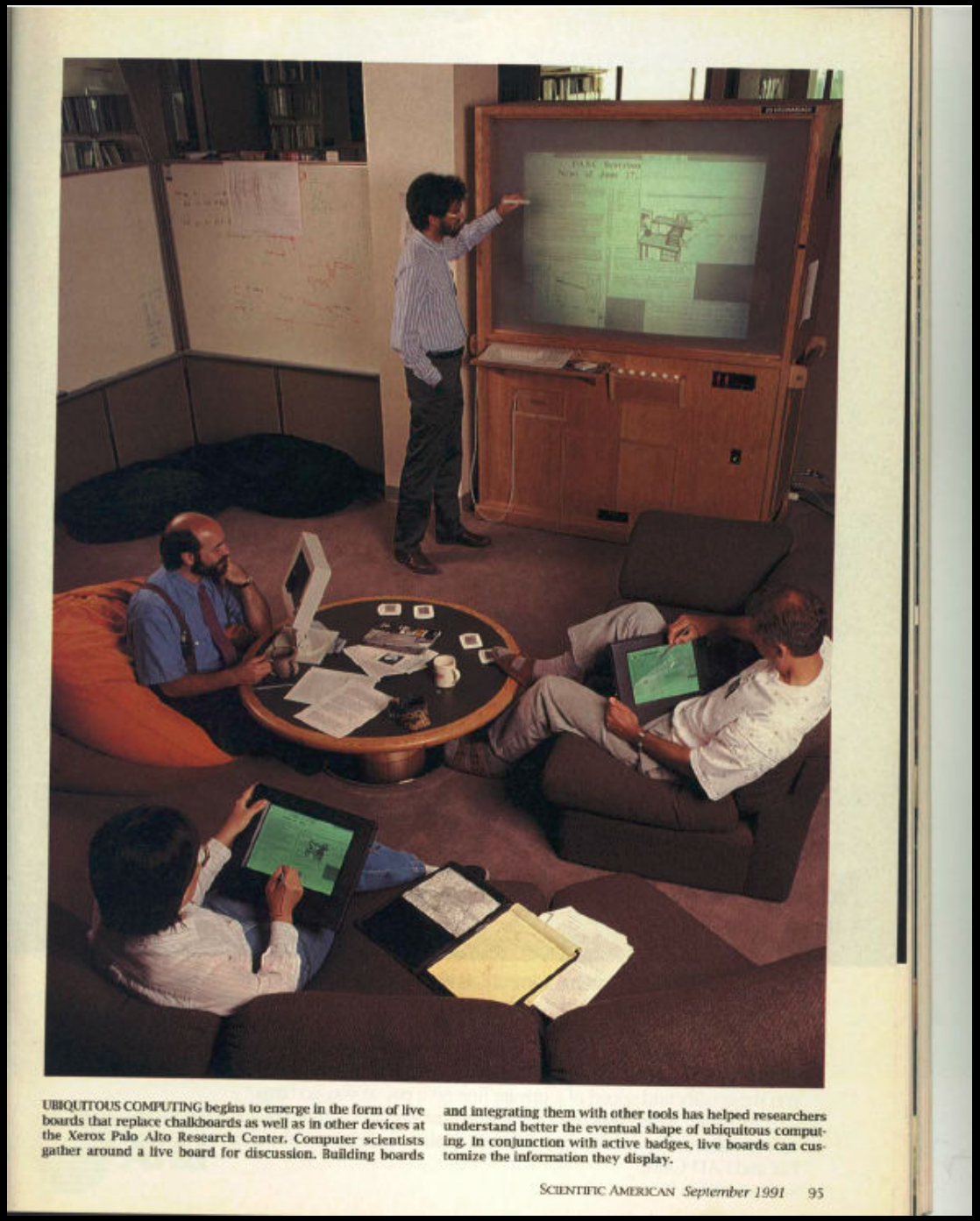
- Systems
- Sensors
- **User Experience**



1st Era – Mainframes (One to Many)

2nd Era – Personal Computer (One to One)

3rd Era – Ubiquitous Computing (Many to One)



UBIQUITOUS COMPUTING begins to emerge in the form of live boards that replace chalkboards as well as in other devices at the Xerox Palo Alto Research Center. Computer scientists gather around a live board for discussion. Building boards and integrating them with other tools has helped researchers understand better the eventual shape of ubiquitous computing. In conjunction with active badges, live boards can customize the information they display.

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

MARK WEISER,
Scientific American,
1991

Weiser's Vision

Traditional computing requires much attention.

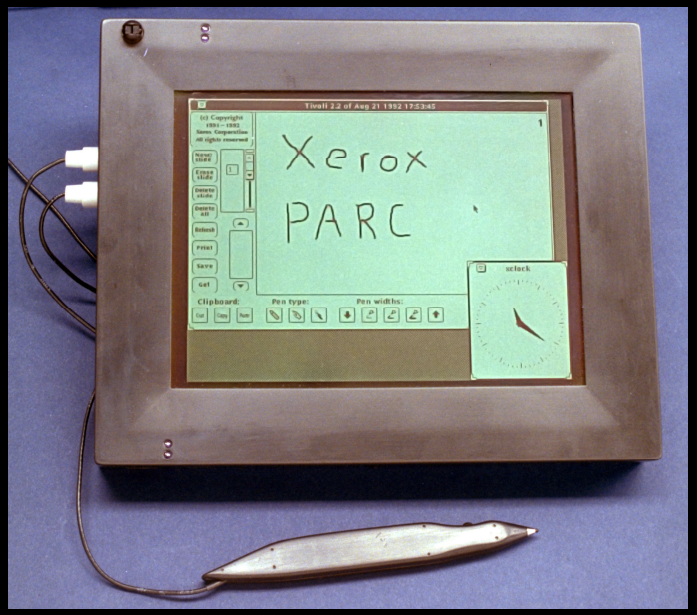
Computation should be integrated with common objects.

