

**week**

**04**



# **Taxonomy of TUIs**

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Tokens, tools, and containers

# Announcements

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- Midterm project proposal due next Tue Sept 25
- Group forming, and Midterm project and Final project
- Crash course on programming by Dave and Ryan next week

# Lecture Outline

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

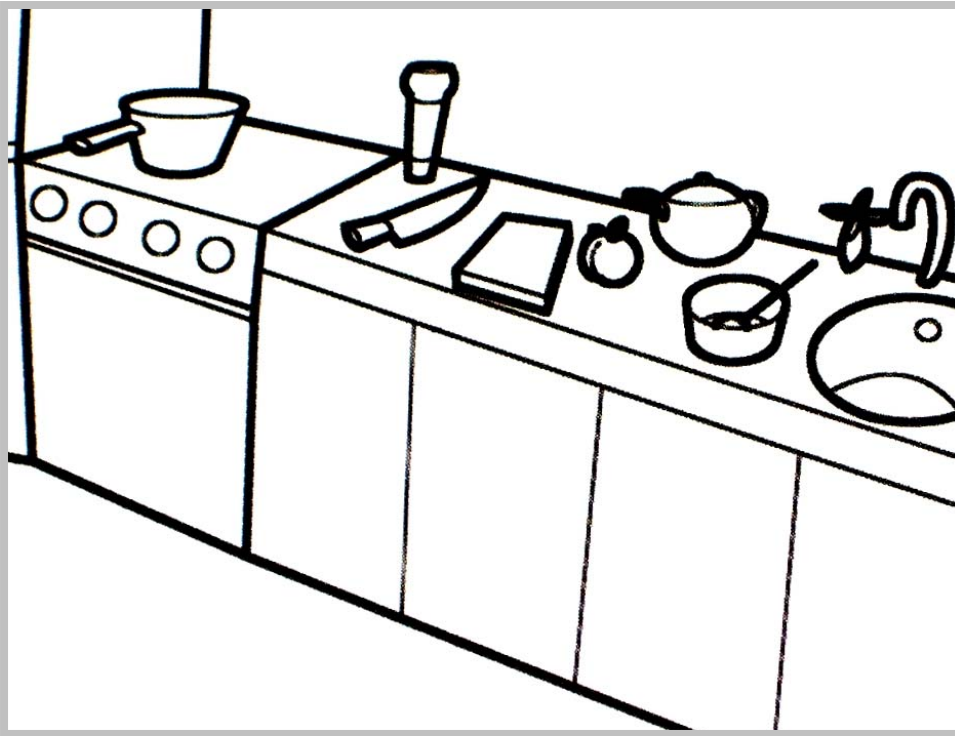
# Physicality of Objects

“Things should be themselves” [Durrell Bishop, 2006]

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

# Self-Evident Objects



# Self-Evident Objects

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Durrell Bishop video

# Self-Evident Objects

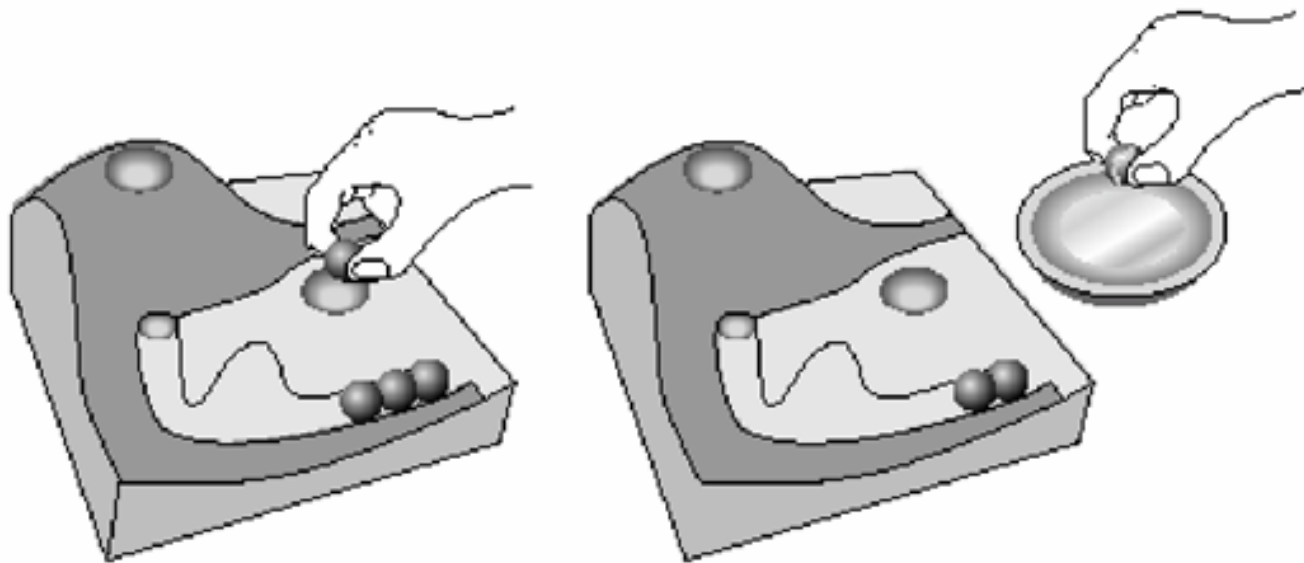
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- Mechanical properties: hard to copy, fits in your pocket, size and shape
- Social properties: value, country, ownership by distance
- Not a pointer to money, it is money



# Marble Answering Machine

Incoming voice messages are represented by marbles.



By Durrell Bishop  
circa mid 1990's



# “Things should be themselves”

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

[Durrell Bishop, 2006]

# Physical Objects as Representations of Information

## Token-Based Access to Digital Information

[Holmquist et al., 2006]

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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

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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

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

## Tokens, Container, and Tools

# Tokens

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Example: metaDESK (Ishii & Ullmer, 1997)



## Tokens, Container, and Tools

# Tokens

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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

