

week

04 A decorative graphic consisting of two rows of squares. The top row has 12 squares, starting with yellow and followed by a red square, then 11 light blue squares. The bottom row has 12 squares, starting with yellow and followed by a light blue square, then 11 more light blue squares.

Taxonomy of TUIs

Tokens, tools, and containers

Lecture Outline

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

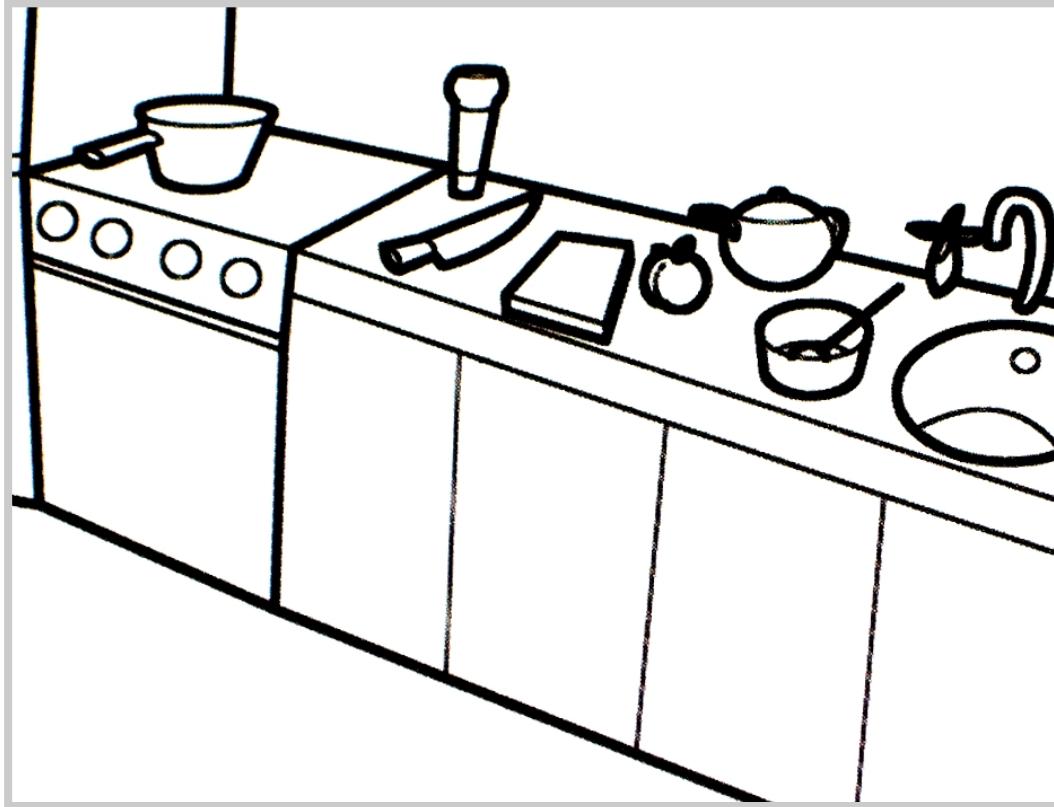
Physicality of Objects

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

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

Self-Evident Objects

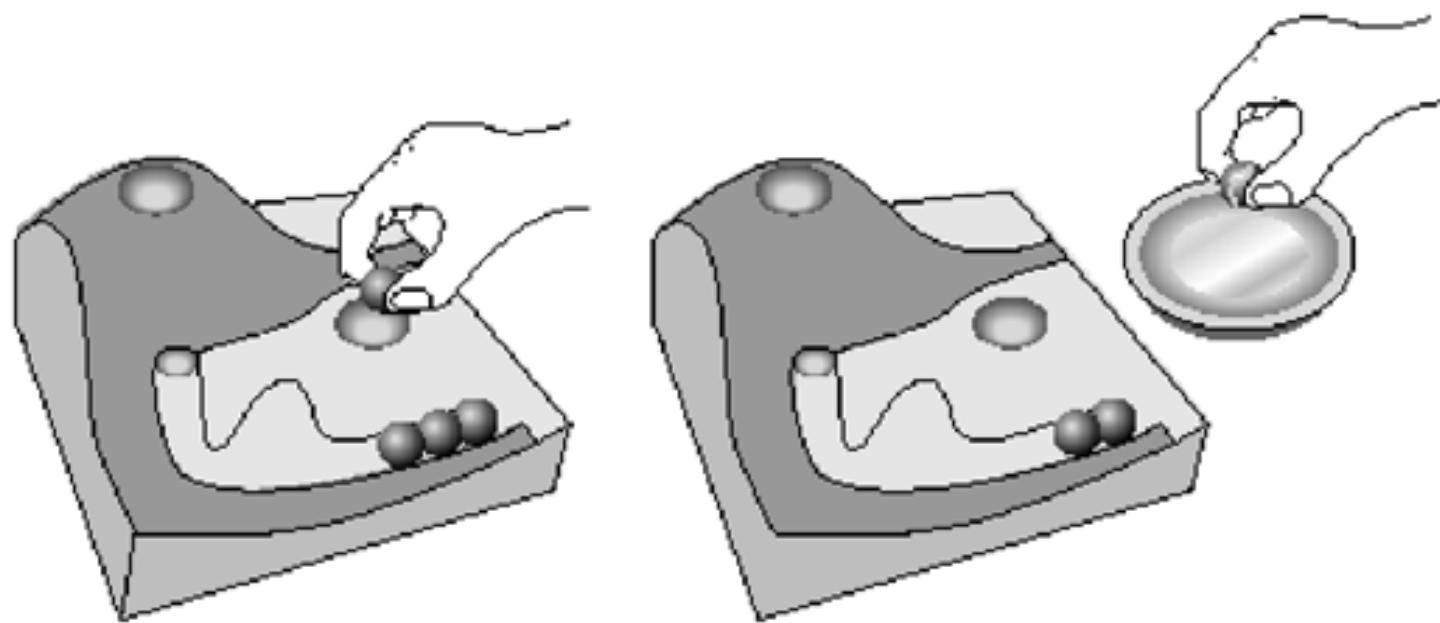
[Durrell Bishop, 2006]



When you see the object, it reminds you of what it does.