Calm Computing

“processing power so distributed throughout the environment that computers per se effectively disappear”

(Greenfield, 2006)


XEROX
PARC
PARC TAB


Xerox
PARC
Clipboard:
Pen type:
Pen widths:
unlock


DRIVE SHAFT
MODIFY ASAP
MAT'L: 302 SS
32
45°
XEROX

Personal Computing

- Wired LAN
- Fixed IPs
- UI:
  - On-screen presentation
  - Manipulation of files and apps through established metaphors (mouse pointer, icons, menus and windows)

Ubicomp

- Heterogeneous devices
- Wireless communication
- Diverse OS, networking interfaces, input capabilities and displays
- Some devices have UI while other don't (sensors)
- Interactions: doesn't require display or input devices
  - Implicit
  - Invisible
  - Natural (speech, gesture, presence)
- Context matters

Ubicomp Systems

Challenges

1. Resource-constrained devices

2. Volatile and heterogeneous execution environments

Challenges

3. Fluctuating usage environments
   - Location
   - Context (who is nearby? temperature, lighting, etc.)
   - Activity (what is the user doing?)

4. Invisible computing

5. Security and Privacy

User Interfaces

Challenge

Provide natural inputs and outputs from a system that allows it to remain in the periphery.

The Controller Hell

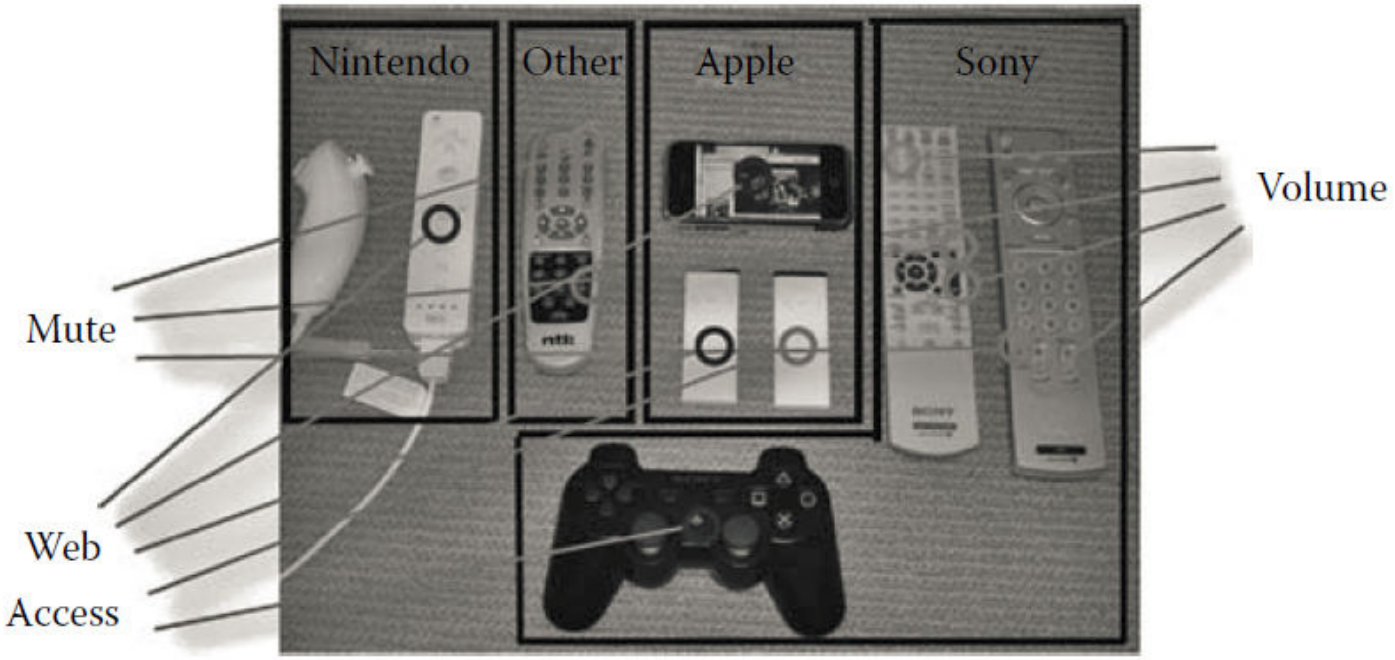


FIGURE 6.3 Three mute options, four volume controls, five web access methods, and 168 buttons for one television with six inputs.

The Lesson

A ubicomp system is made up of subsystems and we must design for the **experience** not the individual subsystem.

Principles

Keep technologies unnoticed

Fluid interaction appropriate to current context

Chumby (Counter-Example)

https://www.youtube.com/v/h8f80bejKJo

Input

Implicit (Context)

- Spatial (location, speed)
- Identity (users and others)
- User model (profile, preferences, intentions)
- Temporal Data (time/date)
- Environmental (noise, light)
- Physiological (heart rate)
- Computing (bandwidth, memory)

Explicit

- Speech
- Gaze
- Gestures
- Movement

Ten Rules of Ubicomp UI Design

RULE	MEANING
Bliss	Learning to interact with a new UUI should not require people to learn another skill or complex command language.
Distraction	Do not demand constant attention in a UUI. Inattention is the norm not the exception.
Cognitive Flow	Ubicomp systems that are everywhere must allow the user to retain total focus on the task at hand.
Manuals	Do not require a user to read a manual to learn how to operate the current UUI. Do leverage prior experience.
Transparency	Do not rely on users to hold application state in the mind to operate the UUI.