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

## Tokens, Container, and Tools

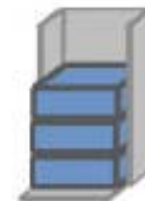
# Container



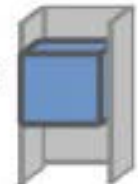
rack



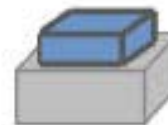
stack



chute



pad



slot

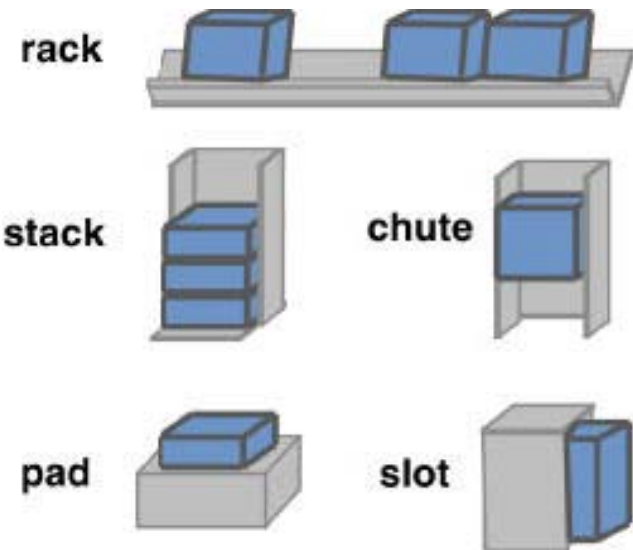




## Tokens, Container, and Tools

# Container

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



## Tokens, Container, and Tools

# Tools

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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

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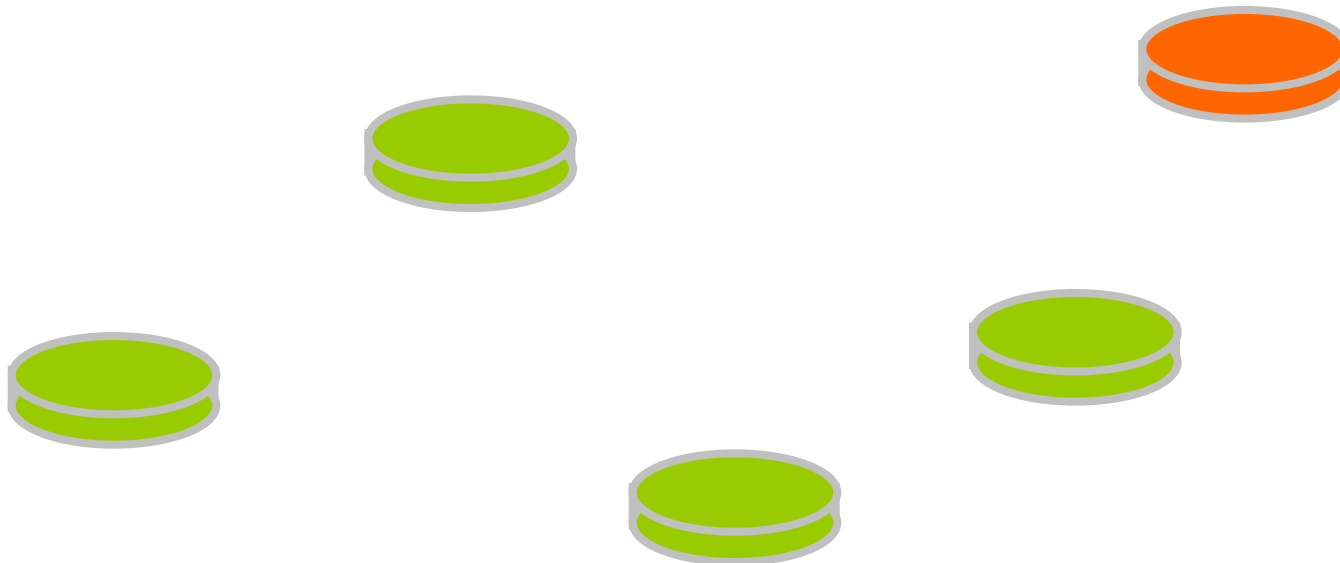
A set of access points for the digital information associated with tokens.

Token-based access to digital information

# Access: Number of copies

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Restrict access via allowing only one instance of a token.



Token-based access to digital information

# Access: Combination

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

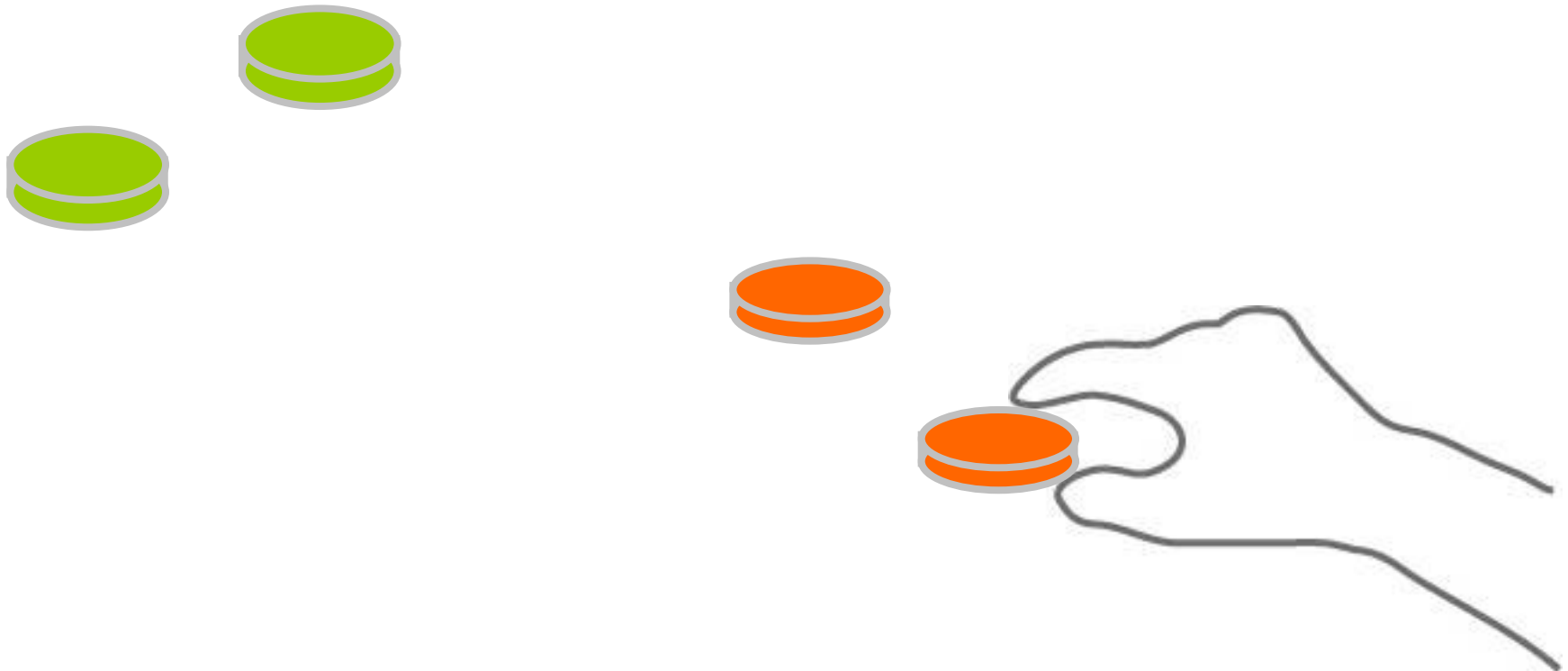


Token-based access to digital information

# Access: Location

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



# Association

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We may want to restrict the association of a certain kind of token to a certain kind of information.