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

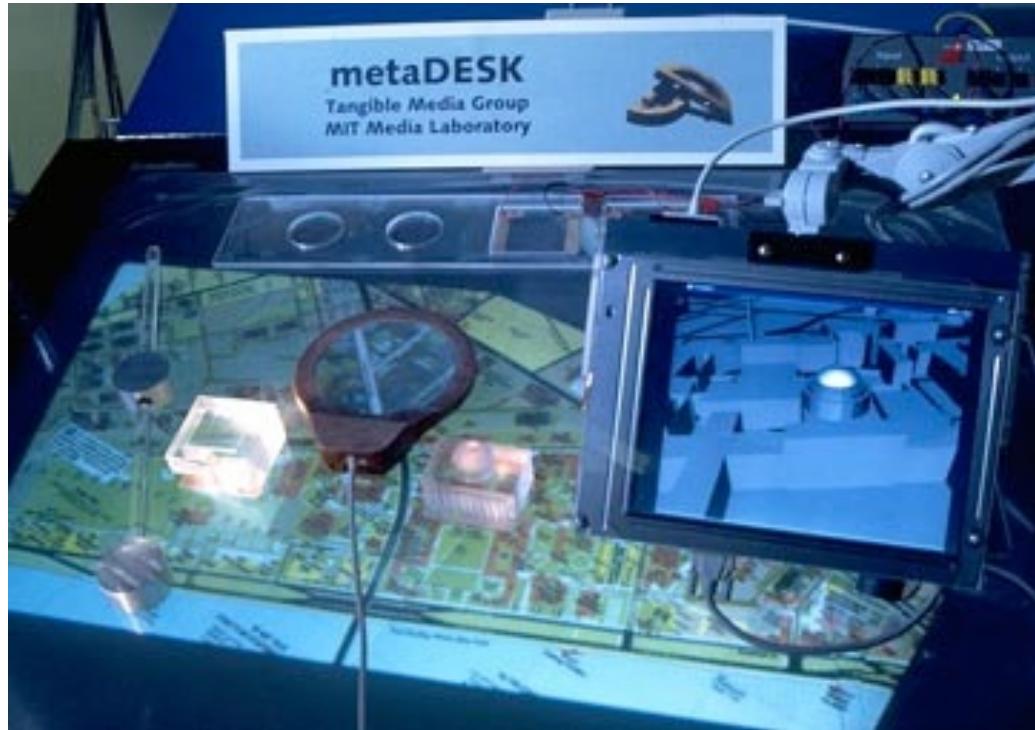
Tokens

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

Tokens, Container, and Tools

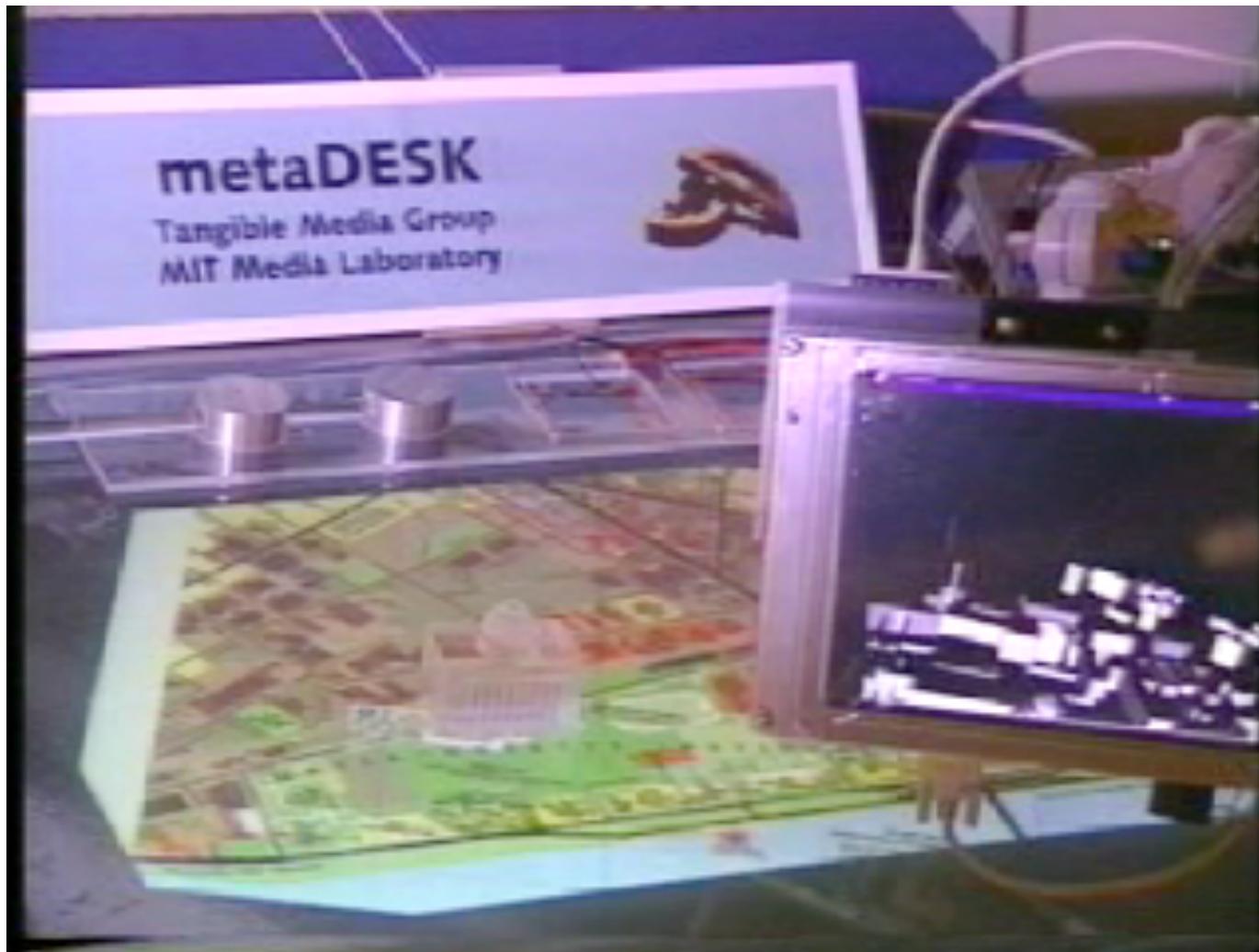
Tokens

Example: metaDESK (Ishii & Ullmer, 1997)



Tokens, Container, and Tools

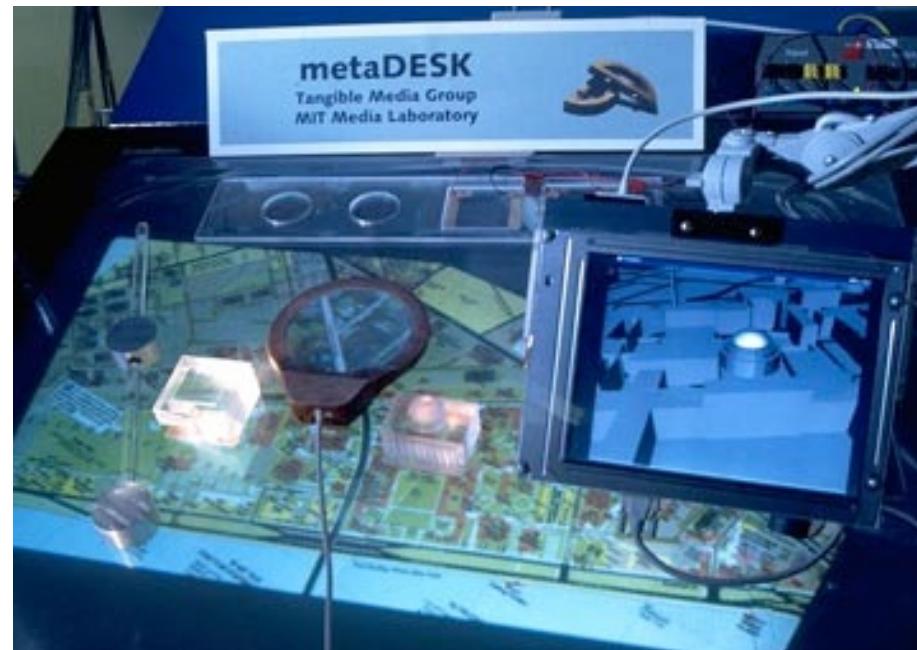
Tokens



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

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.



