

#5 Human-Computer Interaction



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Outline

- Previous lectures:
 - What is HCI & HCI framework
 - Design, HCI artifacts, design thinking, and design methodologies
 - Modeling: cognition, mental, conceptual, activities, prototyping
 - Design principles
- This lecture:
 - More design and cognition:
 - Semiotics
 - Representations
 - How designing things in the external world influences the way we think

Design

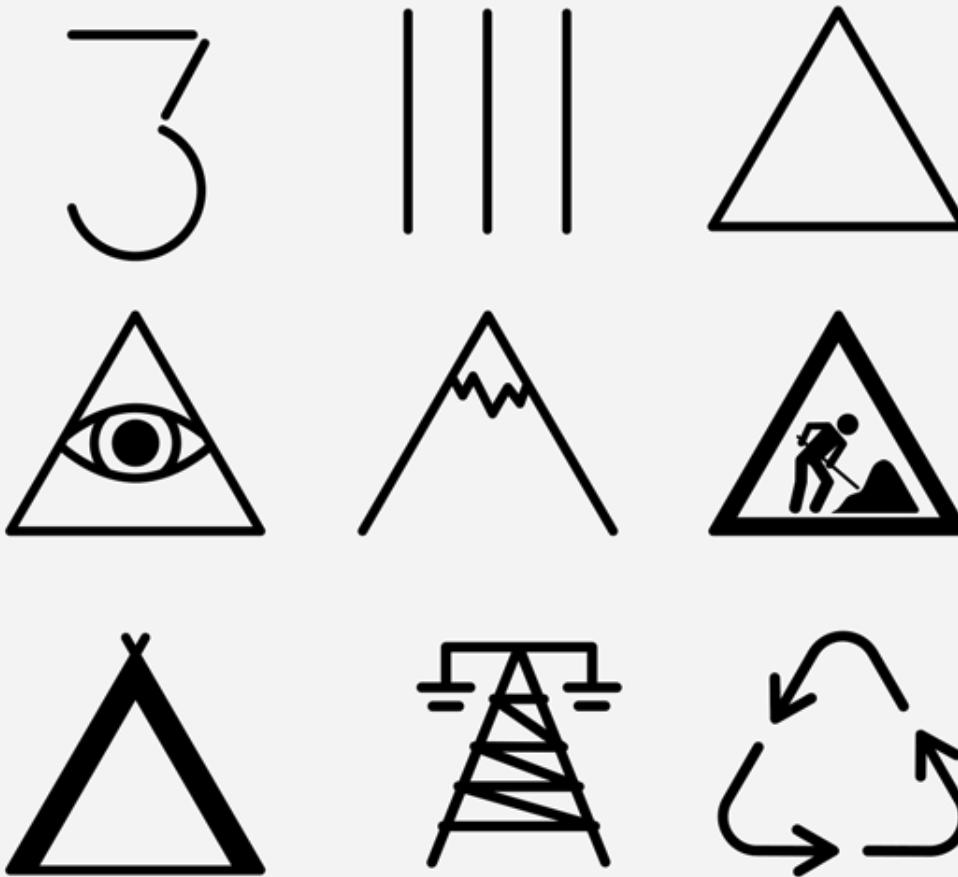
Design is the process by which a **designer** creates an **artifact** to be encountered by **users** in some **context**, engagement with which results in **meaningful experience** as well as **activity (utility & efficacy)**

- engagement: physical, emotional, and/or cognitive
- meaningful experience: interactions that are perceived and integrated
- activity: interactions support desired goals/tasks/activities in an appropriate way

Design: Further Analysis

- We are designing meaning/experience/feeling and cognition/activity
- Not directly—but through second-order design
 - We create a digital context in which these take place
 - Experience, meaning-making, thinking, and action take place from one moment to the next in some space
 - Space can be internal (mental) or external (physical)
- Hence, we need to know about **semiotics—signs and meaning**

Semiotics



https://cdn.dribbble.com/users/672541/screenshots/3332839/dribbble_semiotic_icons_three.gif

What is semiotics?

What is
Semiotics?



