Announcements

- Midterm project proposal due next **Monday Feb 14**
- Form a group (maximum of 3 members) for your project and write a 1-page proposal and post it on the course website
- Brainstorming sessions
  - **Wednesday** Feb 10th, **10:45-11:10am** at Room **110** South Hall
  - **will send a doodle calendar!**

week
04

Taxonomy of TUIs

Tokens, tools, and containers

Lecture Outline

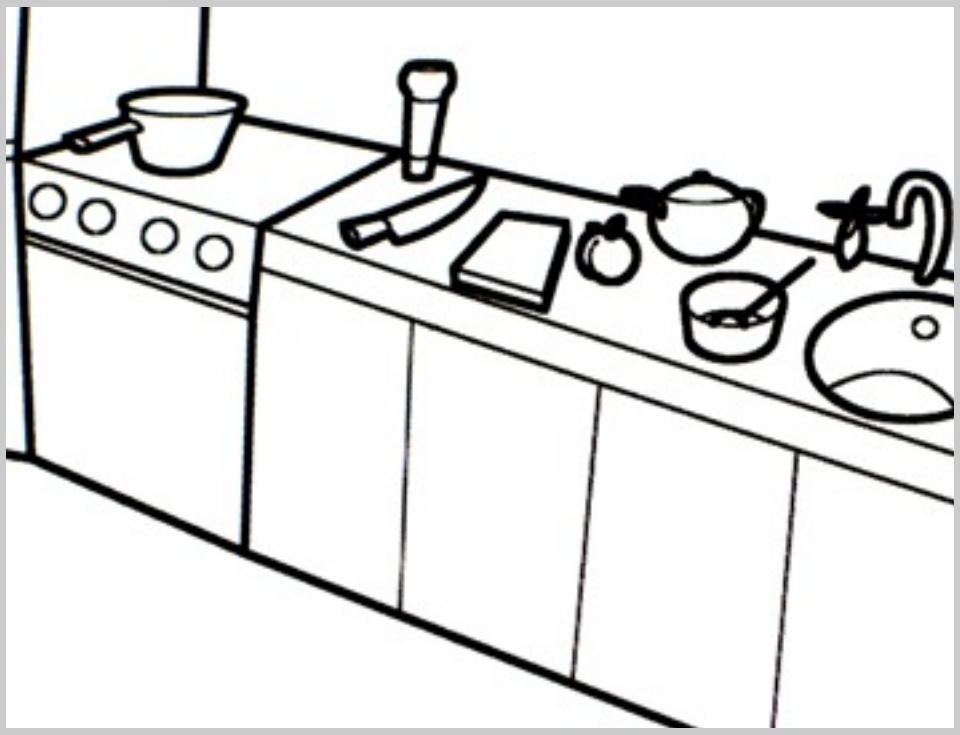
- Physicality of Objects
- Token-Based Access to Digital Information
- Taxonomy of Tangible User Interfaces

Physicality of Objects

"Things should be themselves" [Durrell Bishop, 2006]

Designing objects that are self-evident, whether physical or virtual.

Self-Evident Objects



Self-Evident Objects

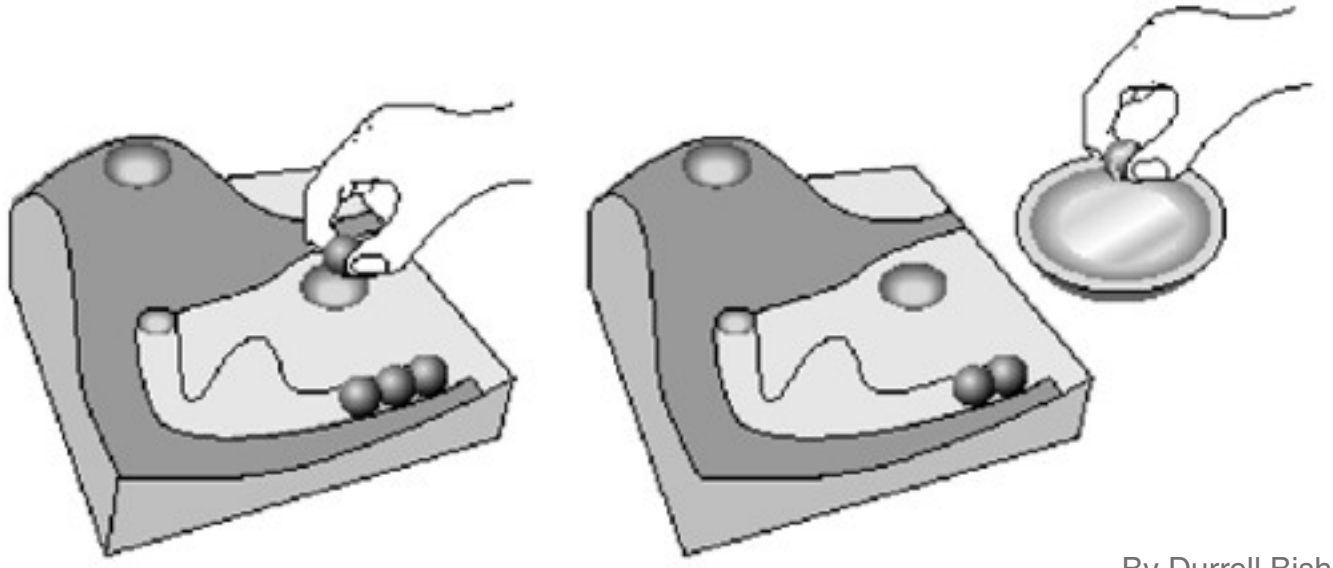
Durrell Bishop video

Self-Evident Objects

- Mechanical properties: hard to copy, fits in your pocket, size and shape
- Social properties: value, country, ownership by distance
- Not a pointer to money, it is money

Marble Answering Machine

Incoming voice messages are represented by marbles.



By Durrell Bishop
circa mid 1990's

“Things should be themselves”

Designing objects that are self-evident, whether physical or virtual. Building a stronger relationship to our perception of reality.

[Durrell Bishop, 2006]

Physical Objects as Representations of Information

Token-Based Access to Digital Information

[Holmquist et al., 2006]

A system where a physical object (token) is used to access some digital information that is stored outside the object, and where the physical representation in some way reflects the nature of the digital information it is associated with.

Souvenirs, photographs, and keepsakes

The remembrance of places, past events, and persons by acting as a trigger for the user to remember certain information.

Tokens, Container, and Tools

Tokens

Tokens in HCI trigger the display of information that is digitally stored outside the token in some way.

Tokens, Container, and Tools

Tokens

Example: metaDESK (Ishii & Ullmer, 1997)

Tokens, Container, and Tools

Tokens

Tokens, Container, and Tools

Tokens

The digital information associated with the object is reflected in the physical properties of the token in some way, thus making the object more closely tied to the information it represents.

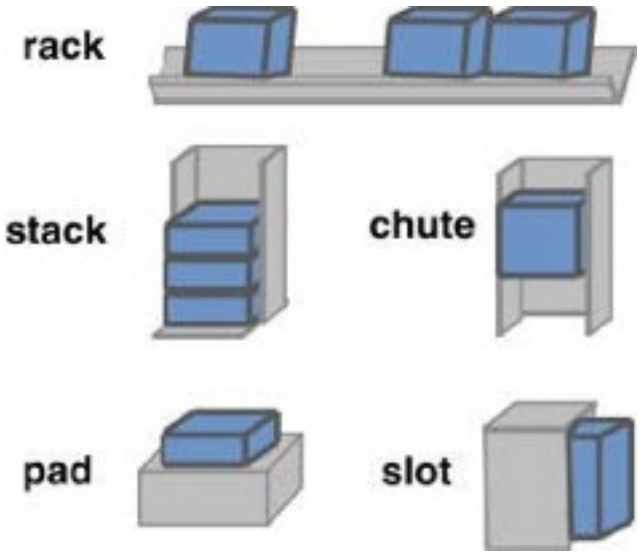
Tokens, Container, and Tools

Container

If it is a generic object that can be associated with any type of digital information.