Ten Rules of Ubicomp UI Design

RULE	MEANING
Modelessness	Avoid “modes” where the system responds differently to the same input stimulus dependent on some hidden state information.
Fear of Interaction	Provide easy means to undo actions, otherwise users may become paralyzed with fear when using the UUI.
Notifications	Feedback to the user can be piggybacked and layered into interactions with their physical environment.
Calming	Interfaces will support situated actions, interfaces will rely on a wide array of human inputs and human senses.
Defaults	Good interfaces judiciously exploit what the system knows or can deduce.

Classes of User Interfaces

- Tangible User Interfaces (TUI)
- Surface User Interface (SUI)
- Ambient User Interface (AUI)
- Proxemics

Tangible User Interfaces (TUIs)

Tangible User Interfaces

A user manipulates a physical artifact with physical gestures, this is sensed by the system, acted upon, and feedback is given

The physical artifacts are digital embodiments of the state and information from a system.

The artifacts provide sites for both input, using well-understood affordances, and can act as output from the system.

Urp (Tangible Urban Planning)

http://vimeo.com/48600713

Urp (Tangible Urban Planning)

- Natural interaction
  - Gestures + manipulation of physical objects.
- Rapid response
  - In the real world, there is no “loading” or “processing”.
- In situ nature of the simulation
  - No need to setup parameters.
- Urp, as a computer, is almost “invisible”

Embodiment in TUIs

The extent to which a user thinks of the state of computation as being embodied within the physical housing of the artifact.

Dimensions of embodiment

Full: output device is the input device.

Nearby: the output takes place near the input object, typically, directly proximate to it.

Environment: output embodiment is around the user.

Distant: output is “over there” on another device.

Dimensions of Metaphor

None: the physical actions with the TUI are not connected to any real-world analogy.

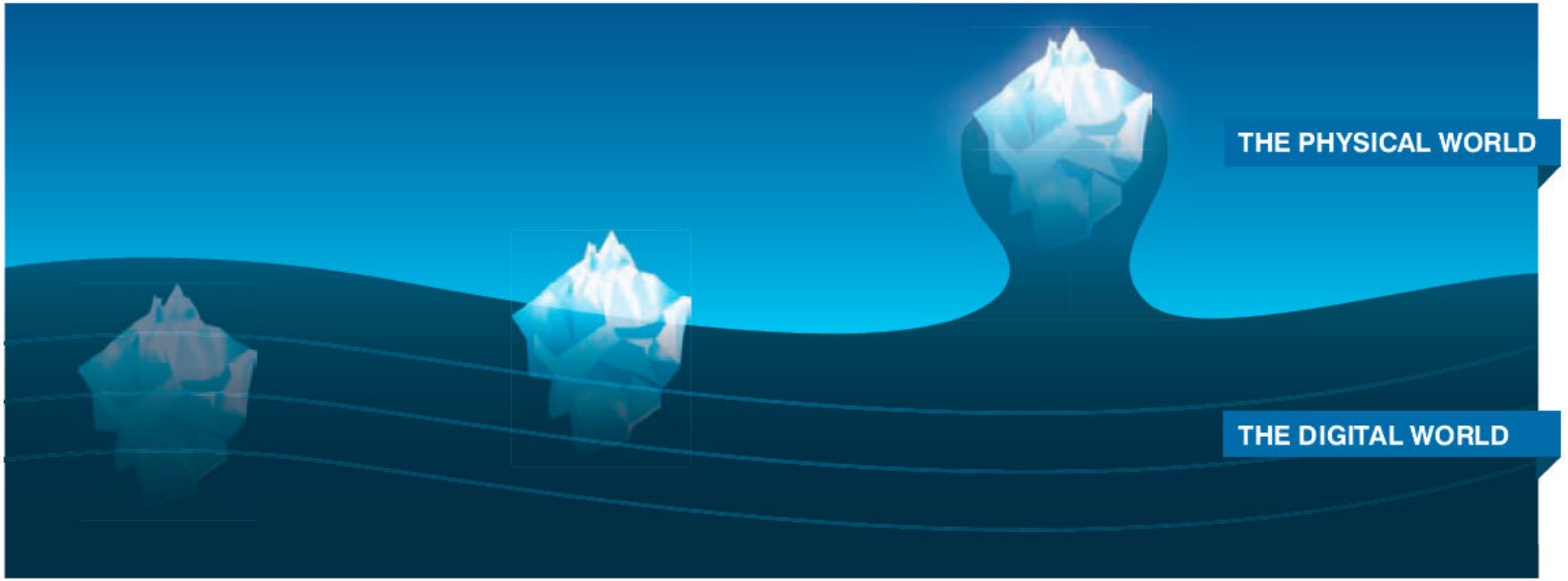
Noun: the look of an input object is closely tied to the look of some real-world object but this is a superficial spatial analogy only.

Verb: the analogy is to the gesture used.

Noun and verb: the physical and virtual objects still differ but are related with appeal to analogy (e.g., Urp).

Full: gives a level of analogy where the virtual system is the physical system. there is no disconnect.