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

# Designing Token-Based Interactions

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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

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



# Materials

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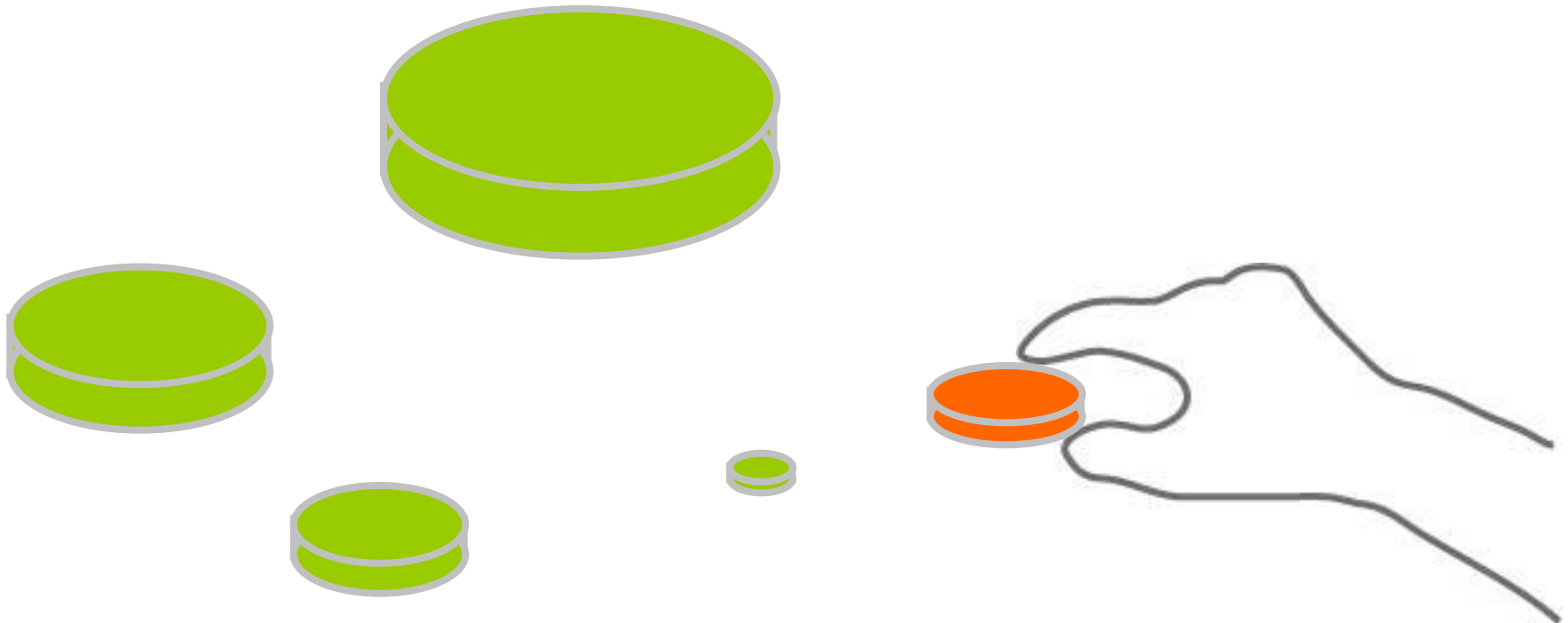
E.g., glue on Post-It and postage stamp.



# Sizes

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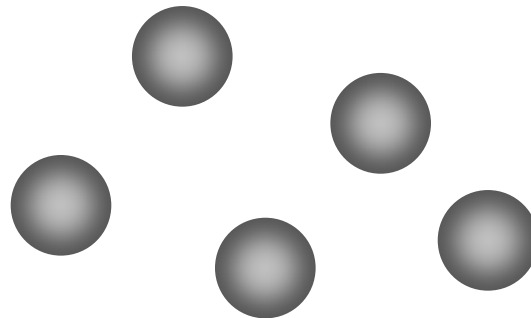
Graspable, fit in pocket, etc.



# Shapes

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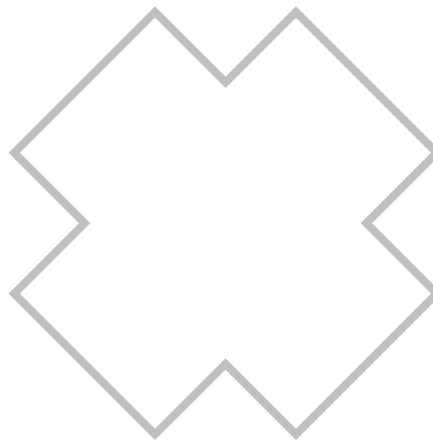
Card size? Marbles? Jigsaw puzzle pieces fit in certain ways.



# Shapes

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



# Context of Use

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



# Taxonomy for Analysis

Metaphor and embodiment

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# Broad Script of TUIs

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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

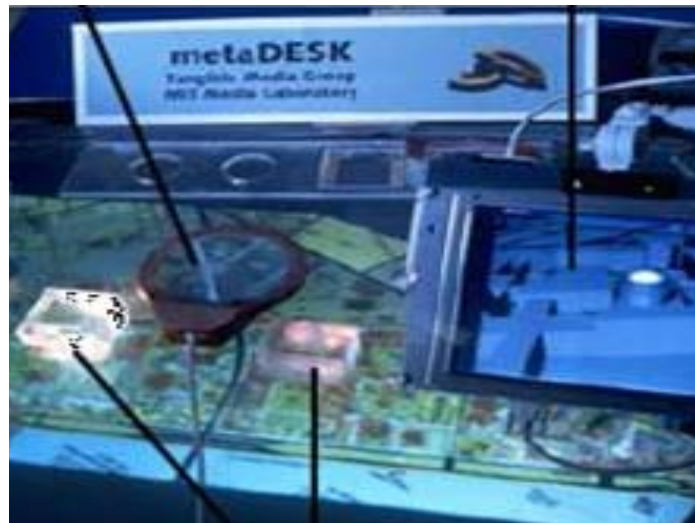
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**Input object:** indicative of a building