Tokens, Container, and Tools

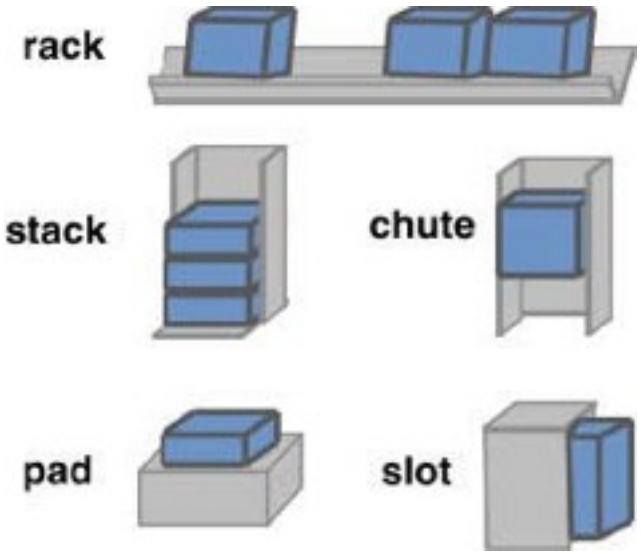
Container



Tokens, Container, and Tools

Container

Ullmer et al. (1998) mediaBlocks: Physical Containers, Transports, and Controls for Online Media
full paper presented at SIGGRAPH



Tokens, Container, and Tools

Tools

They are used to actively manipulate digital information, usually by representing some kind of computational function. E.g., metaDESK: "**magic lenses**."

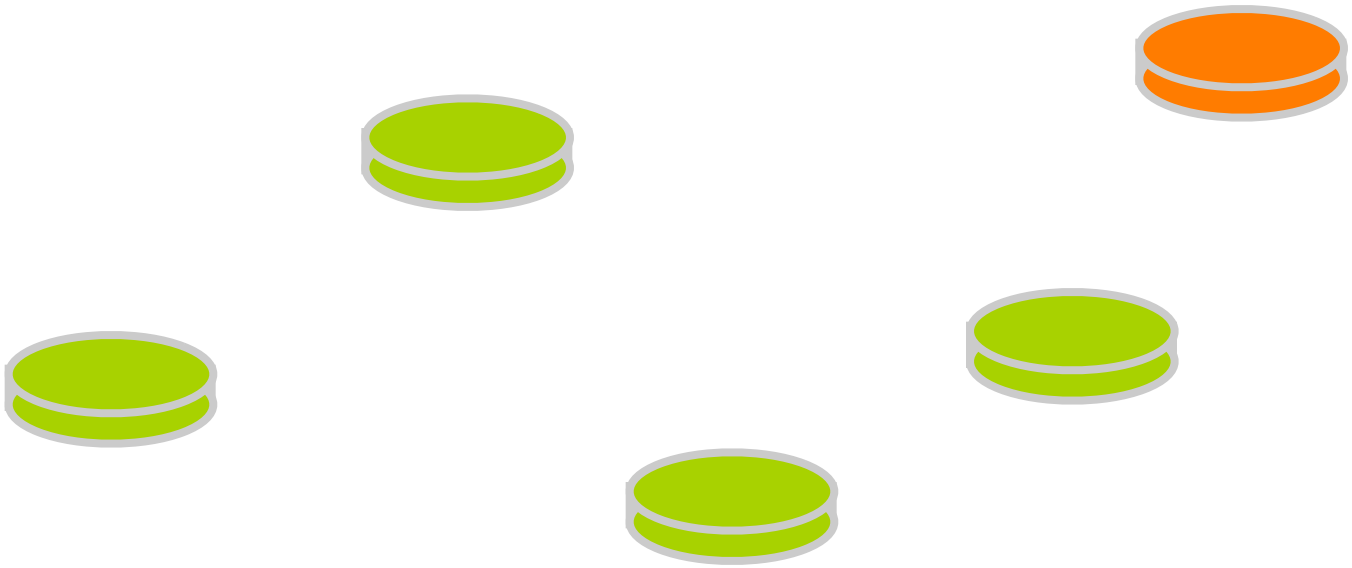
Token-Based Access to Digital Information

Access and Association: Interacting with tokens can be either to access the information associated with a certain token, or to create or modify such associations.

Token-based access to digital information

Access: Number of copies

Restrict access via allowing only one instance of a token.



Token-based access to digital information

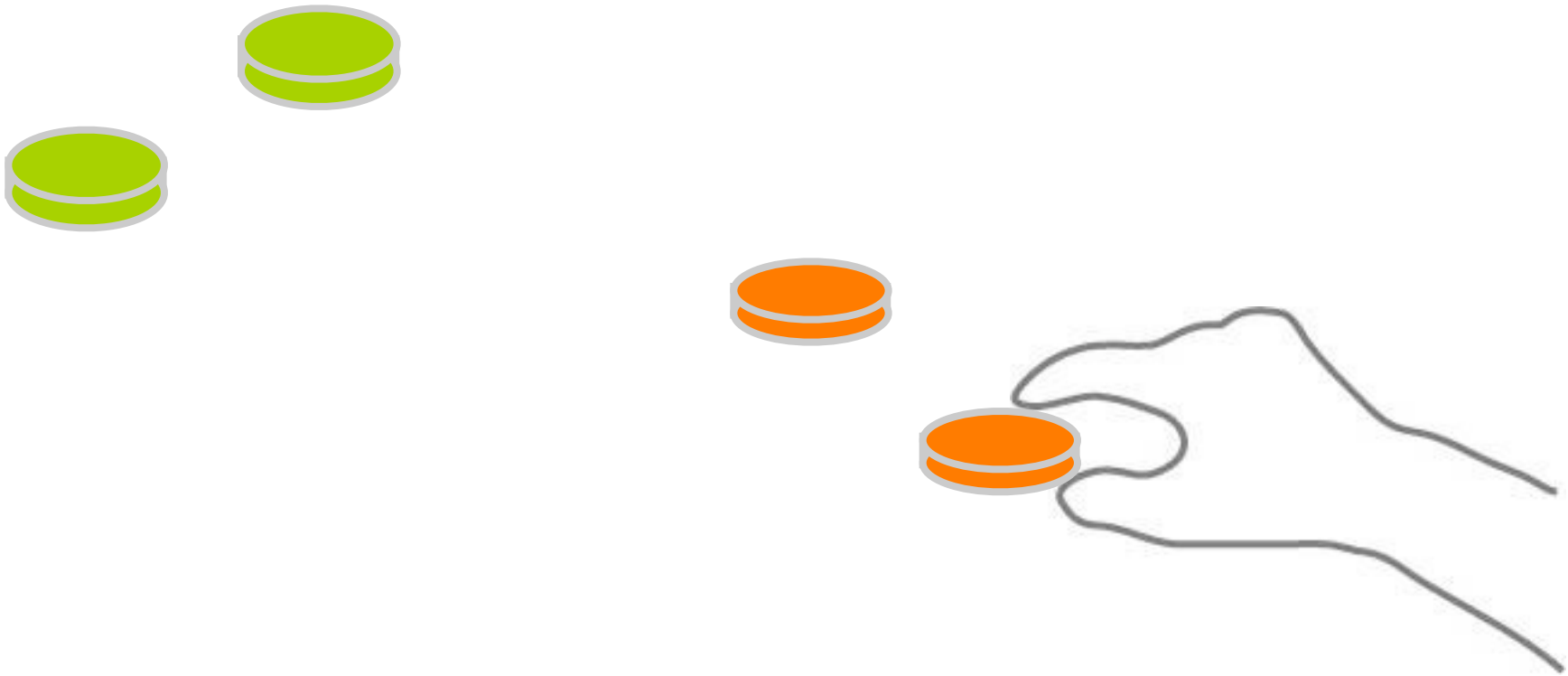
Access: Combination

Combination of tokens for accessing information associated with all the tokens simultaneously.