Apptivity by Mattel



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

Tools

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



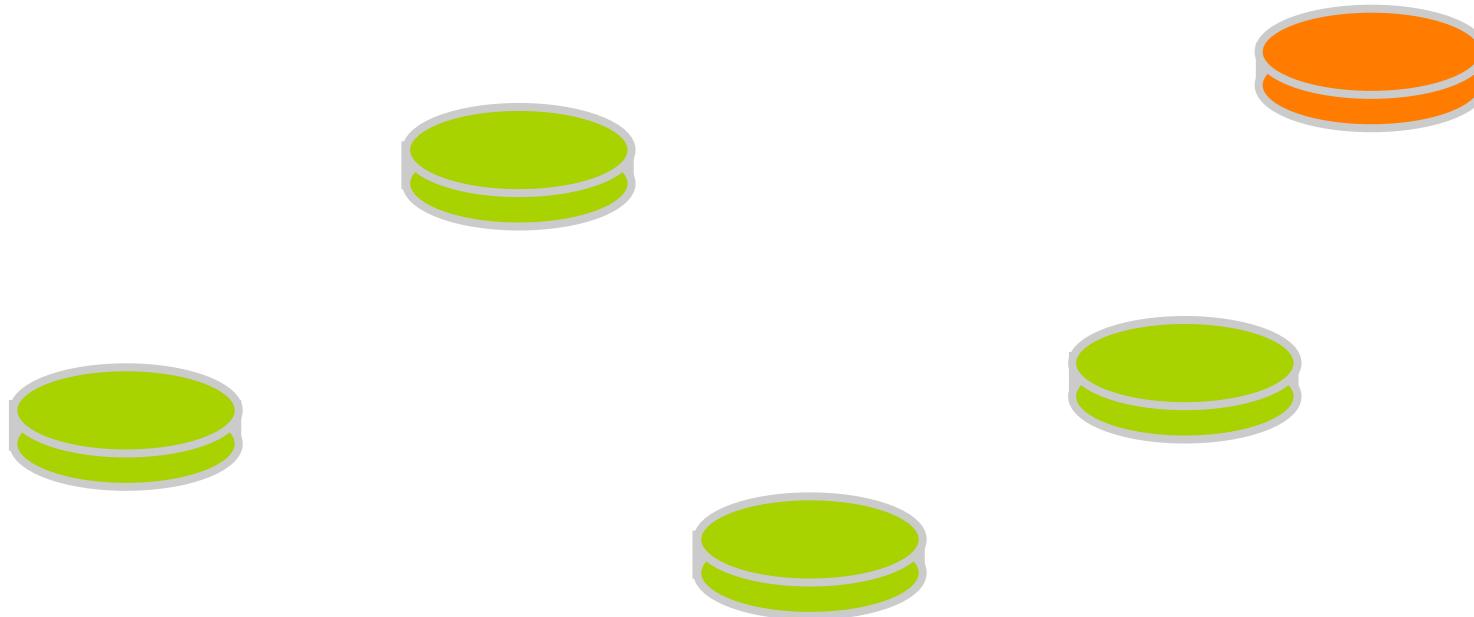
Token-Based Access to Digital Information

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

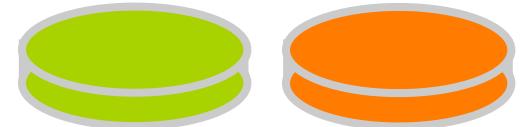
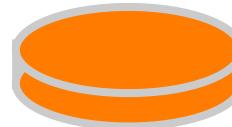
Restrict access via allowing only one instance of a token.



Token-based access to digital information

Access: Combination

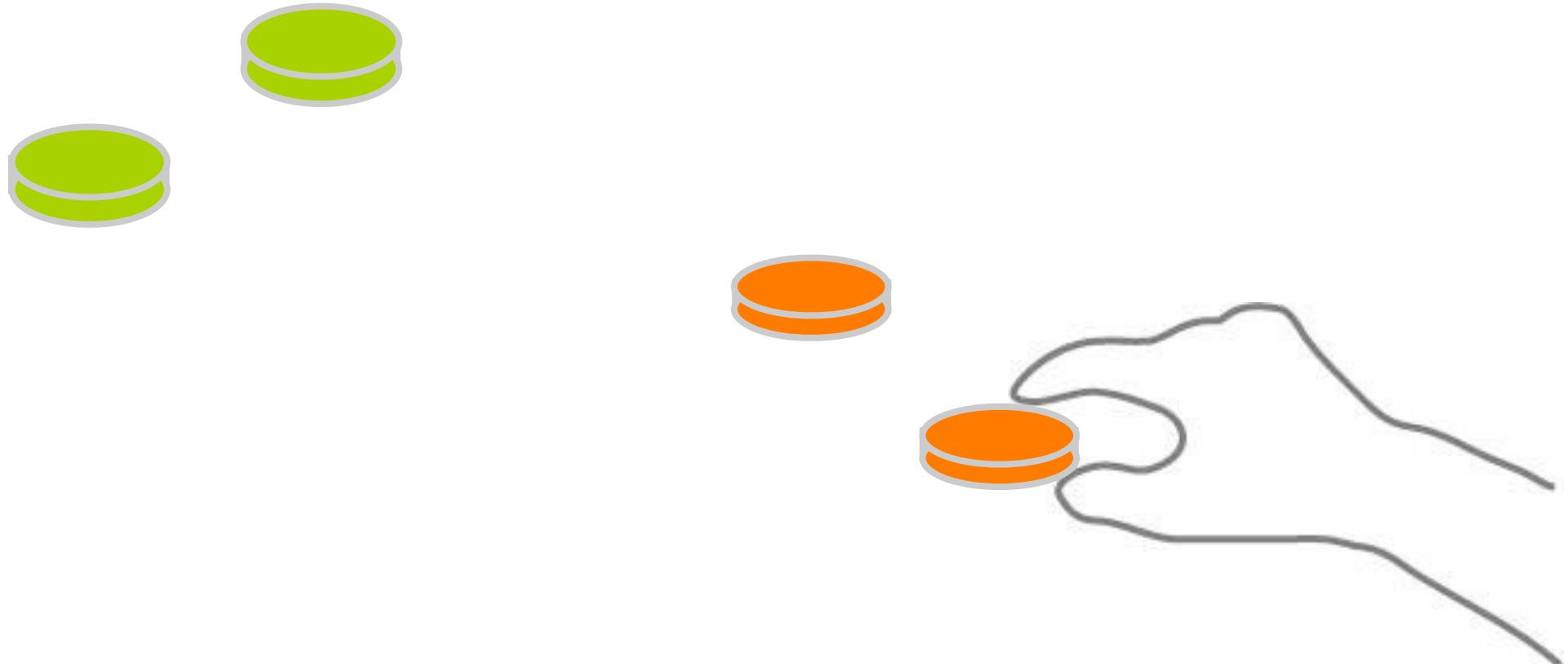
Combination of tokens for accessing information associated with all the tokens simultaneously.



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.