**Input:** positions and rotations

**Output object:** augmented desktop

**Output:** altered display of the workspace



# Example 2: Doll's Head

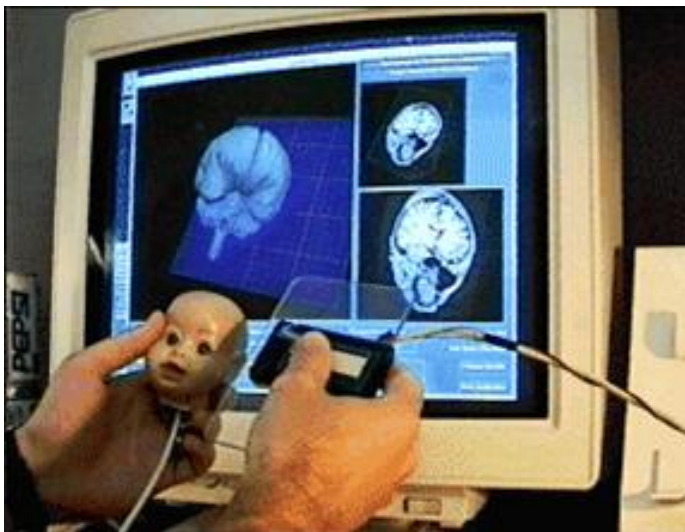
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**Input object:** doll's head and a plate

**Input:** positions and rotations

**Output object:** computer monitor

**Output:** altered display of the display



**Hinckley et al. (1994)**

# Embodiment

Full, nearby, environmental, distant

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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**

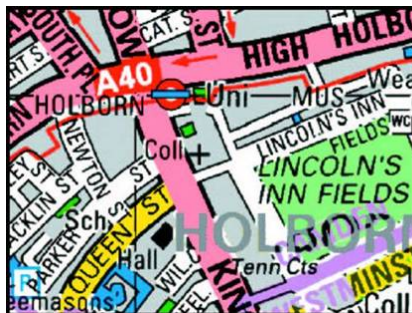
# Full Embodiment

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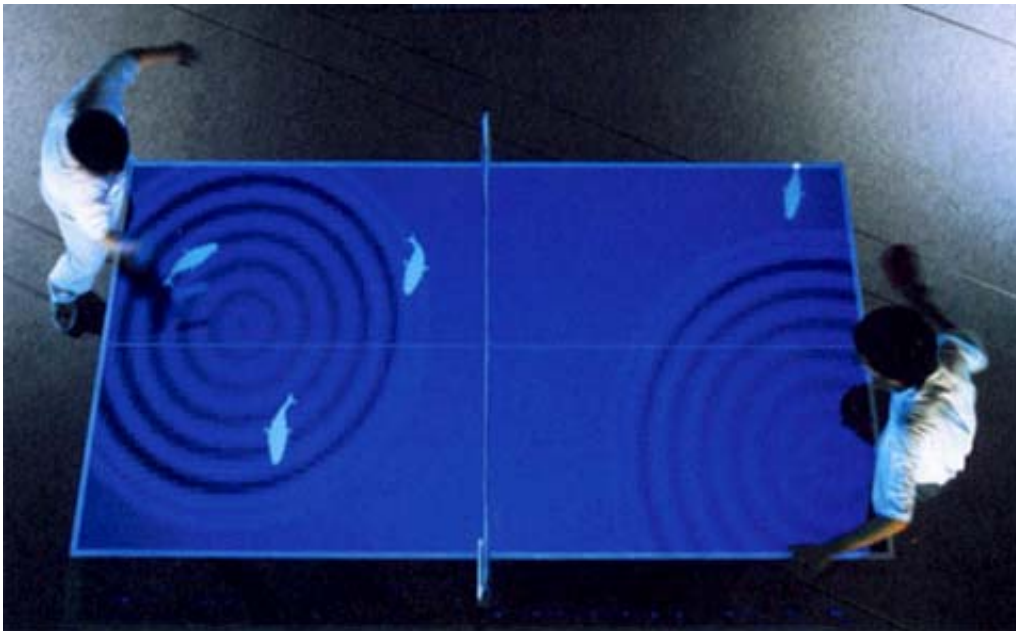