Token-based access to digital information

Access: Location

Physical location sensitive (e.g., local vs. public).



Association

We may want to restrict the association of a certain kind of token to a certain kind of information (c.f. “container”).

We also don’t want to *overload* a token with multiple meanings.

Designing Token-Based Interactions

Design the tokens in a way that clearly displays what they represent and what can be done with them, i.e. their affordances. Matching the affordances of the token with the task it is designed to be used in.

Materials

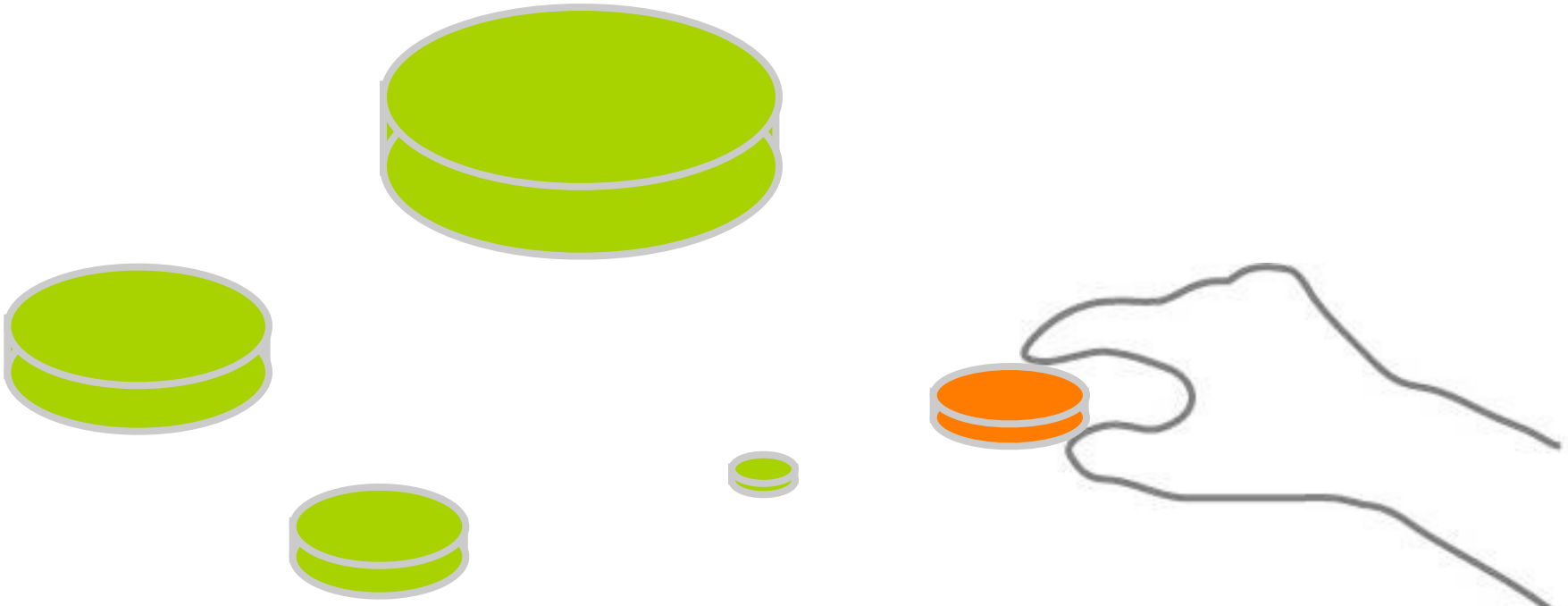
E.g., paper quality in books and newspapers.

Materials

E.g., glue on Post-It and postage stamp.

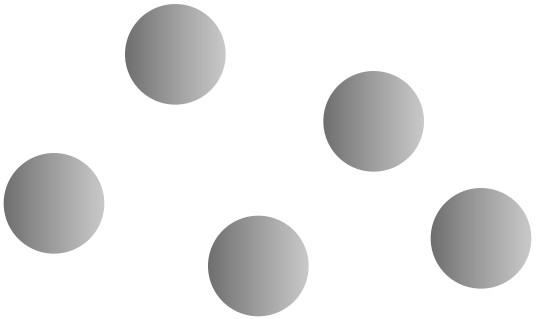
Sizes

Graspable, fit in pocket, etc.



Shapes

Card size? Marbles? Jigsaw puzzle pieces fit in certain ways.



Shapes

Certain shapes and colors convey values or meaning specific to a culture, e.g., a cross.

Context of Use

Everyday objects removed from their context change “meaning.”
The very location of tools and objects can convey meaning.

Taxonomy for Analysis

Metaphor and embodiment [Fishkin, 2004]

Broad Script of TUIs

1. Some input event occurs. This input event is typically a physical manipulation performed by a user with her hands on some “everyday physical object,” such as tilting, shaking, squeezing, pushing, or, most often, moving.
2. A computer system senses this input event, and alters its state.
3. The system provides feedback. This output event is via a change in the physical nature of some object—it alters its display surface, grows, shrinks, makes a sound, gives haptic feedback, etc.

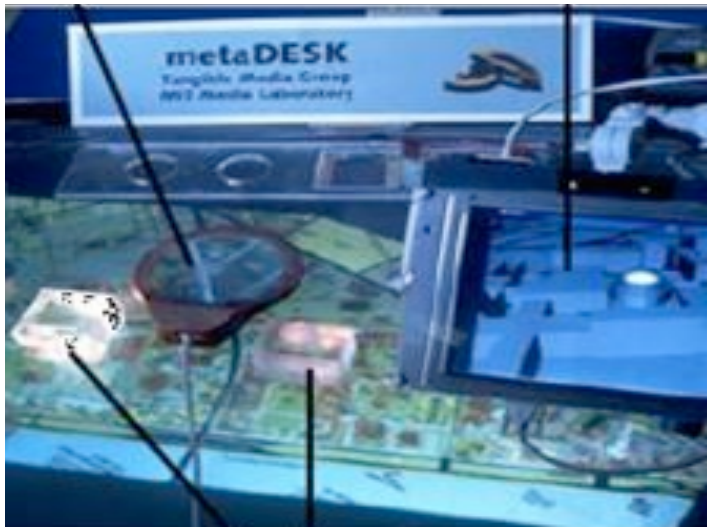
Example 1: metaDESK

Input object: indicative of a building

Input: positions and rotations

Output object: augmented desktop

Output: altered display of the workspace



Example 2: Doll's Head

Input object: doll's head and a plate

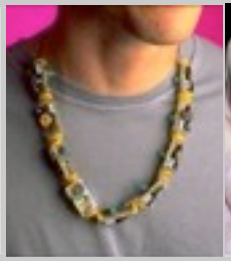
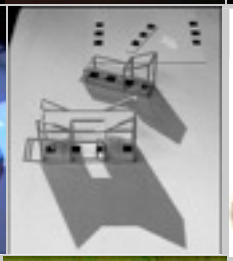
Input: positions and rotations

Output object: computer monitor

Output: altered display of the display

Hinckley et al. (1994)

Metaphor / Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Embodiment

Full, nearby, environmental, distant

How closely tied is the input focus to the output focus? To what extent does the user think of the states of the system as being “inside” the object they are manipulating? To what extent does the user think of the state of computation as being **embodied** within a particular physical housing?