Beyond Tangible Bits (MIT Media Lab)



a) *A graphical user interface only lets users see digital information through a screen, as if looking through the surface of the water. We interact with the forms below through remote controls such as a mouse, a keyboard, or a touchscreen.*

b) *A tangible user interface is like an iceberg: There is a portion of the digital that emerges beyond the surface of the water – into the physical realm – that acts as physical manifestations of computation, allowing us to directly interact with the "tip of the iceberg."*

c) *Radical Atoms is our vision for the future of interaction with hypothetical dynamic materials, in which all digital information has physical manifestation so that we can interact directly with it – as if the iceberg had risen from the depths to reveal its sunken mass.*

▸ Figure 1. Iceberg metaphor—from (a) GUI (painted bits) to (b) TUI (tangible bits) to (c) Radical Atoms.

inFORM - Interacting With a Dynamic Shape Display

http://vimeo.com/79179138

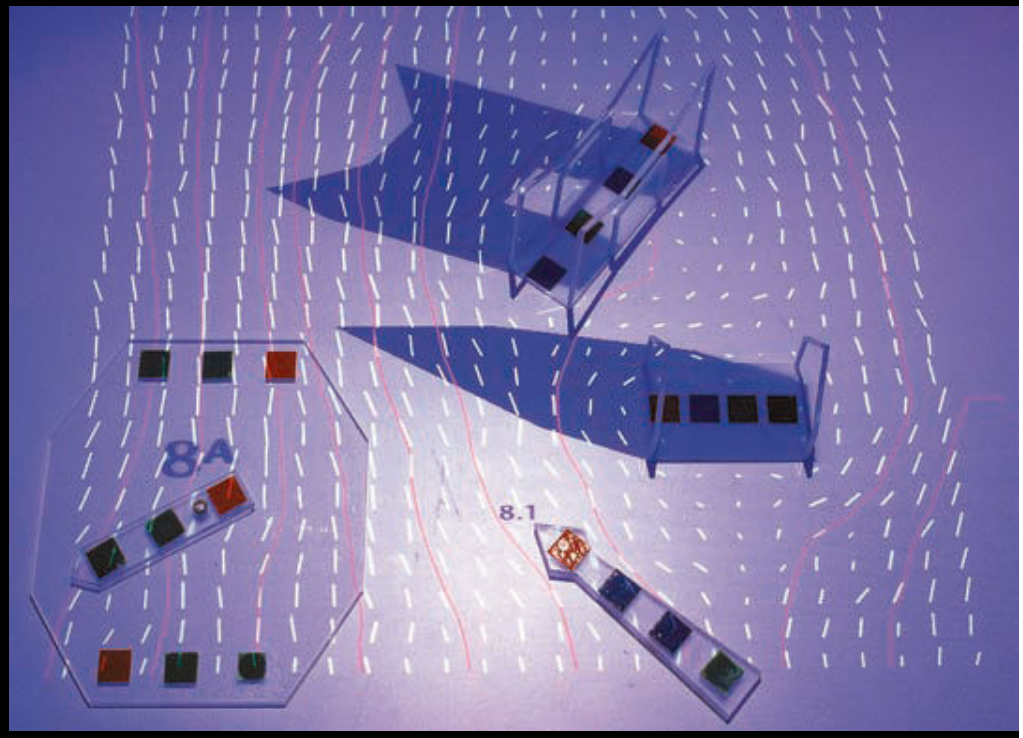
Motivation

- TUIs have limited ability to represent change in many material or physical properties:
  - Form
  - Position
  - Color
  - Size
  - Stiffness

Tabletop TUIs

Overcome limitations with video projection/digital shadowing

Visual feedback is provided onto the surface of the workbench via video projection maintaining input/output space coincidence.



PICO

http://vimeo.com/44539342

Kinetic Tangibles

From static/inert to active/kinetic

Do not depend on intangible representation

Motors and gears, tiny robots, and shape-memory alloys (SMAs)

Active feedback throughout tangible representation serves as the main display channel