**Gummi**



# Nearby Embodiment

The output is tightly coupled to the focus of the input



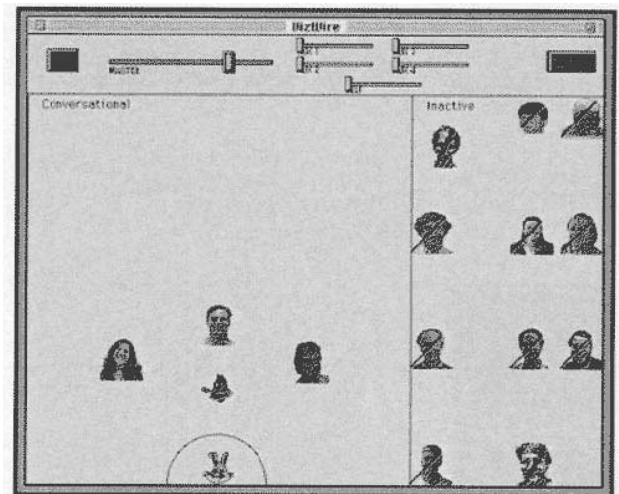
**Ping Pong Plus**

# Environmental Embodiment

The output is “around” the user



**ToonTown**

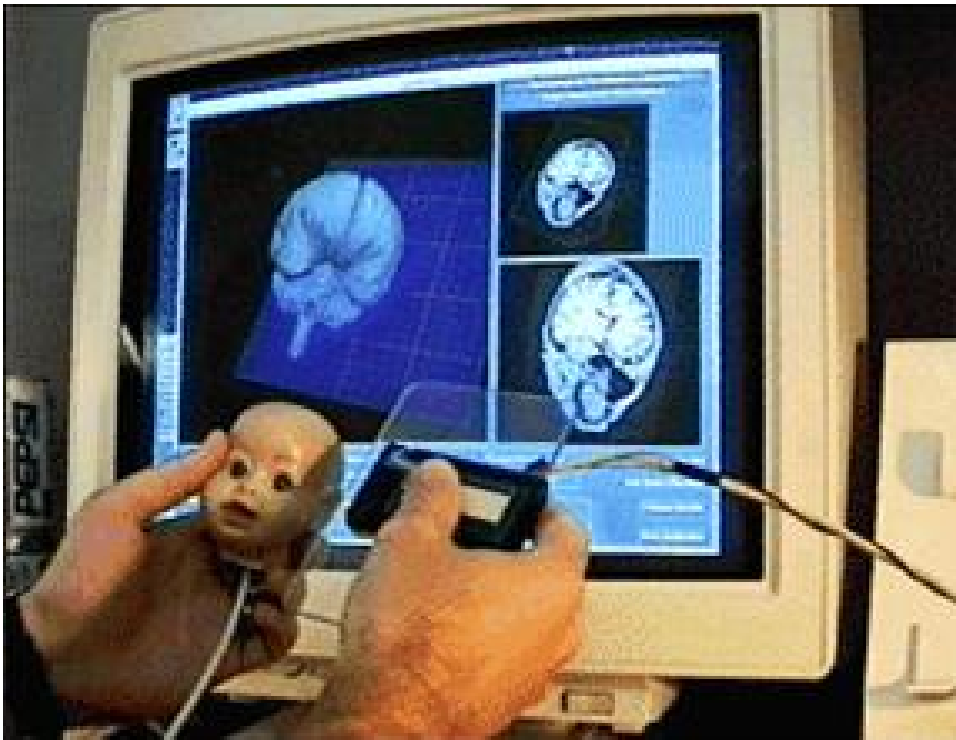


Left pan		S	O	F	T	E	S	T		Right pan	
Left pan					Center Pan					Right pan	
Left pan					Center Pan					Right pan	Info Zone
Left pan		L	O	U	D	E	S	T		Right pan	Assign Zone

# Distant Embodiment

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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

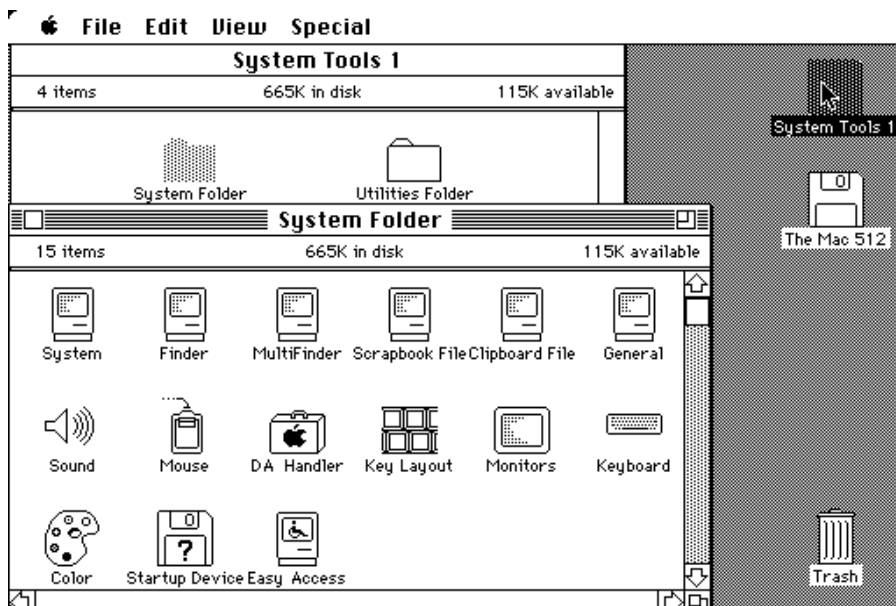
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Metaphor as a powerful ingredient in thought and design. May be particularly appropriate for TUIs due precisely to their physical tangibility.

# 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.

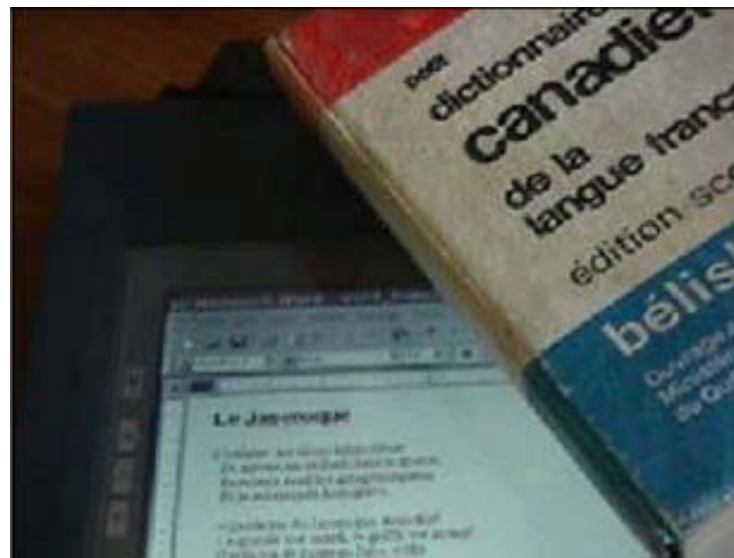


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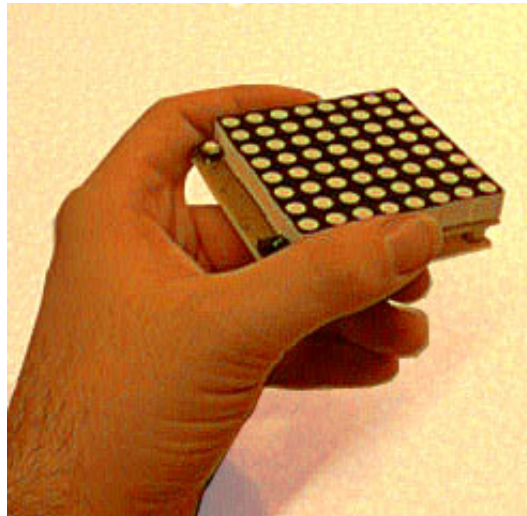
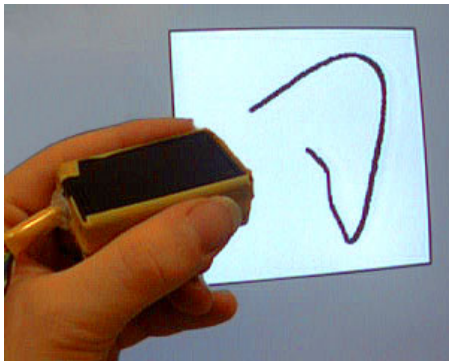
**Tagged Objects**

# Verb Metaphor

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Object *acts like* the real thing.