Full Embodiment

The output is the input device, “input output coincidence”

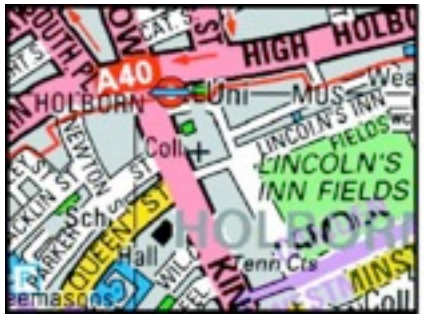
Topobo

Curlybot

Full Embodiment

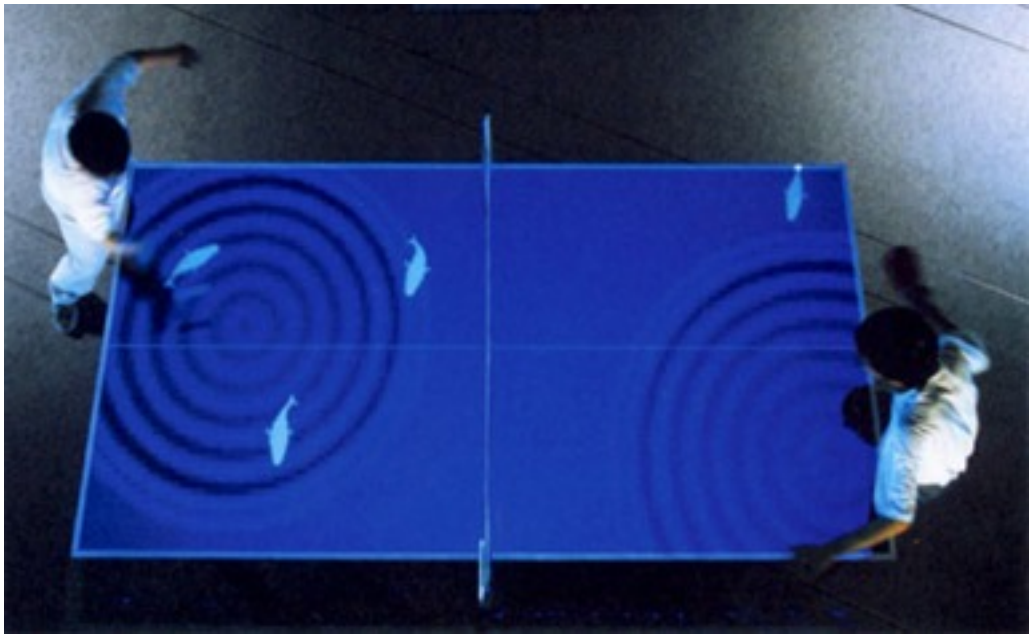
The output is the input device, input output coincidence

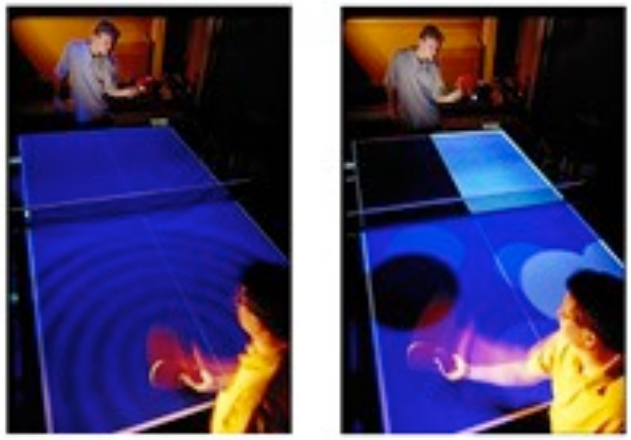
Gummi



Nearby Embodiment

The output is tightly coupled to the focus of the input

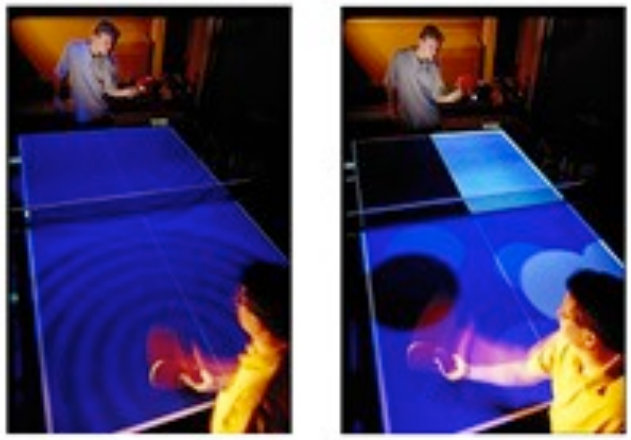




Ping Pong Plus

Nearby Embodiment

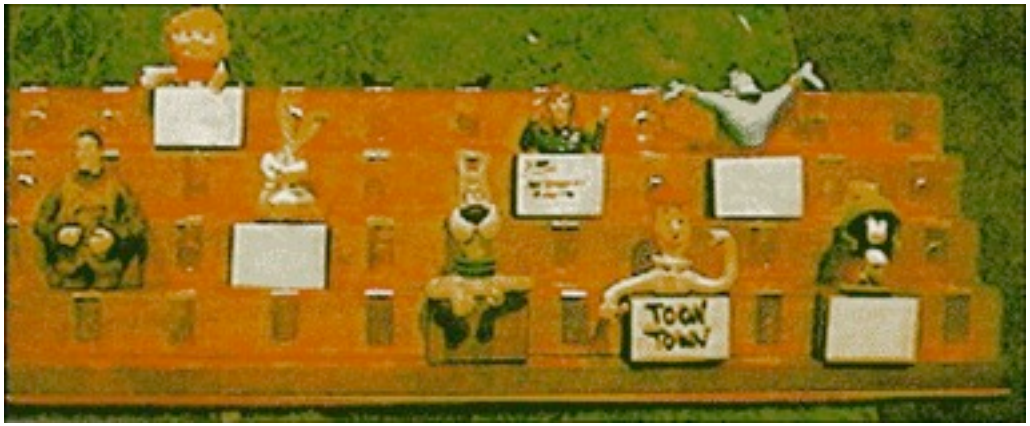
The output is tightly coupled to the focus of the input



Ping Pong Plus

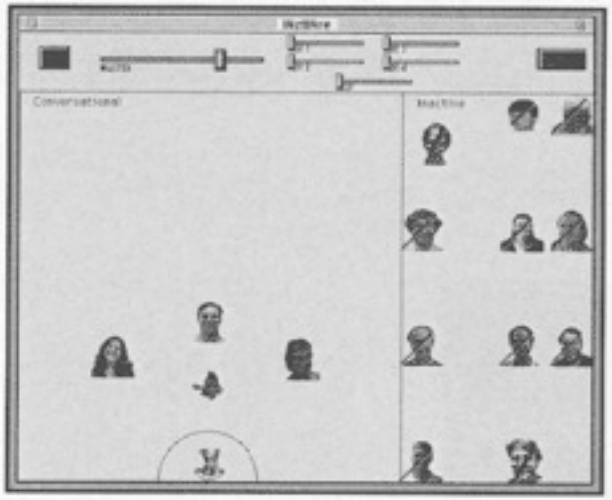
Environmental Embodiment

The output is “around” the user



Left pan		S	O	F	T	E	S	T		Right pan	
Left pan					Center Pan					Right pan	
Left pan					Center Pan					Right pan	Info Zone
Left pan		L	O	U	D	E	S	T		Right pan	Assign Zone

ToonTown



Distant Embodiment

The output is “over there” on another screen, or even another room, like a remote control.