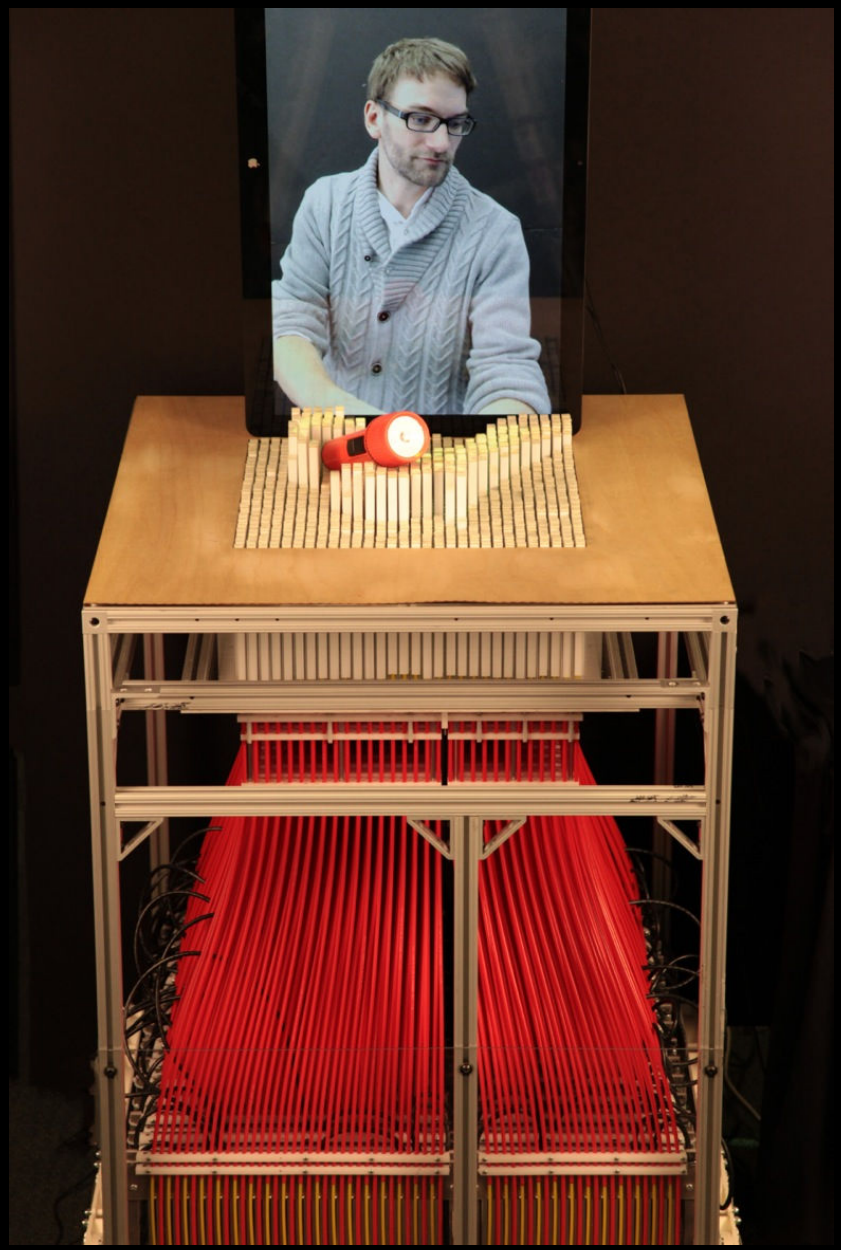
Topobo

https://www.youtube.com/v/50JdK_K2NWk

Transformable Tangibles

- Capability to change form.
- Continuous tangible materials (e.g., clay and sand).
- Rapid form creation and sculpting for landscape design.

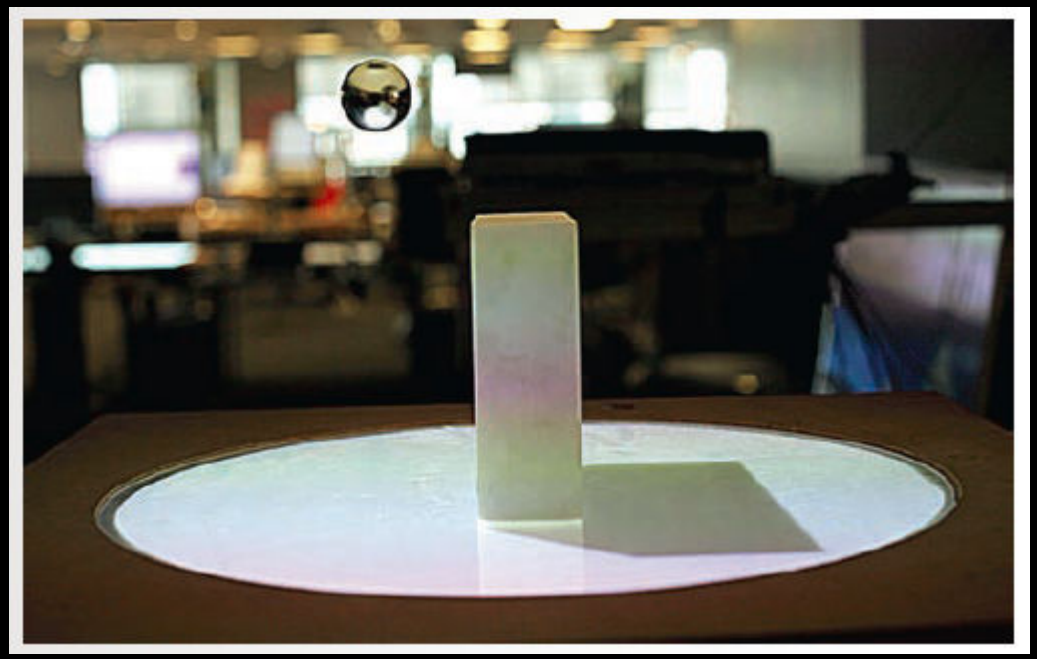
Tangible Telepresence



Antigravity tangibles

Overcoming limitations of atoms' rigidity.

Gravity as main constraint of physical world.



ZeroN

http://vimeo.com/41796732

Radical Atoms

Vision for human interactions with dynamic physical materials that are computationally transformable and reconfigurable.

Based on hypothetical, extremelly malleable and dynamic physical material that is *bidirectionally* coupled with an underlying digital model (bits) so that dynamic changes of the physical form canbe reflected in the digital states in real time, and vice-versa.

Characteristics

Transform its shape to reflect underlying computational state and user input.

Conform to constraints imposed by the environment and user input.

Inform users of its transformational capabilities (dynamic affordances).

Foundations

- Nanotechnology
- Mechatronics
- Material Science
- Computer Science

Proxemic Interaction

Proxemic Interaction

“When you walk up to your computer, does the screen saver stop and the working windows reveal themselves? Does it even know if you are there? How hard would it be to change this? Is it not ironic that, in this regard, a motion-sensing light switch is “smarter” than any of the switches in the computer…?”

Bill Buxton

Proxemics

"An area of study that identifies the culturally dependent ways in which people use interpersonal distance to understand and mediate their interactions with other people."