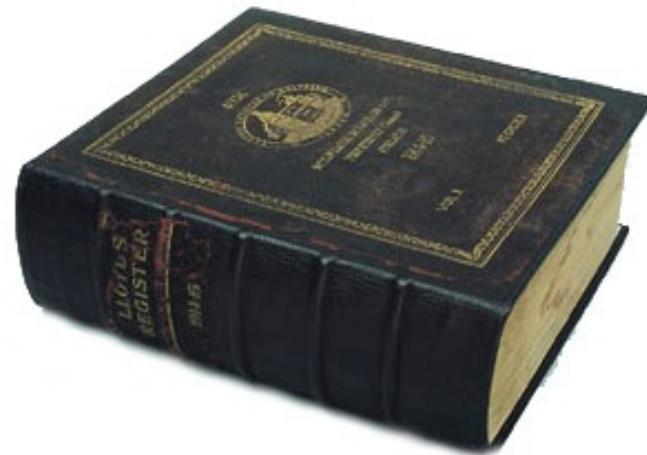


Designing Token-Based Interactions

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.

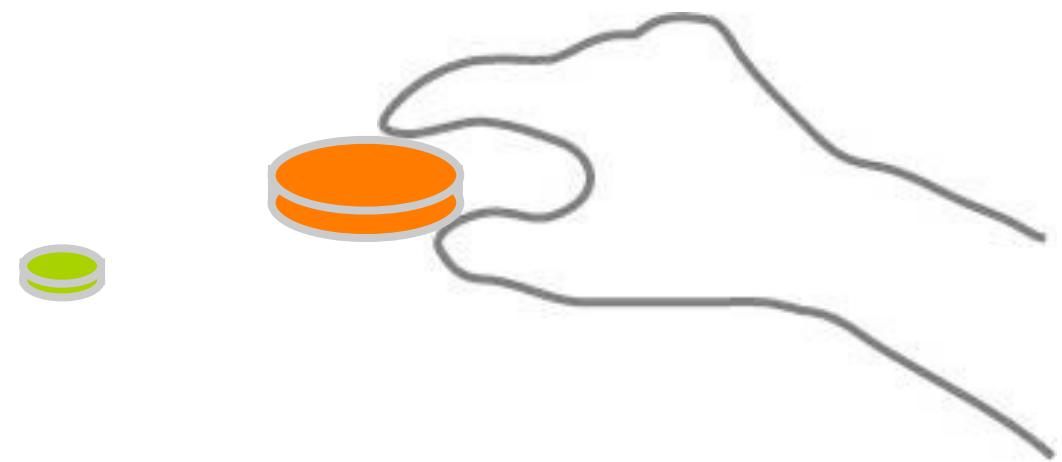
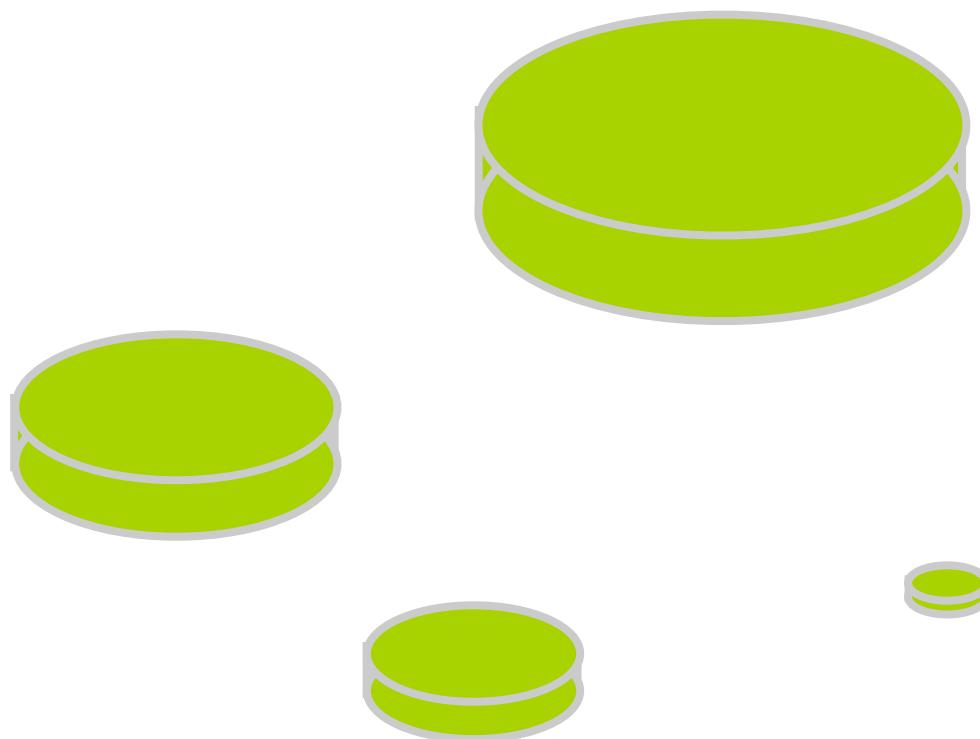
Materials

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



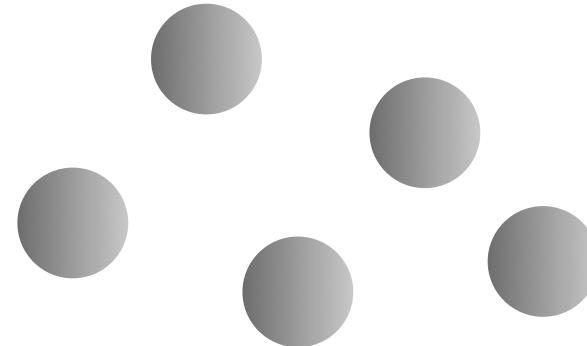
Sizes

Graspable, fit in pocket, etc.



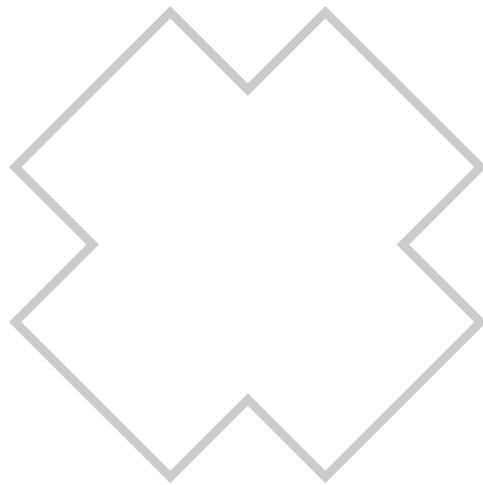
Shapes

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 normal context can change their “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 monitor



Hinckley et al. (1994)