“\_\_\_\_\_ing in our system is like \_\_\_\_\_ing in the real world.”

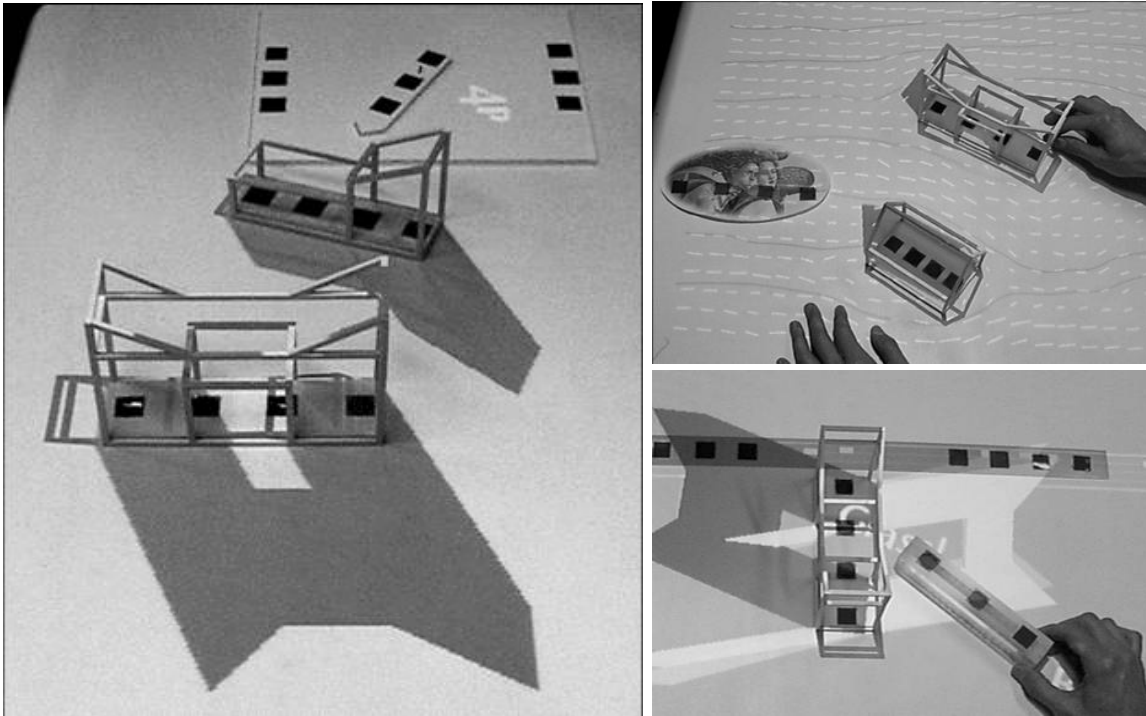


**Shakepad**

# 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

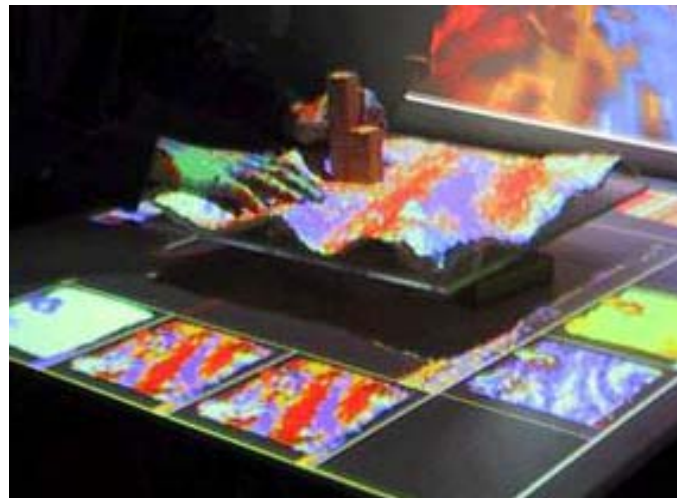
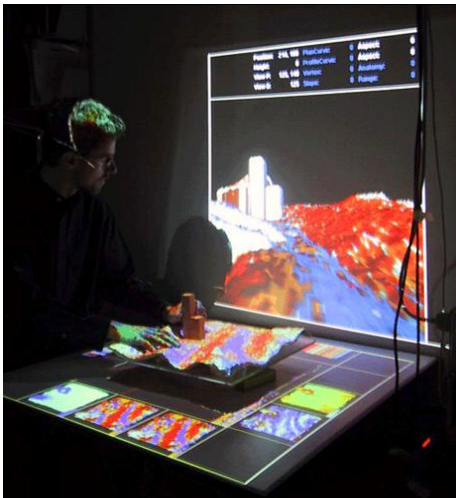
# Full Metaphor

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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”

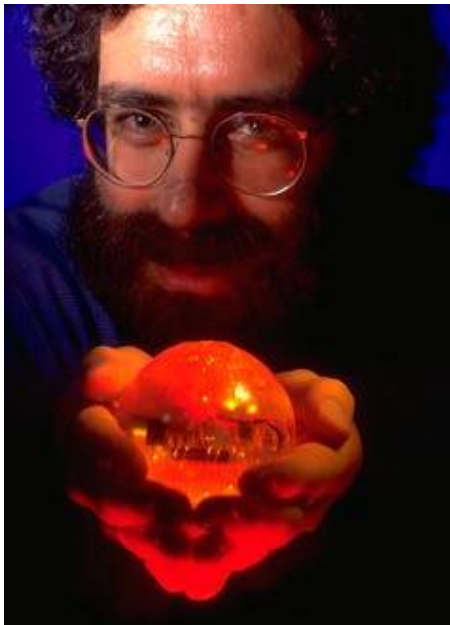


**Illuminating Clay**

# No Metaphor

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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