Edward Hall, 1966

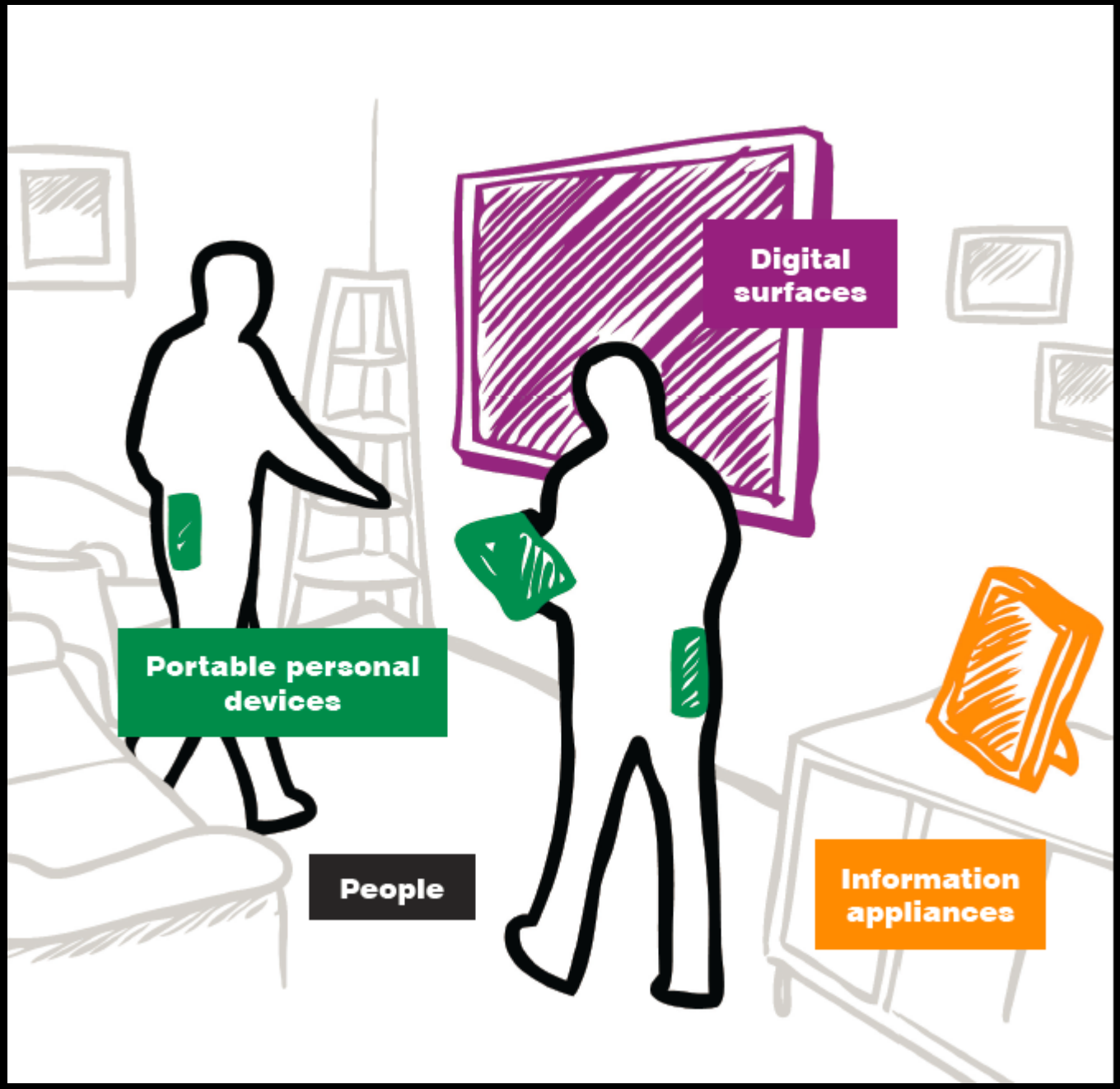
Proxemic Zones

Intimate: less than 1.5 feet

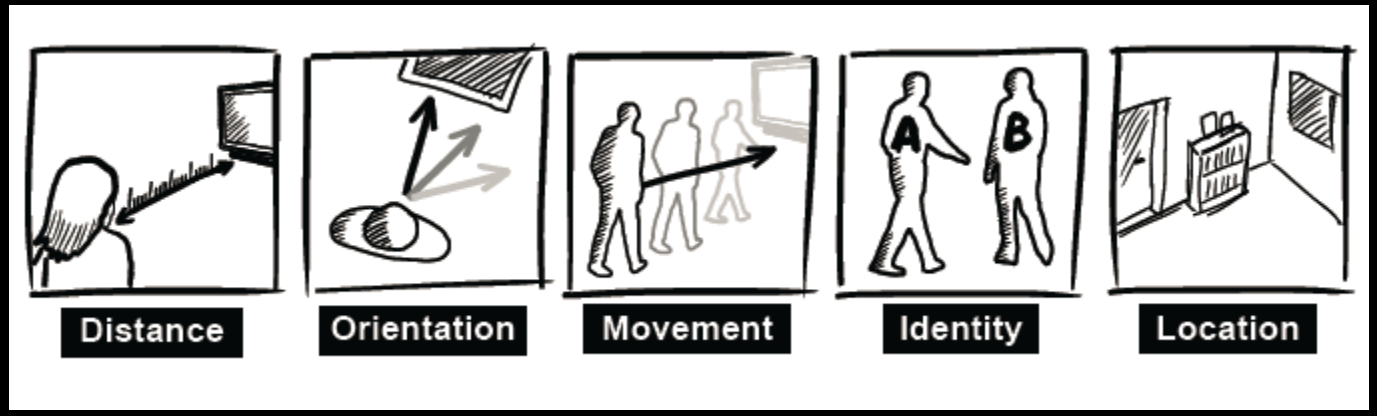
Personal: 1.5 to 4 feet

Social: 4 to 12 feet

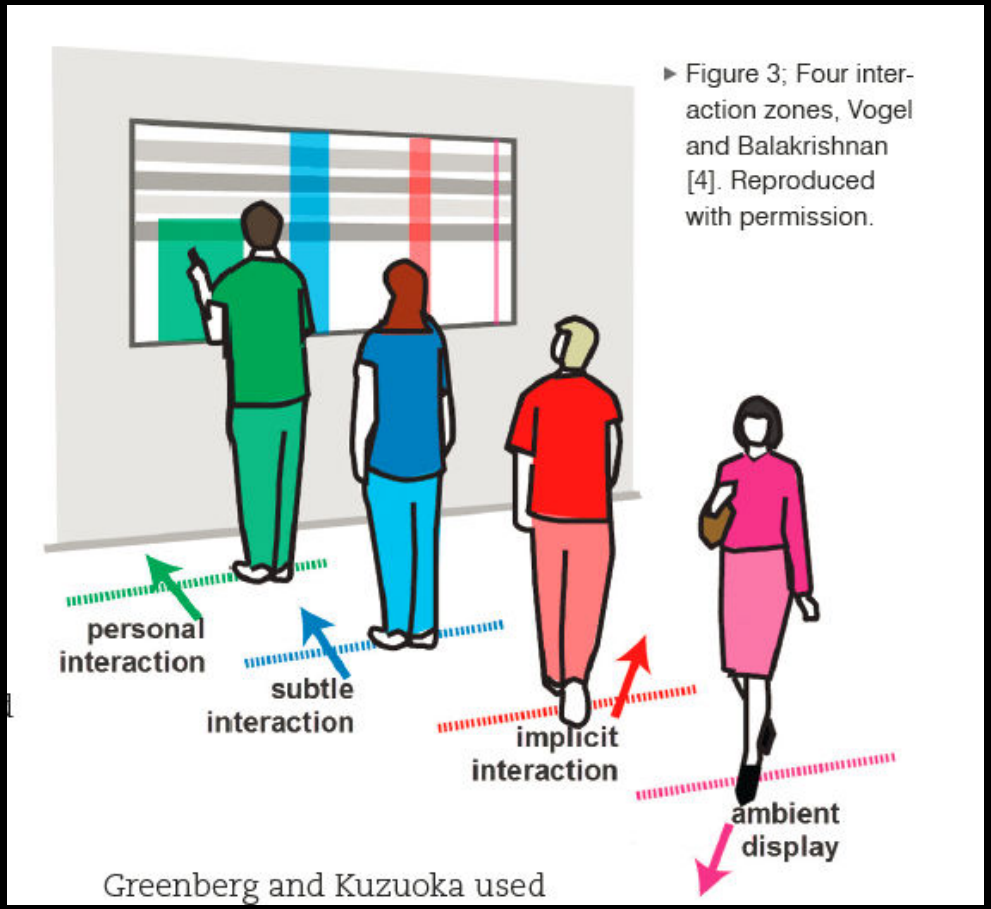
Public: 12 to 25 feet


Digital surfaces
Portable personal devices
People
Information appliances

Proxemic Dimensions



Distance



▸ Figure 3; Four interaction zones, Vogel and Balakrishnan [4]. Reproduced with permission.

Greenberg and Kuzuoka used

Proxemic Interaction (Video)

http://www.youtube.com/v/OHm9teVoNE8

Knowledge of the Feature Space

Fixed (e.g., door)

vs.

Semi-fixed (e.g., furniture)

Interpreting Attention

- Attending to the system itself
- Attention to other surrounding objects and devices.
- Attention to other people.