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

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

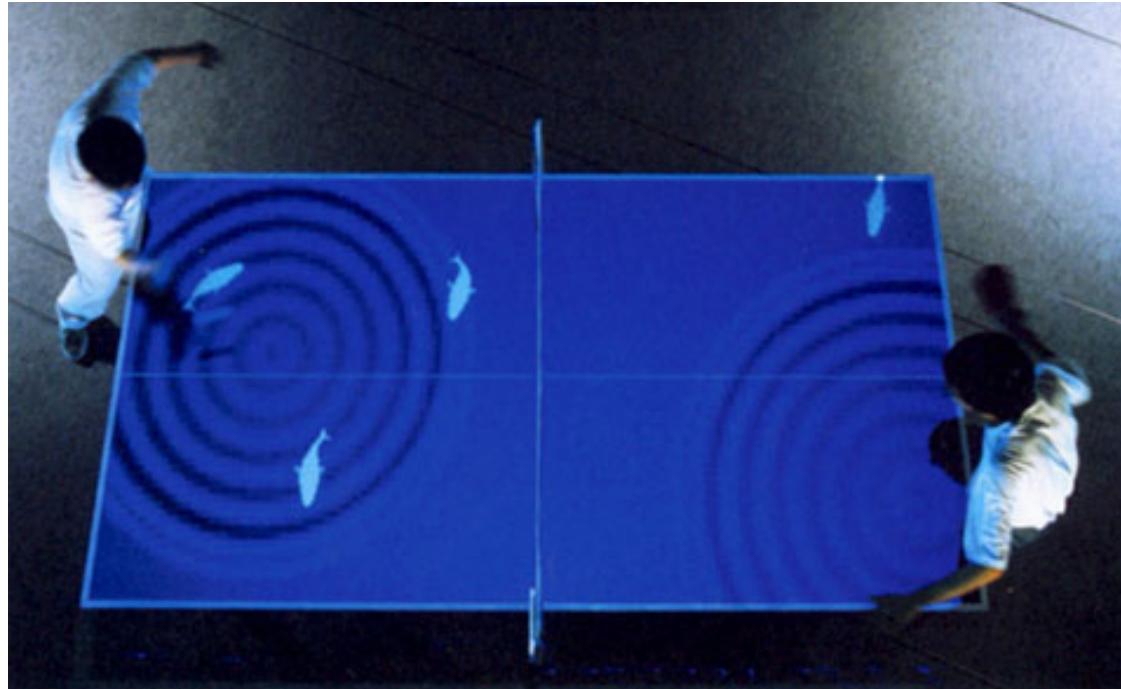


Gummi



Nearby Embodiment

The output is tightly coupled to the focus of the input



Ping Pong Plus

Nearby Embodiment

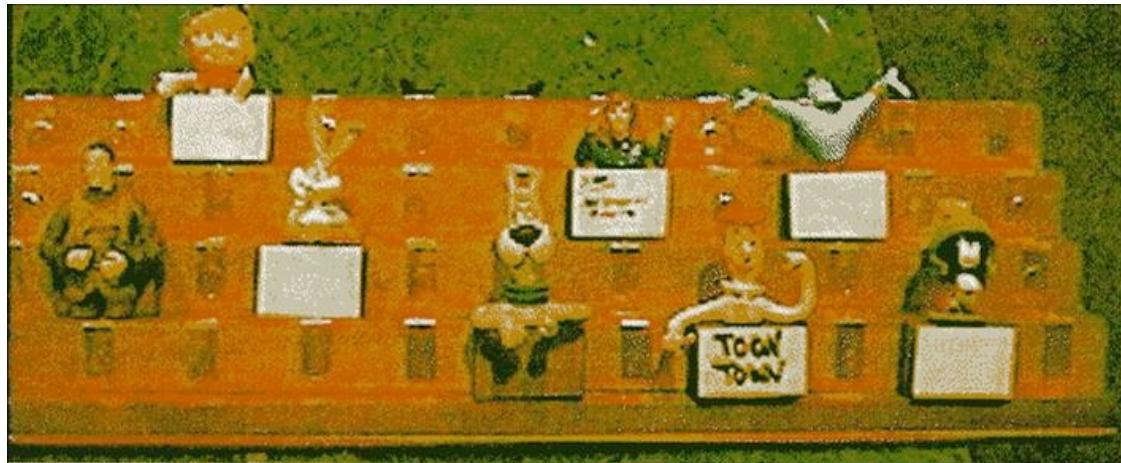
The output is tightly coupled to the focus of the input



Ping Pong Plus

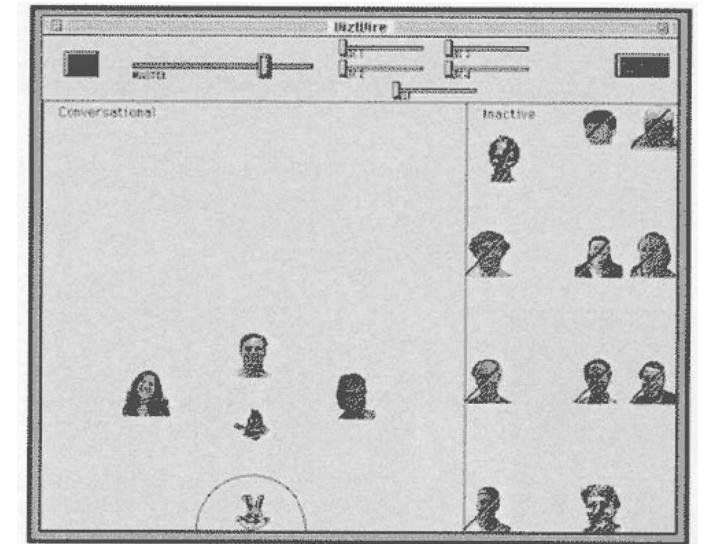
Environmental Embodiment

The output is “around” the user



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

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



Doll's Head

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

Metaphor

Noun, verb, noun & verb, full, none

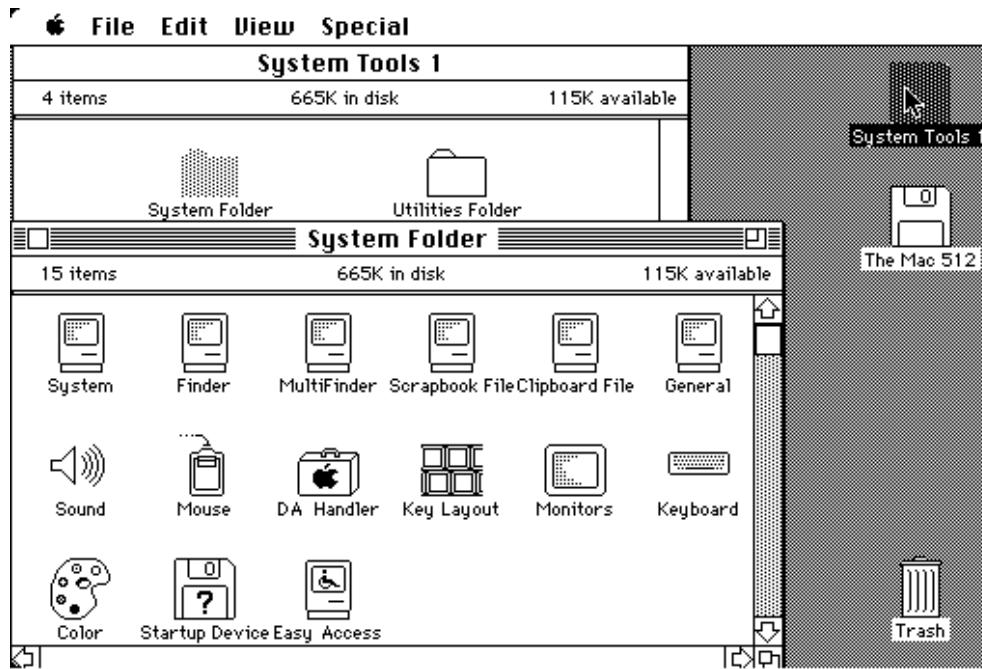
Metaphor as a powerful ingredient in thought and design. May be particularly appropriate for TUIs due precisely to their physical tangibility.

Noun Metaphor

“A _____ in our system is like a _____ in the real world.”

Object **looks like** the real thing.