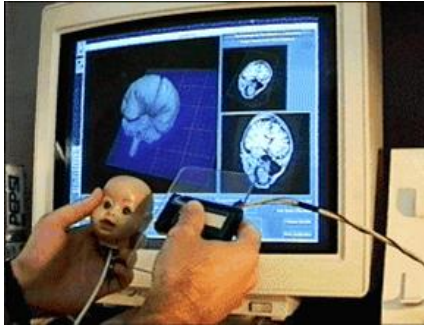
Noun, verb, noun & verb, full, none

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

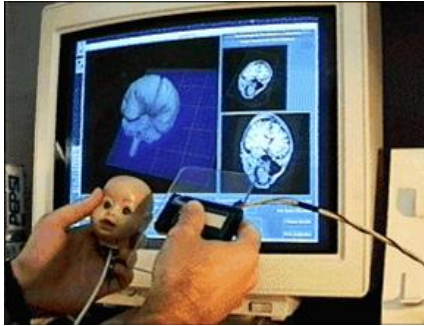


Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ- ment					
Distant					



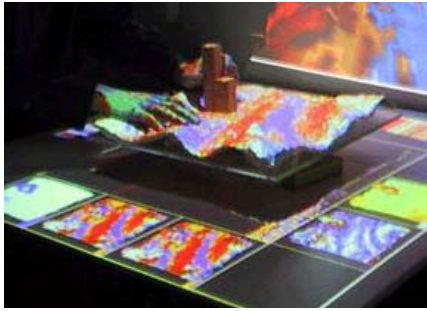
**Doll's Head**

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					



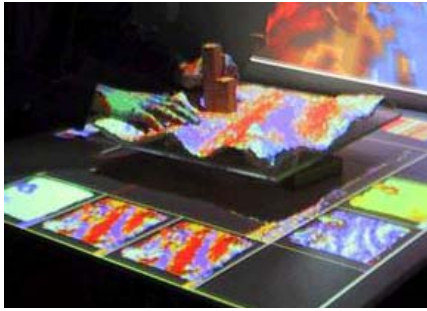
**Doll's Head**

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
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Distant					

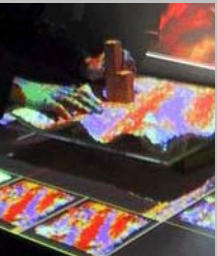



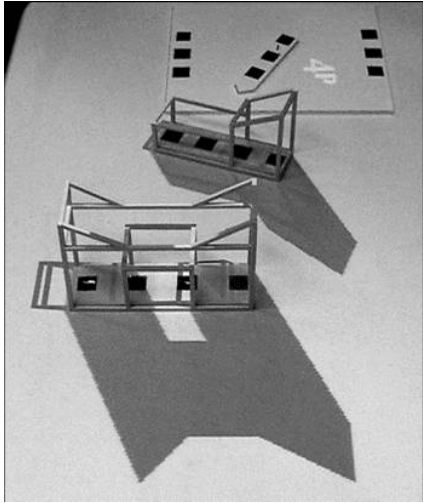
## Illuminating Clay

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

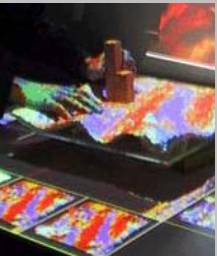



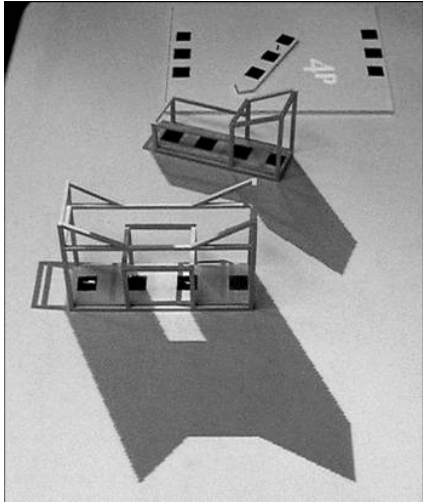
## Illuminating Clay

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Full					
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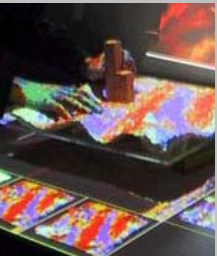
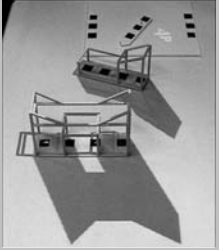



**Urp**

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

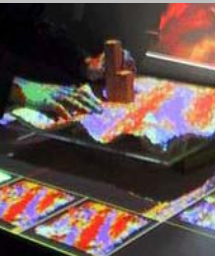



**Urp**

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
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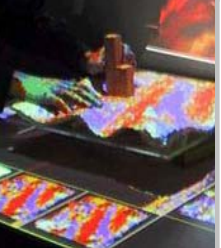
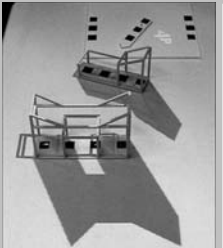

**Gummi**

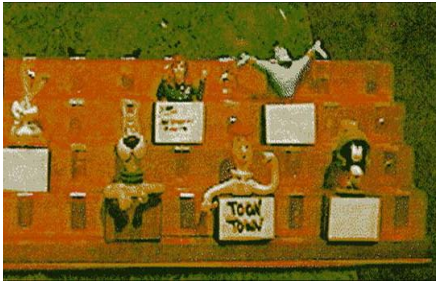
Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environ- ment					
Distant					




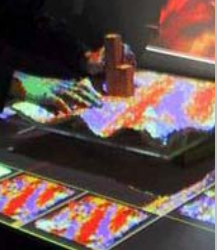
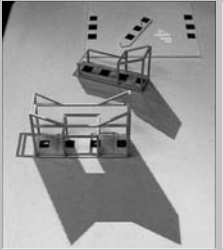



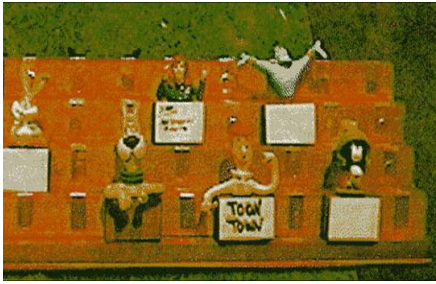
**Gummi**

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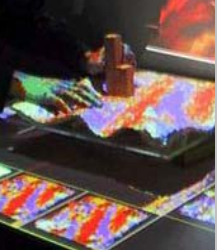
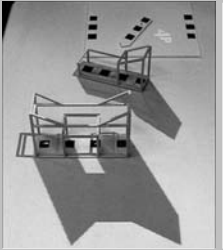
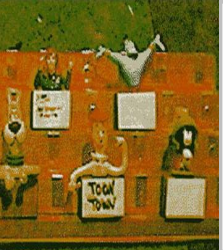



# ToonTown

Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					




# ToonTown

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



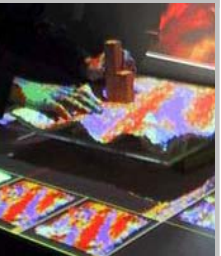
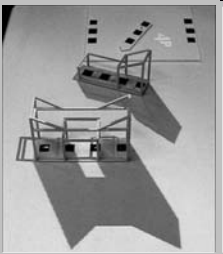
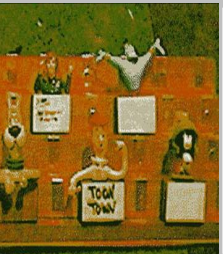