Doll’s Head

Metaphor

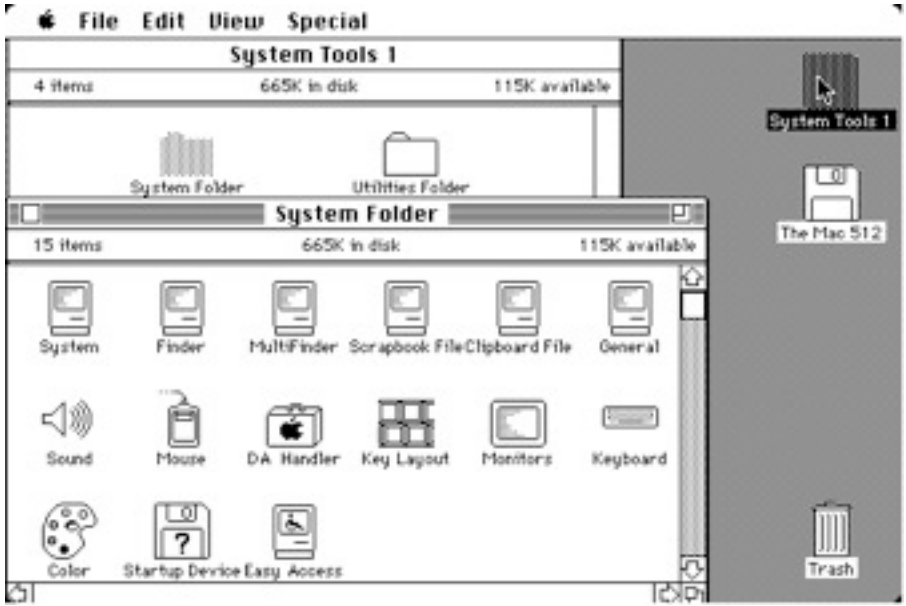
Noun, verb, noun & verb, full, none

Metaphor as a powerful ingredient in thought and design. May be particularly appropriate for TUIs due precisely to their physical tangibility.

Noun Metaphor

"A _____ in our system is like a _____ in the real world."
Object **looks like** the real thing.

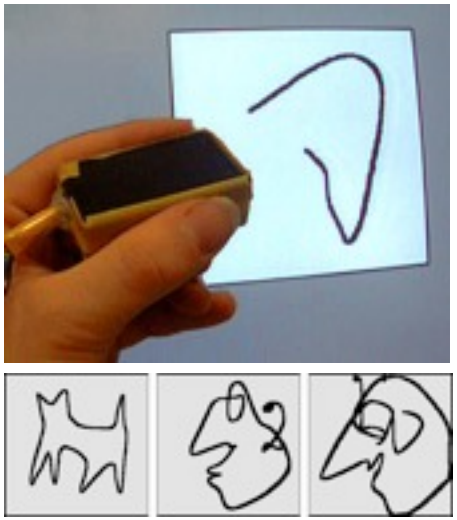
However, the actions employed on/with that object are either not analogous or only weakly.



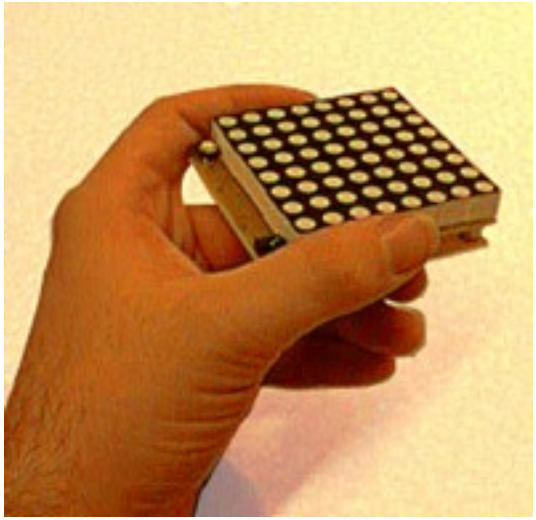
Verb Metaphor

Object **acts like** the real thing.

"_____-ing in our system is like _____-ing in the real world."



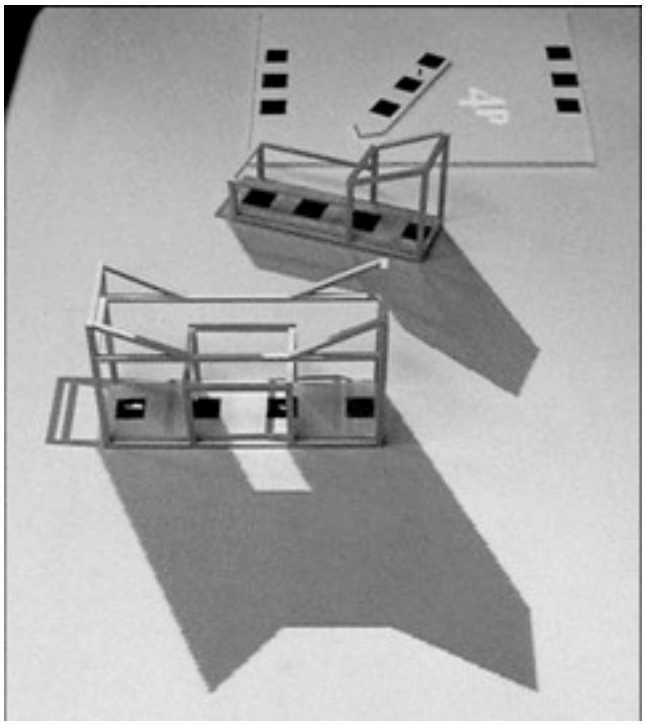
Shakepad

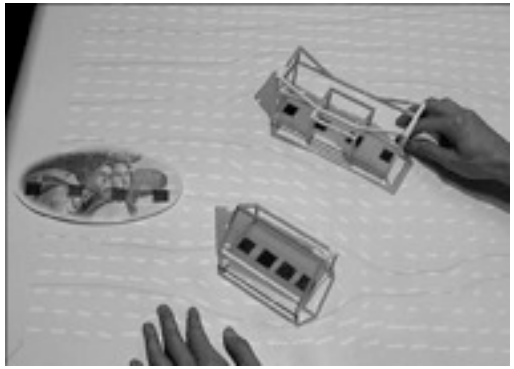


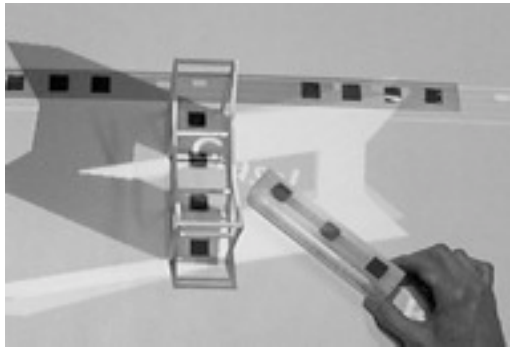
Noun & Verb Metaphor

Object **looks and acts** like the real thing – but they are still different.

Based on both the noun and verb metaphors.







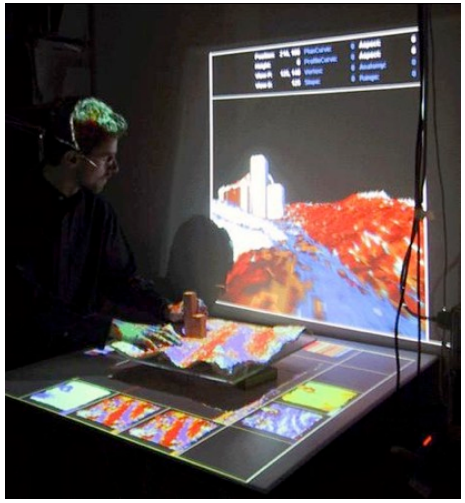
Urp

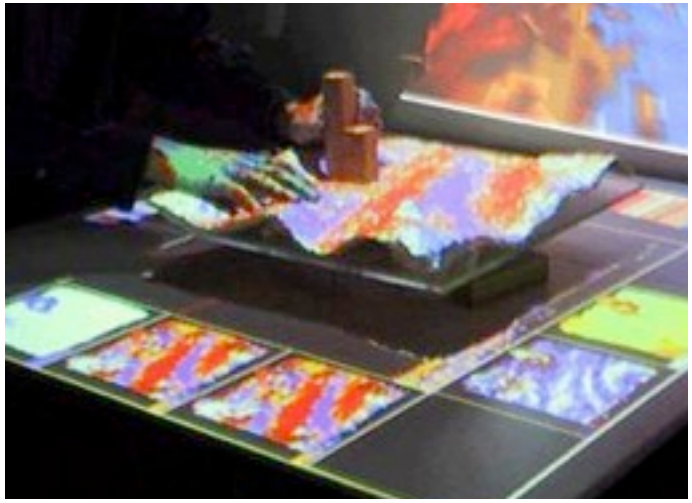
Full Metaphor

The virtual system is the physical system.