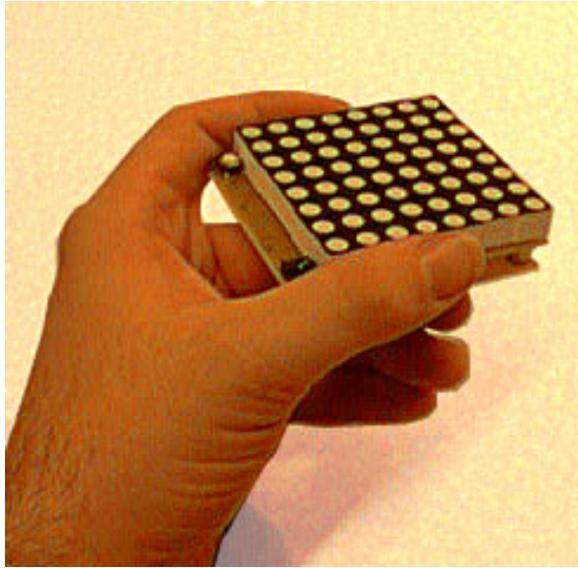
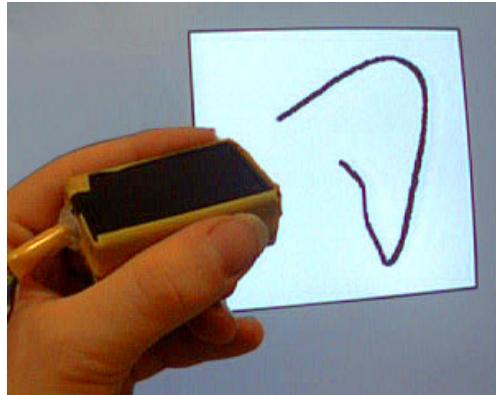
However, the actions employed on/with that object are either not analogous or only weakly.



Verb Metaphor

Object **acts like** the real thing.

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

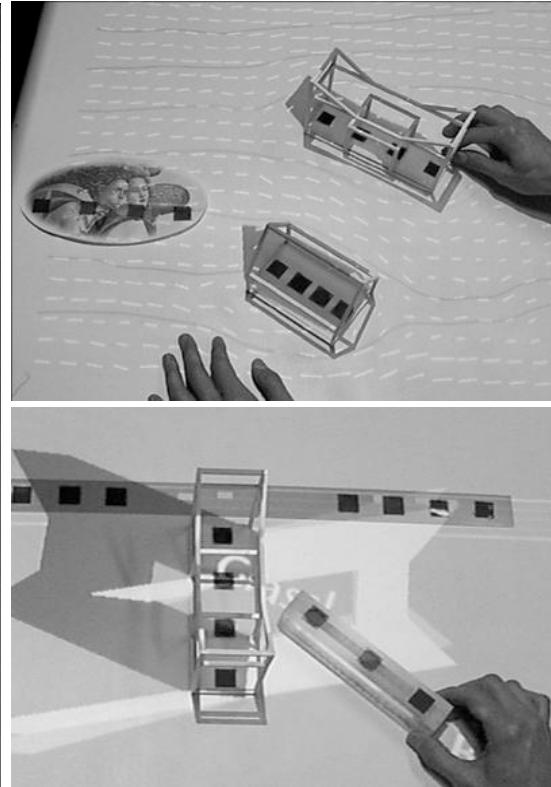
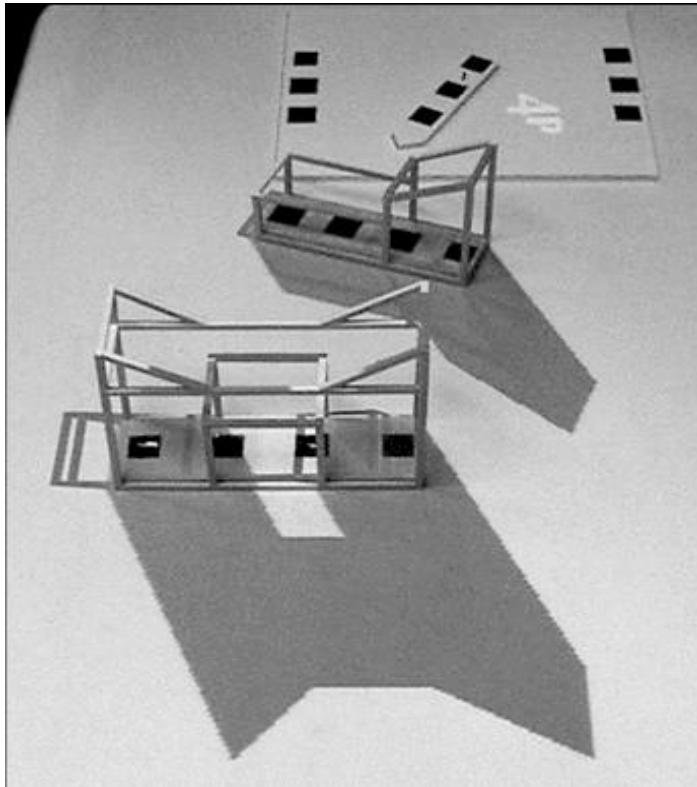


Shakepad

Noun & Verb Metaphor

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

Based on both the noun and verb metaphors.



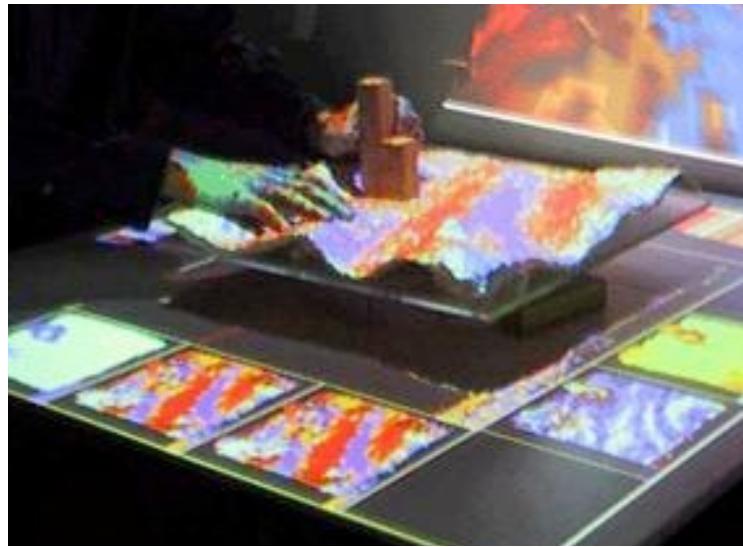
Urp

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.