Continuous Movement x Discrete Zones

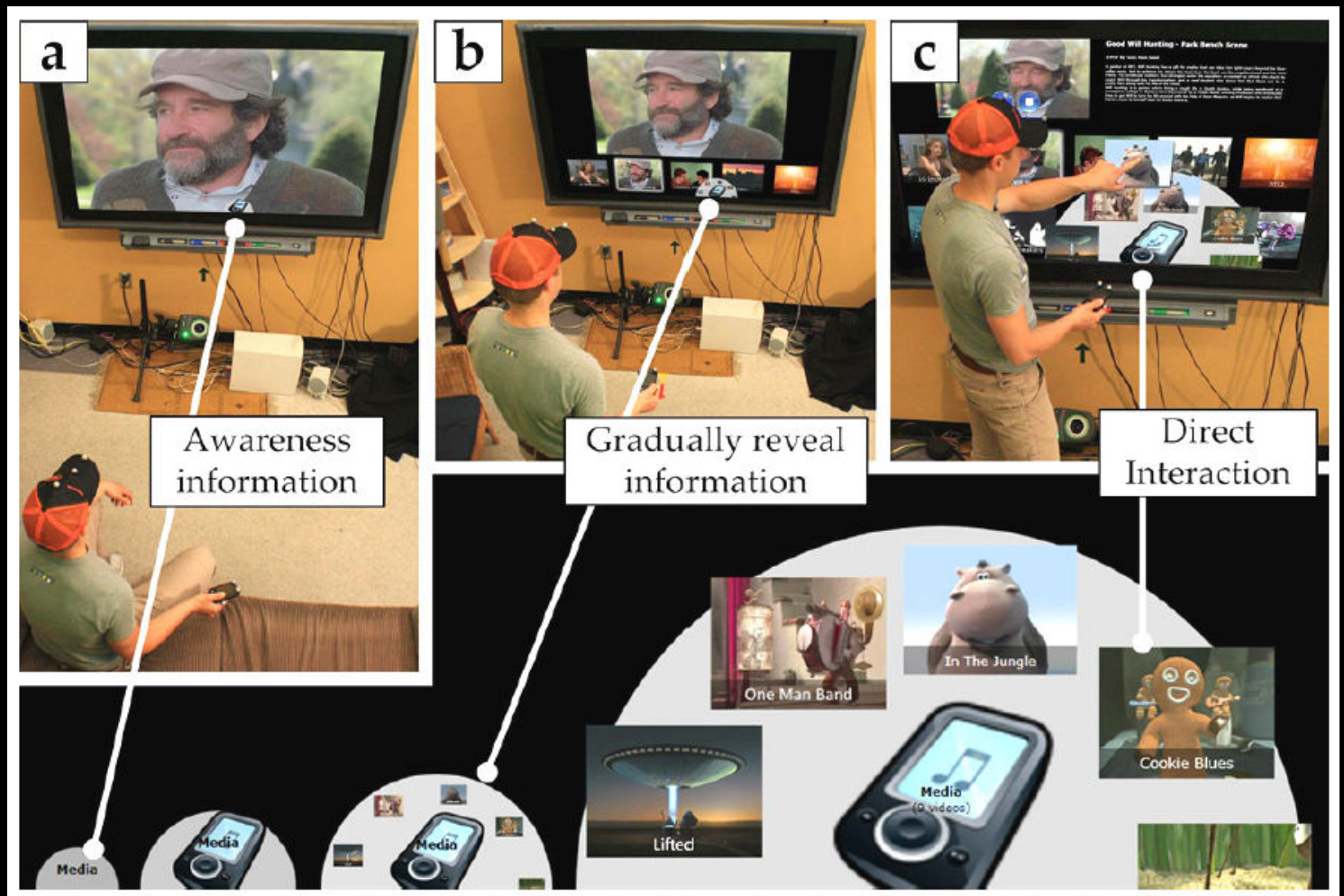


Figure 5. Proximity mediates device to device interaction: from awareness to direct interaction.

Mediating People's Simultaneous Interaction

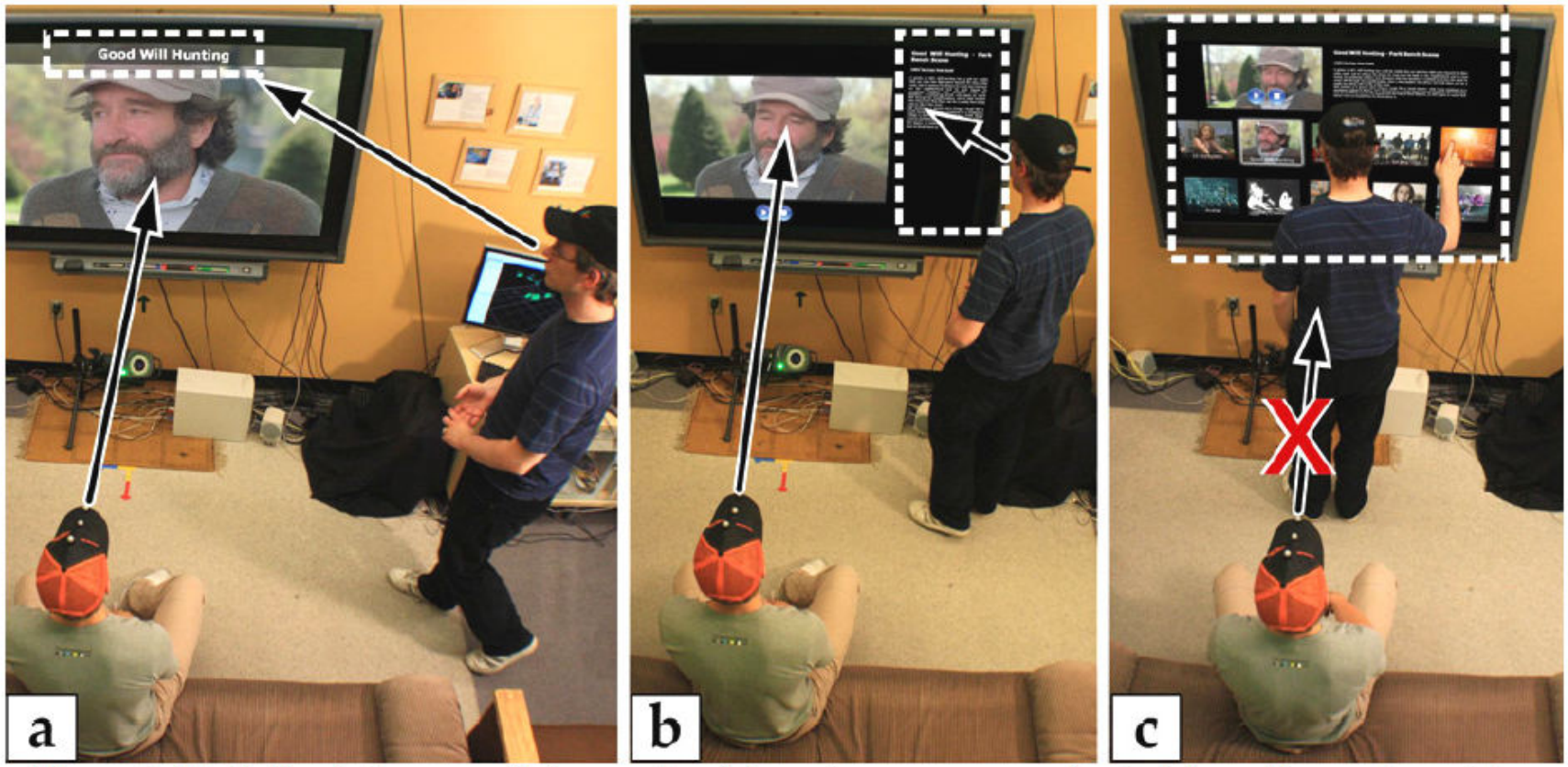


Figure 6: Mediating between multiple people: a) incoming person sees basic information such as video title; b) as one moves closer, the split view provides a more detailed video description; c) when within reach of the display, the person gets full control.

VICON System

- https://www.youtube.com/watch?v=qgS1pwsHQIA

References

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- Till Ballendat, Nicolai Marquardt, and Saul Greenberg. 2010. **Proxemic interaction: designing for a proximity and orientation-aware environment**. In *ACM International Conference on Interactive Tabletops and Surfaces* (ITS '10). ACM, New York, NY, USA, 121-130
- Ishii, Hiroshi, et al. "**Radical atoms: beyond tangible bits, toward transformable materials**." *Interactions* 19.1 (2012): 38-51.