**Shakepad**

Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					



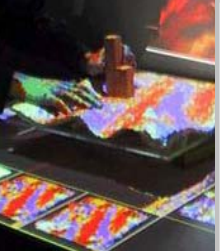
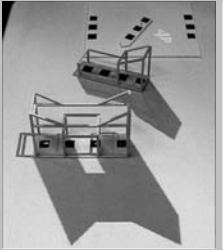
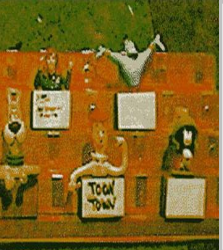


**Shakepad**

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




**BitBeads**

Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					







**BitBeads**

Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					









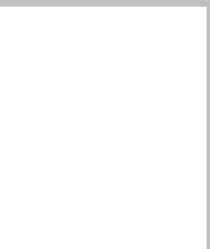
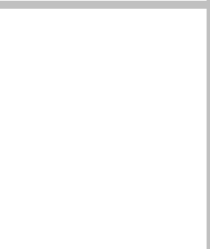
**I/O Brush**

<p>Metaphor</p> <p>Embodiment</p>	<p>None</p>	<p>Noun</p>	<p>Verb</p>	<p>Noun and Verb</p>	<p>Full</p>
<p>Full</p>					
<p>Nearby</p>					
<p>Environment</p>					
<p>Distant</p>					





**I/O Brush**

<p>Metaphor</p> <p>Embodiment</p>	<p>None</p>	<p>Noun</p>	<p>Verb</p>	<p>Noun and Verb</p>	<p>Full</p>
<p>Full</p>					
<p>Nearby</p>					
<p>Environment</p>					
<p>Distant</p>					



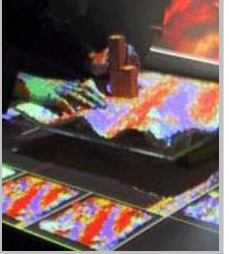

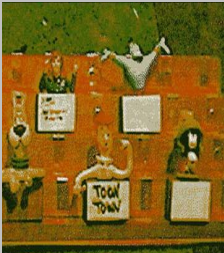

# Industrial Design Examples

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Joystick, car seat button, **dance dance revolution**, Wii.

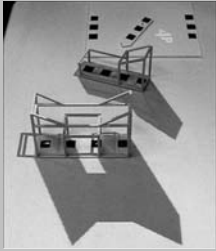



**Wii**

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					



**Wii**

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					

# Utility of the Taxonomy

Embodiment and metaphor

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Taxonomy as a tool for understanding the design space

# Evolution of the Field

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Tools for children's storytelling.

# Tangibles for Kids



StoryMat (1999)


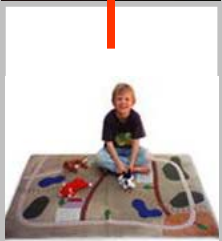


Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					

# Tangibles for Kids



**Curlybot (2000)**




Metaphor					
Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					



# Tangibles for Children



**Topobo (2004)**

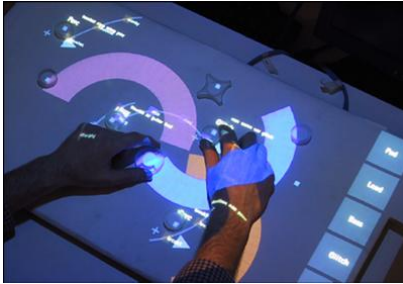
Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					

# Evolution of the Field

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Workbenches

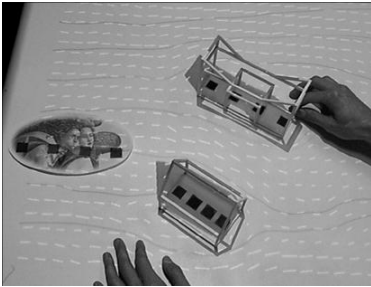
# Workbenches



**AudioPad**

Metaphor		None	Noun	Verb	Noun and Verb	Full
Embodiment						
Full						
Nearby						
Environment						
Distant						

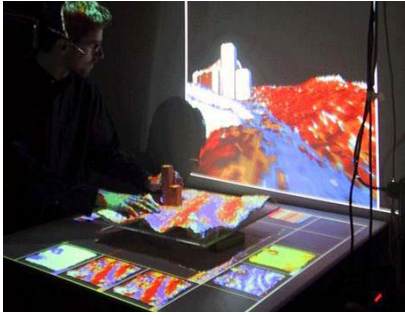
# Workbenches



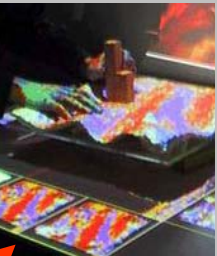
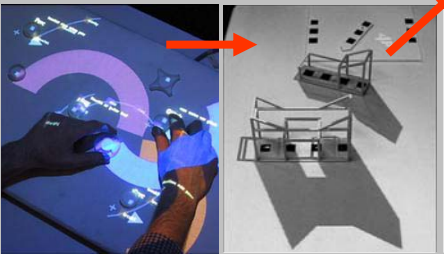
Urp

Metaphor					
	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					

# Workbenches



Illuminating Clay

Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					





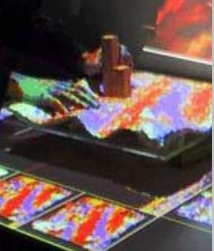

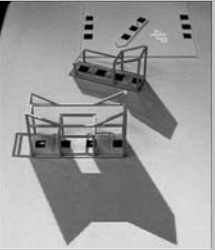






# Unexplored Territories?

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Any gaps?

Any other ideas?

# Unexplored territories?

Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full					
Nearby					
Environment					
Distant					

# Containers, Tools, Tokens

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## 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			<h1>Containers</h1>		
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			Containers		
Nearby	Tools				
Environment		Tokens		Tokens	
Distant					

**Again: Any unexplored territories?**

Metaphor Embodiment	None	Noun	Verb	Noun and Verb	Full
Full				<b>Containers</b> 	
Nearby	<b>Tools</b>				
Environment		<b>Tokens</b>			<b>Tokens</b>
Distant					

# For Thursday

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- Download and install Processing from [processing.org](http://processing.org)
- Brighter red LEDs are here
- Office hours today, 3:30-4:30pm

# Thanks!