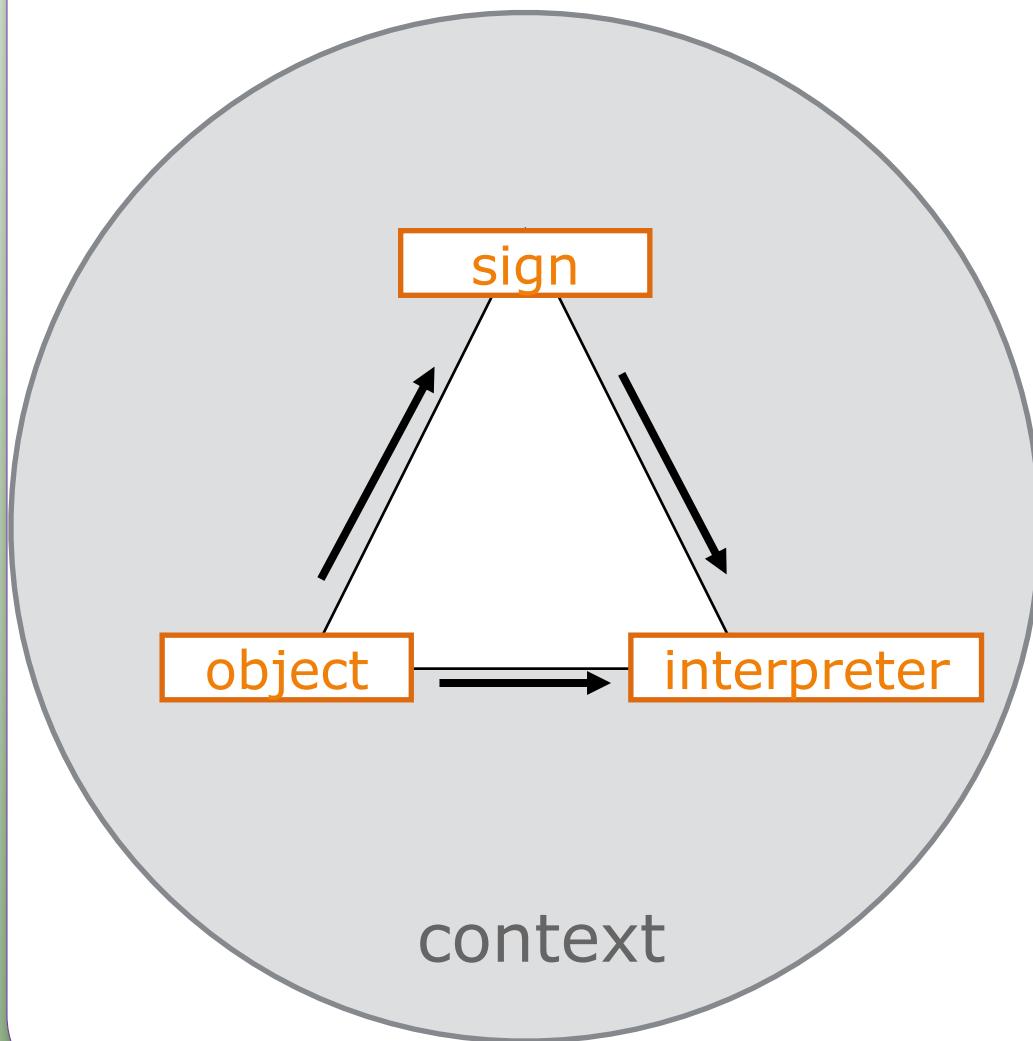
<https://www.youtube.com/watch?v=R7VA95JdbMQ>

Also see: <https://www.youtube.com/watch?v=aGYOHKCigAo>

And: http://www.youtube.com/watch?v=rEgxTKUP_WI

Semiotics

- 4 important concepts
- Sign
 - Represents, denotes, signifies something other than itself
- Interpreter
 - Signs are interpreted by someone
- Meaning
 - Results when signs are interpreted
- Context
 - Shapes how signs are interpreted