The users need make no analogy at all—in their mind, the virtual system is the physical system.

“Really Direct Manipulation”

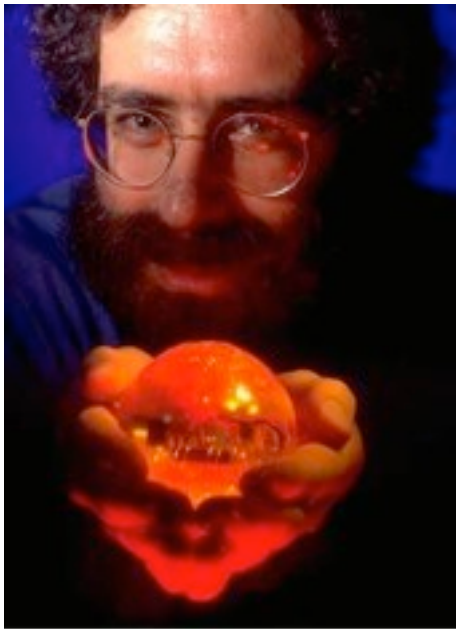




Illuminating Clay

No Metaphor

Users employ various physical manipulations to control the system, but these manipulations are deliberately not connected to any real-world analogy.



Bit Ball

Beads

Analysis of TUIs

Noun, verb, noun & verb, full, none

Metaphor as a powerful ingredient in thought and design. Perhaps particularly appropriate for TUIs due precisely to their physical tangibility.

Metaphor / Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Doll's Head

Metaphor / Embodiment	None	Noun	Verb	Noun and Verb	Full
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Doll's Head

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
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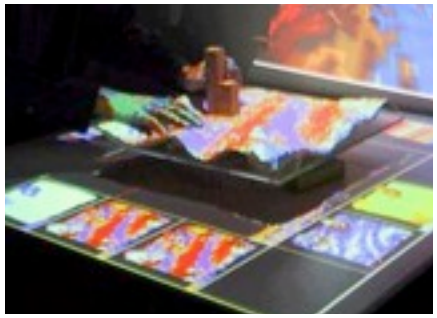

Illuminating Clay

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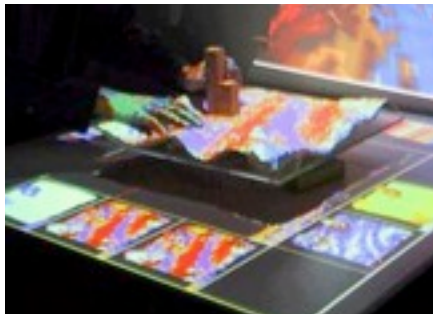

Illuminating Clay

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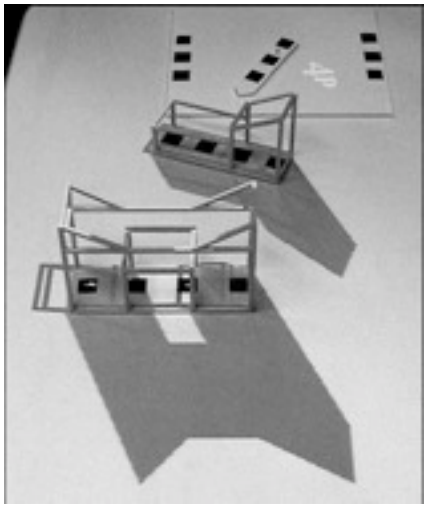

Urp

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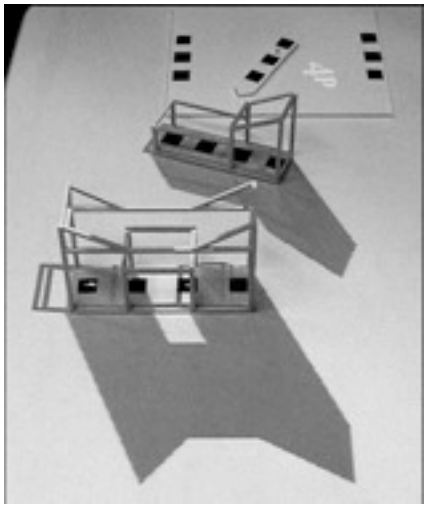

Urp

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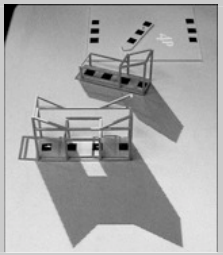
Full					
Nearby					
Environ-ment					
Distant					

Gummi

Metaphor / Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
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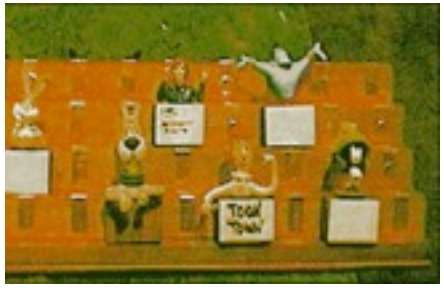
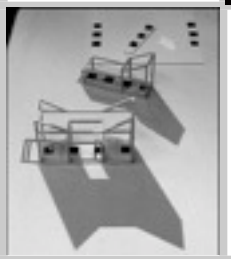
Environ-ment					
Distant					

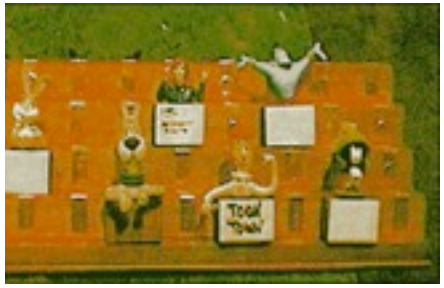
Gummi

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					



ToonTown

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					



ToonTown

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Shakepad

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Shakepad

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

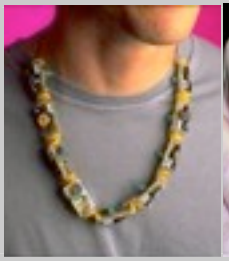
BitBeads

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

BitBeads

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

I/O Brush

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
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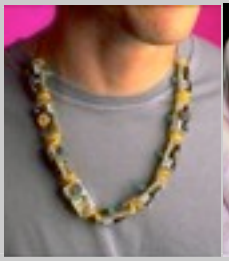
I/O Brush

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
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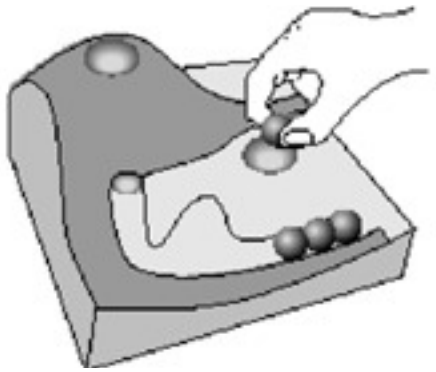
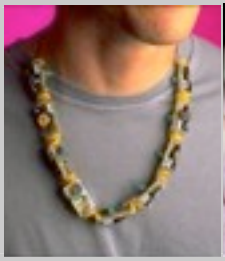
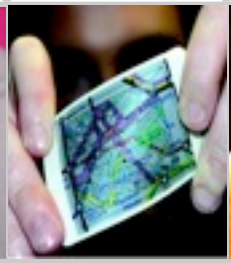
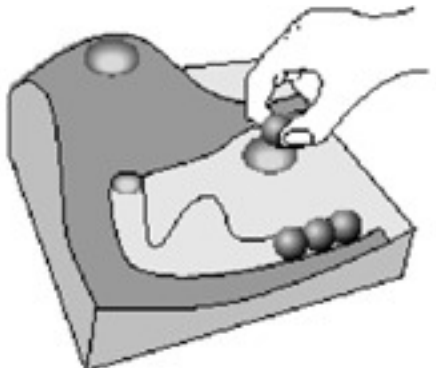
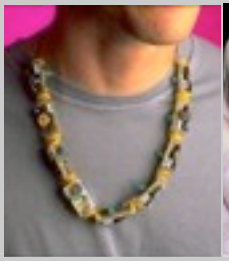
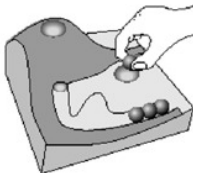