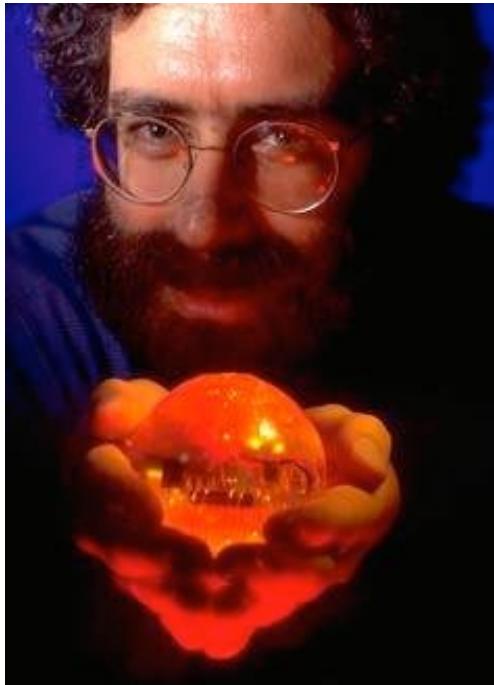
“Really Direct Manipulation”



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



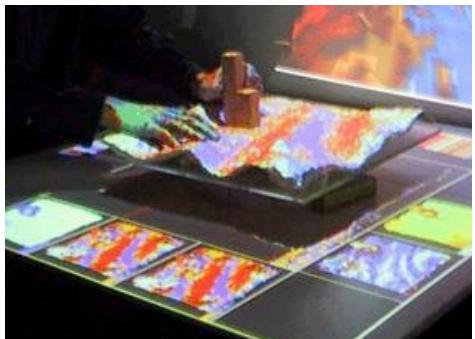
Doll's Head

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



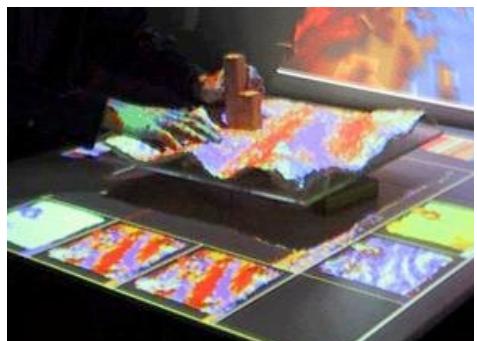
Doll's Head

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					A photograph showing a close-up of a person's hand holding a small, pale, realistic-looking doll head. The doll head is connected to a small electronic device with wires. In the background, a computer monitor displays several grayscale brain scan images (likely fMRI or DTI scans) arranged in a grid. The setting appears to be a laboratory or medical research environment.



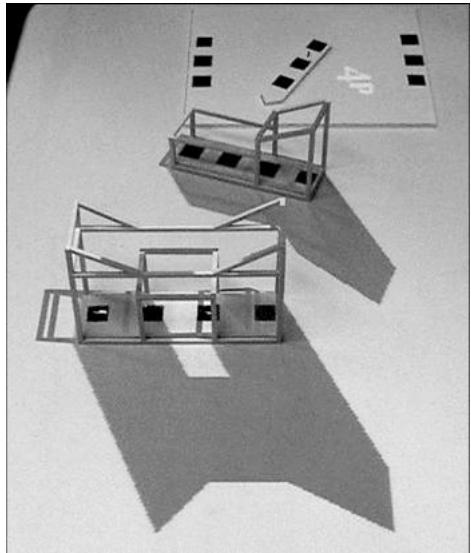
Illuminating Clay

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					A photograph showing a person's hand holding a small clay head. In the background, a computer monitor displays several grayscale brain scan images (likely fMRI or CT scans) arranged in a grid.



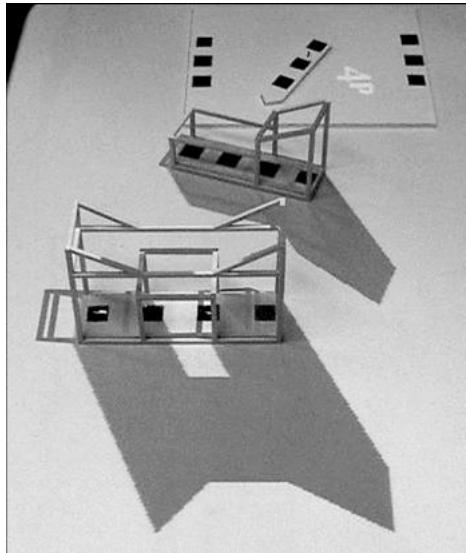
Illuminating Clay

Metaphor	None	Noun	Verb	Noun and Verb	Full
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Urp

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
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Distant					



Urp

Metaphor	None	Noun	Verb	Noun and Verb	Full
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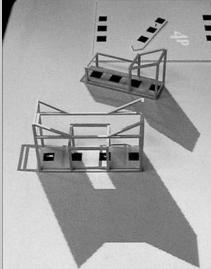
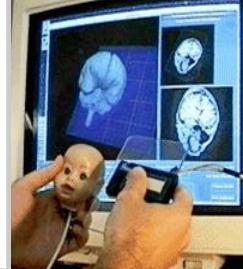


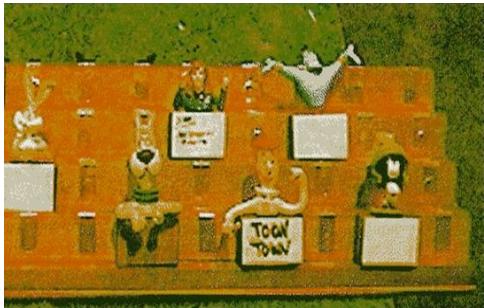
Gummi

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					A photograph of a person's hands interacting with a large, multi-touch table. The table has a grid-like pattern of colored squares (red, orange, yellow) across its surface. A small brown object, possibly a stylus or a piece of candy, sits on the table. The background shows some blurred lights and equipment.
Nearby				A 3D rendering of a small, white, open-frame vehicle or robot. It has two black wheels and is positioned on a track with black and white striped barriers. The vehicle is shown from a slightly elevated angle, casting a shadow.	
Environment					
Distant				A photograph of a person's hands interacting with a computer monitor. The monitor displays several grayscale brain scan images, likely fMRI or CT scans, arranged in a grid. The person is holding a small, white, head-shaped object, possibly a stylus or a prop, near their face.	



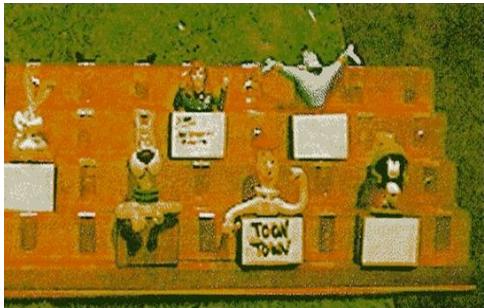
Gummi

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



ToonTown

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

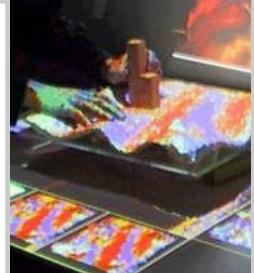
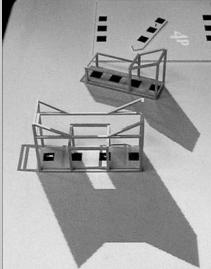


ToonTown

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

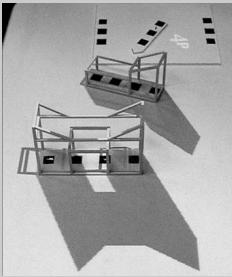


Shakepad

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

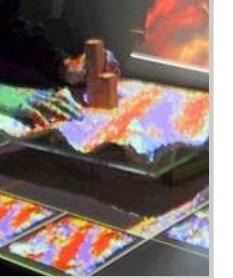
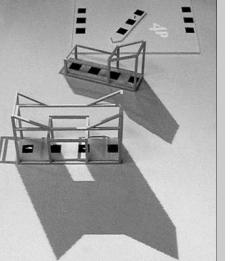
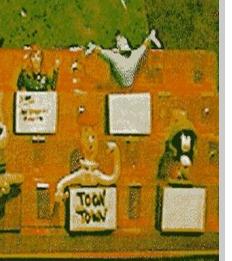
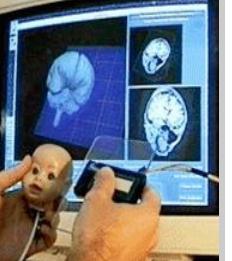