Marble Answering Machine

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					



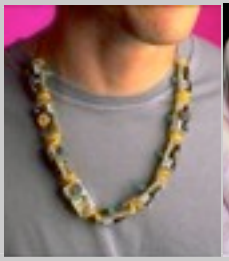
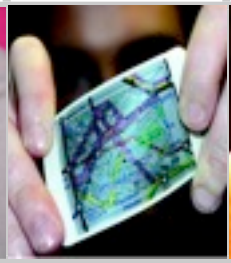
Marble Answering Machine

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

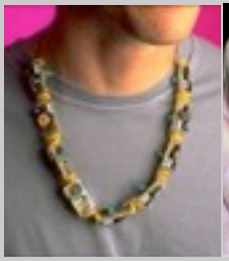
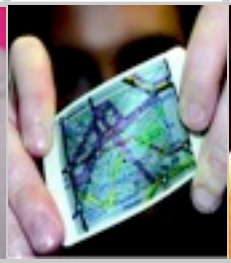
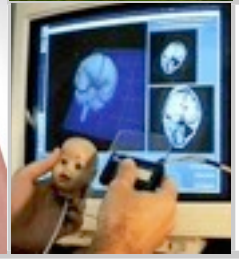
Industrial Design Examples

Joystick, dance dance revolution, and Wii?

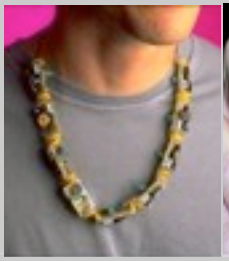
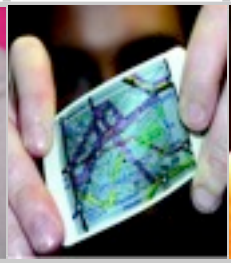
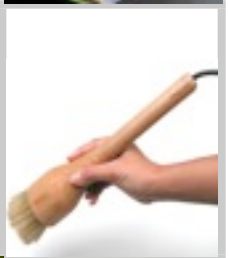
Wii

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

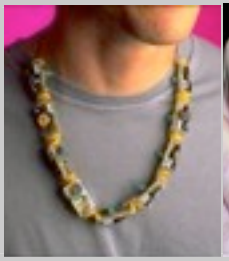
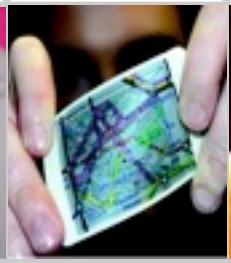
Wii

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Kinect

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Kinect

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Utility of the Taxonomy

Embodiment and metaphor

Taxonomy as a tool for understanding the design space

Evolution of the Field

Tools for children's storytelling.

Tangibles for Kids

StoryMat (1999)

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Tangibles for Kids

Curlybot (2000)

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Tangibles for Children

Topobo (2004)

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Evolution of the Field

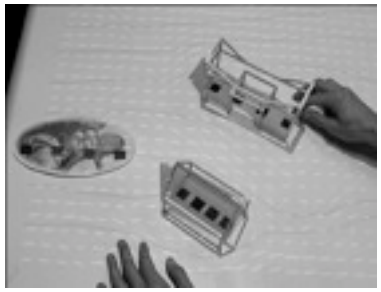
Workbenches

Workbenches

AudioPad

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

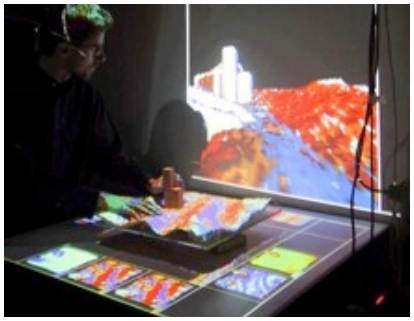
Workbenches



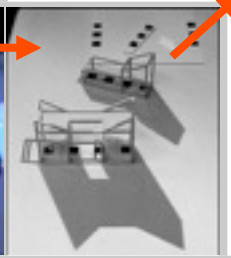
Urp

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Workbenches



Illuminating Clay

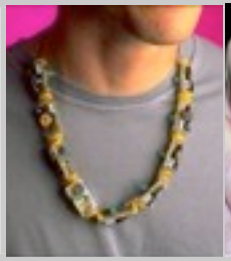
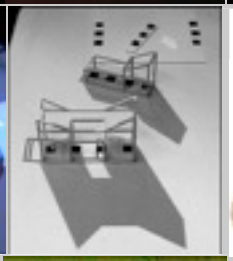
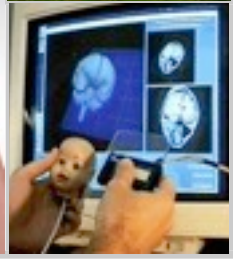
Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Unexplored Territories?

Any gaps?

Any other ideas?

Unexplored territories?

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ-ment					
Distant					

Containers, Tools, Tokens

Containers

Fully embodied (the information is considered to “live” within an object), and which use a particular metaphor of verb (“moving the container is like moving data”).