Shakepad

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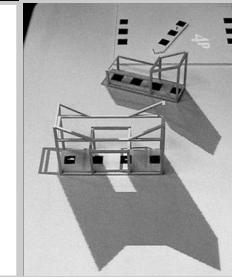
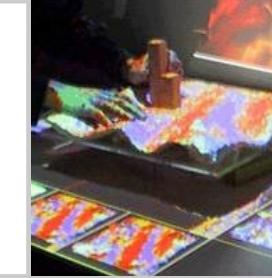


BitBeads

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



BitBeads

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



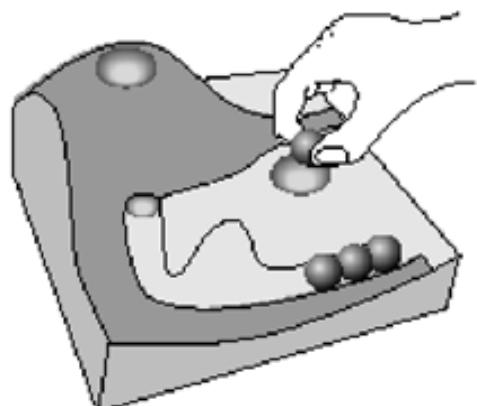
I/O Brush

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



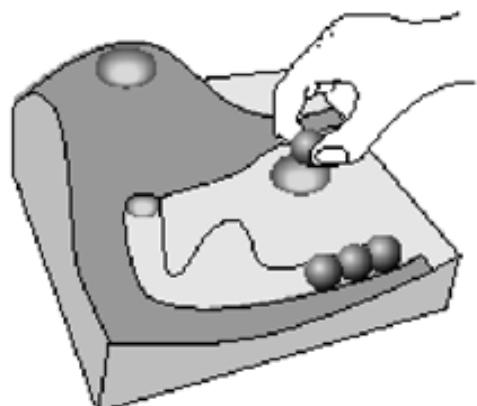
I/O Brush

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



Marble Answering Machine

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



Marble Answering Machine

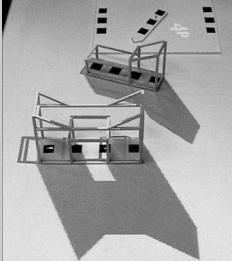
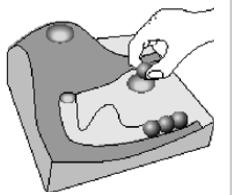
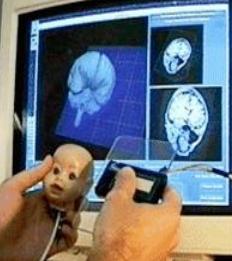
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Embodiment /					
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Industrial Design Examples

Joystick, dance dance revolution, and Wii?

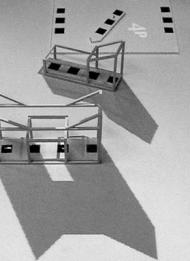
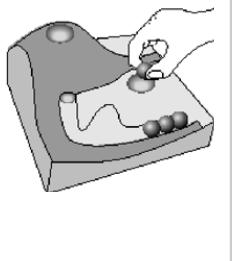


Wii

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

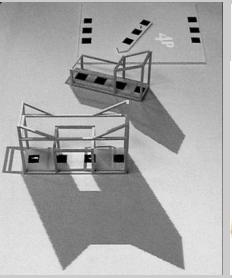
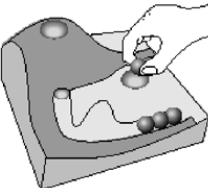


Wii

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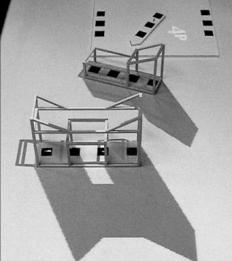
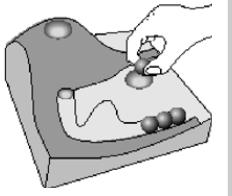


Kinect

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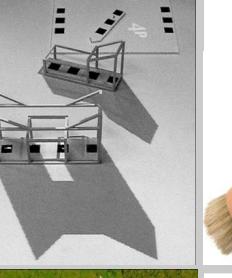
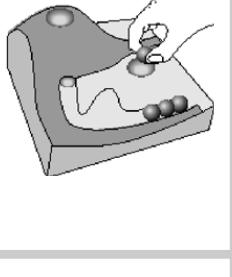


Kinect

Metaphor \\	None	Noun	Verb	Noun and Verb	Full
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Distant			 	 	

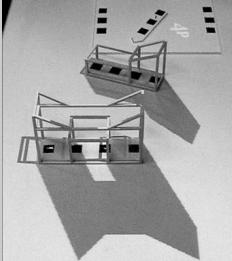
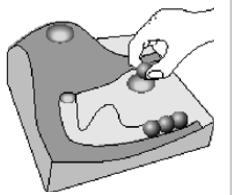
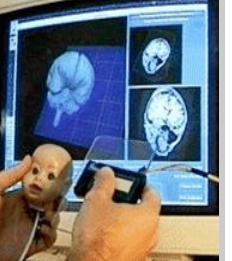
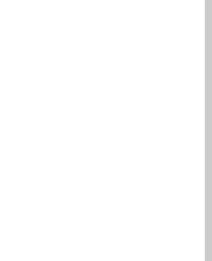


**multi-touch tablet
running a
water simulation**

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



**multi-touch tablet
running a
water simulation**

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



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

Tangibles for Kids



Curlybot (2000)

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					A photograph of a child sitting on a mat, playing with a toy train set. A red arrow points upwards from this cell towards the 'Full' row.
Environment					
Distant					

Tangibles for Children



Topobo (2004)

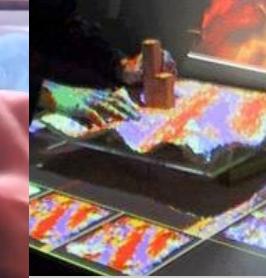
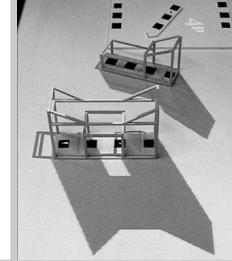
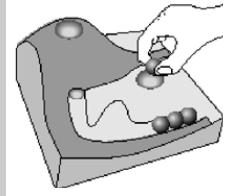
Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment					
Full					
Nearby					
Environment					
Distant					

Unexplored Territories?

Any gaps?

Any other ideas?

Unexplored territories?

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

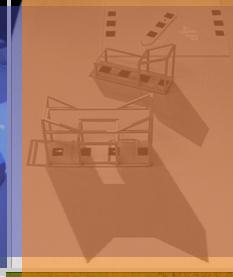
“Objects that physically resemble the information they represent.” This is analogous to our metaphor of noun.

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

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

Metaphor	None	Noun	Verb	Noun and Verb	Full
Embodiment	Full				
				Containers	
Nearby	Tools				
Environment		Tokens			Tokens
Distant					

Again: Any unexplored territories?

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