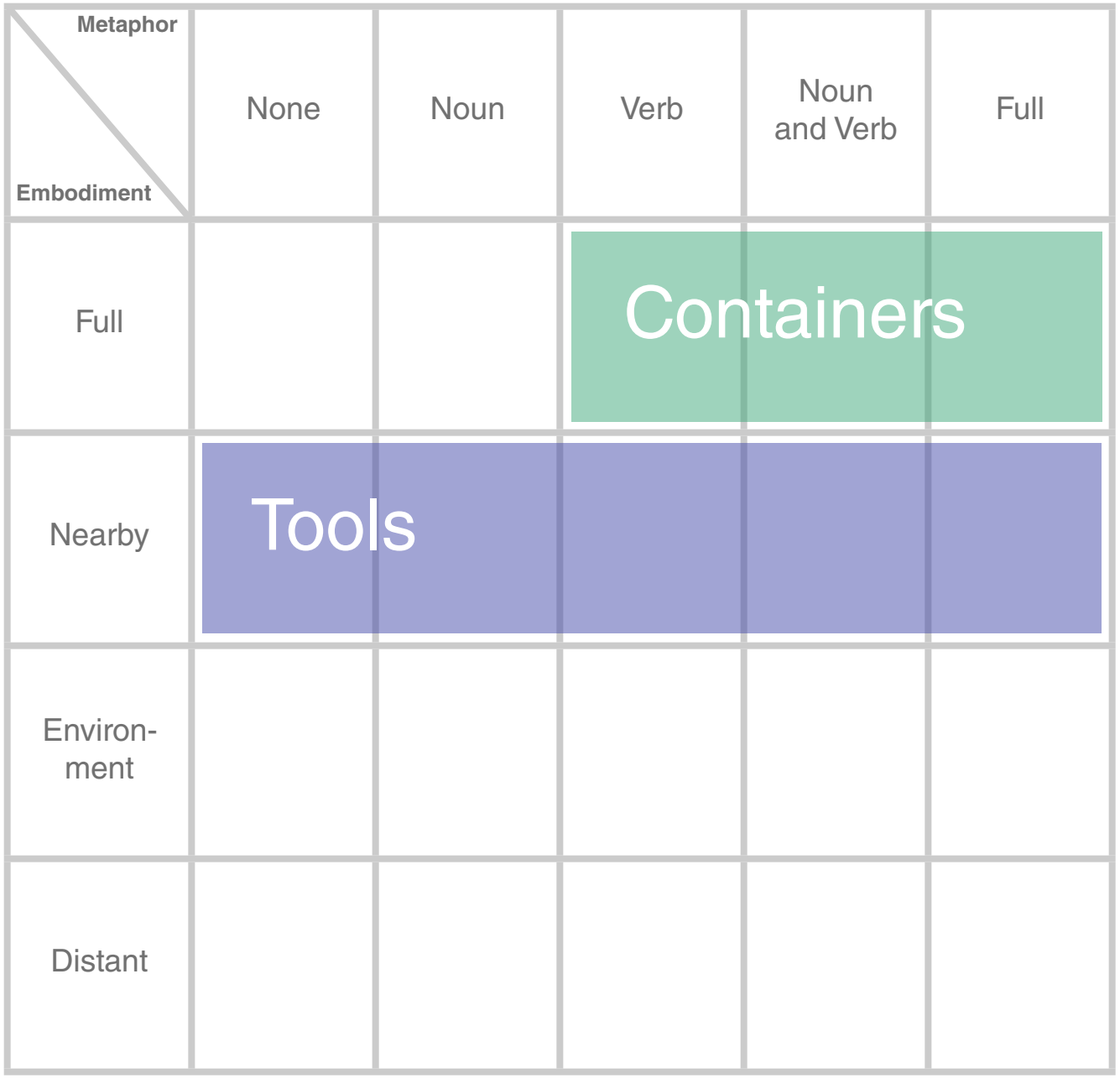
Tools

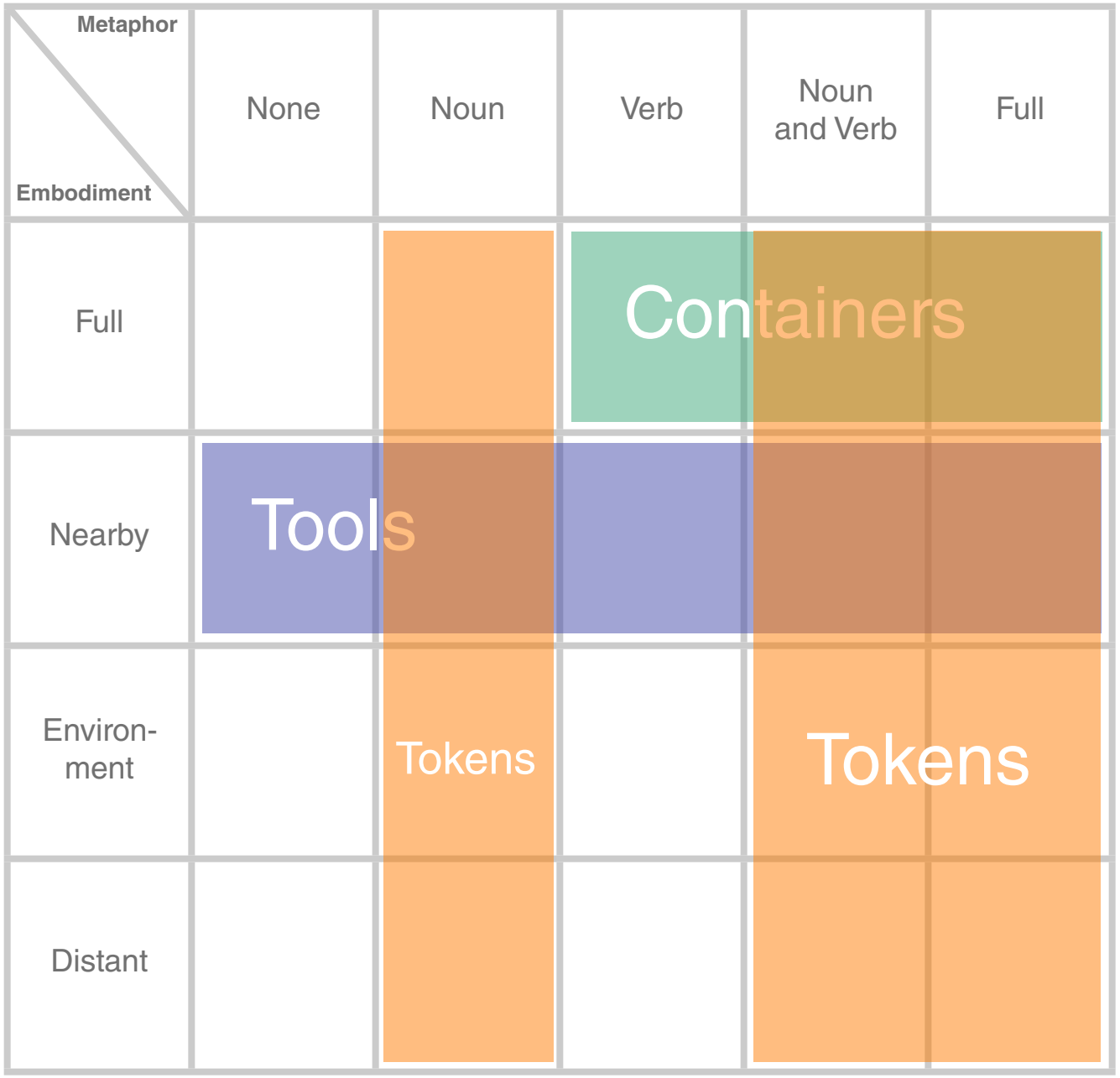
“Actively manipulate digital information.” Nearby embodied (the tool manipulates something next to its surface of action: e.g., a digital desk or the display on a tablet).

Tokens

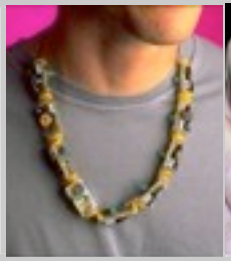
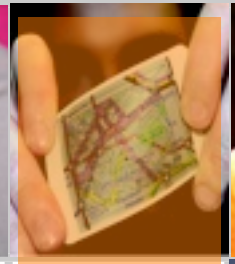
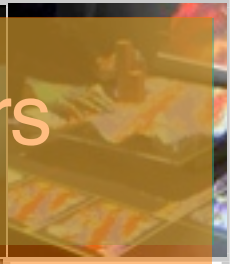
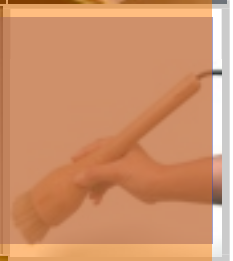
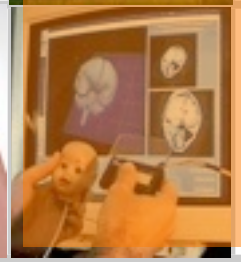
“Objects that physically resemble the information they represent.” This is analogous to our metaphor of noun.

Metaphor / Embodiment	None	Noun	Verb	Noun and Verb	Full
Full			Containers		
Nearby					
Environ-ment					
Distant					


Metaphor
Embodiment
None
Noun
Verb
Noun and Verb
Full
Full
Containers
Nearby
Tools
Environ-ment
Distant


Metaphor
Embodiment
None
Noun
Verb
Noun and Verb
Full
Full
Nearby
Environ-ment
Distant
Containers
Tools
Tokens
Tokens

Again: Any unexplored territories?

Embodiment \ Metaphor	None	Noun	Verb	Noun and Verb	Full
Full			Containers		
Nearby	Tools				
Environ-ment		Tokens		Tokens	
Distant					

Readings for Wednesday

- Analog input: p. 102-104. *Physical Computing*
- Soldering: p. 41-42. *Physical Computing*

If you happen to have a soldering iron, please bring it to the class!

Thanks!