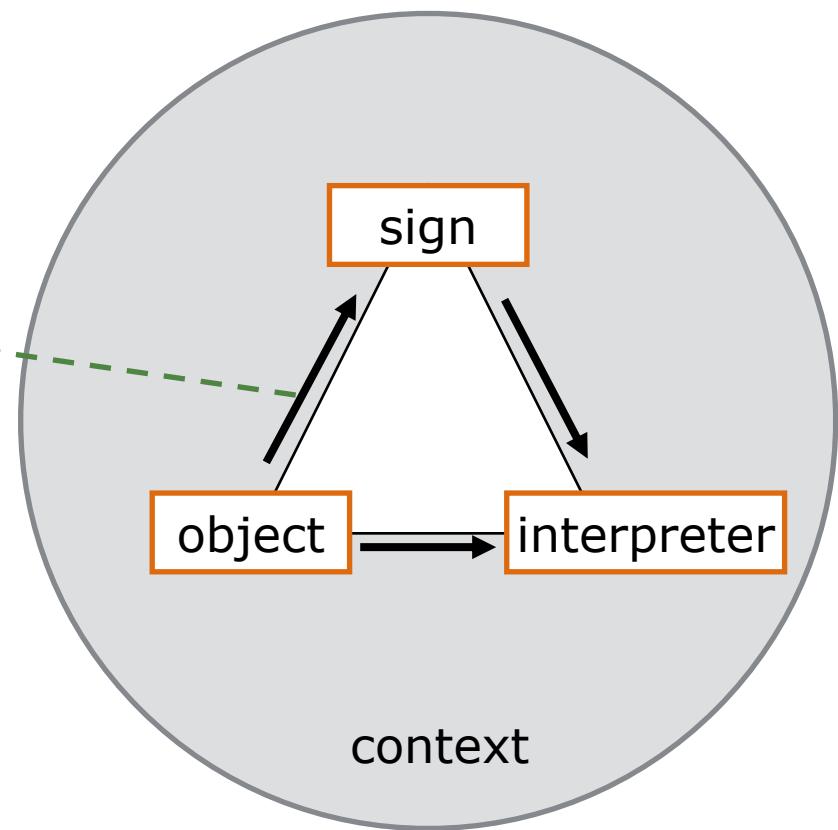
Semiotics and HCI Artifacts

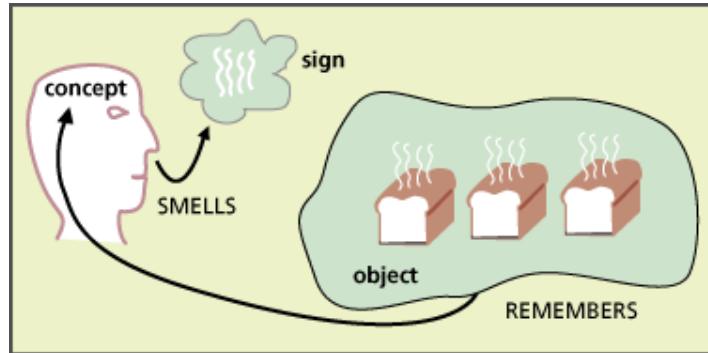
- HCI spaces are full of signs
 - Not physical spaces, but digital or virtual
- Signs represent physical and non-physical things
 - objects, places, processes, categories, events, ...
- Signs can be:
 - textual, auditory, graphical, olfactory, tactile, ...

Three types of signs

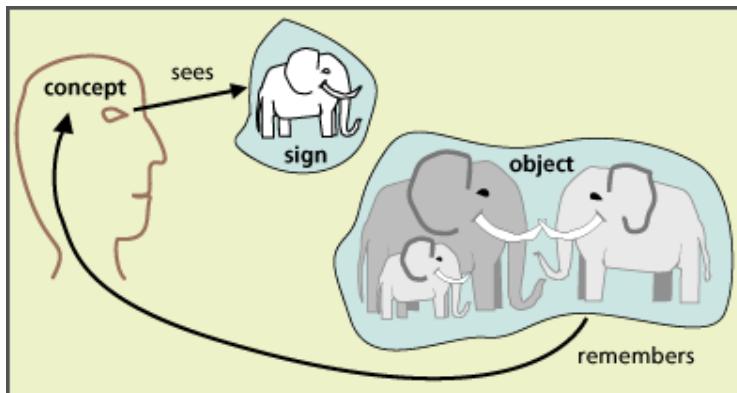
- Three types of relationships between signs and their referents (objects)

- 1. Iconic
 - Looks like object
- 2. Indexical/causal
 - Directly related to object
- 3. Symbolic/conventional
 - Arbitrary relationship

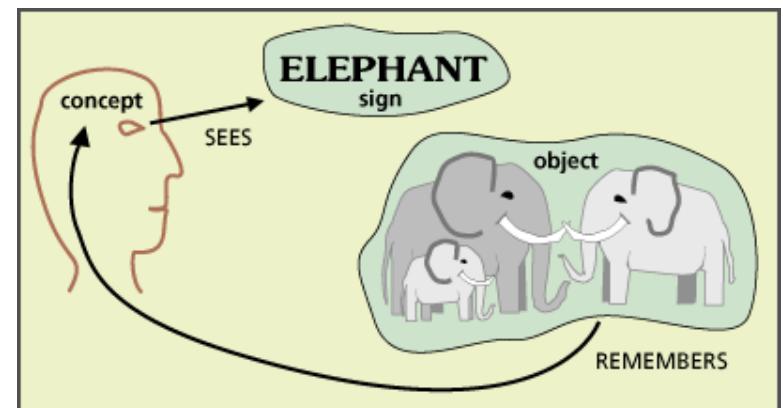




Indexical
Direct/causal connection
without resemblance



Iconic
Physical resemblance



Symbolic
Arbitrary relationship

Example

- What about this red X? What type of sign is it?



- Symbolic
 - Why?

Signs and semantics

- Signs are to be interpreted by the user
 - What sign is appropriate and how will it be interpreted?
 - Another reason why designers need to know users
- Meaning comes from interpretation of signs
- Does anything influence interpretation of signs?

Context and Meaning

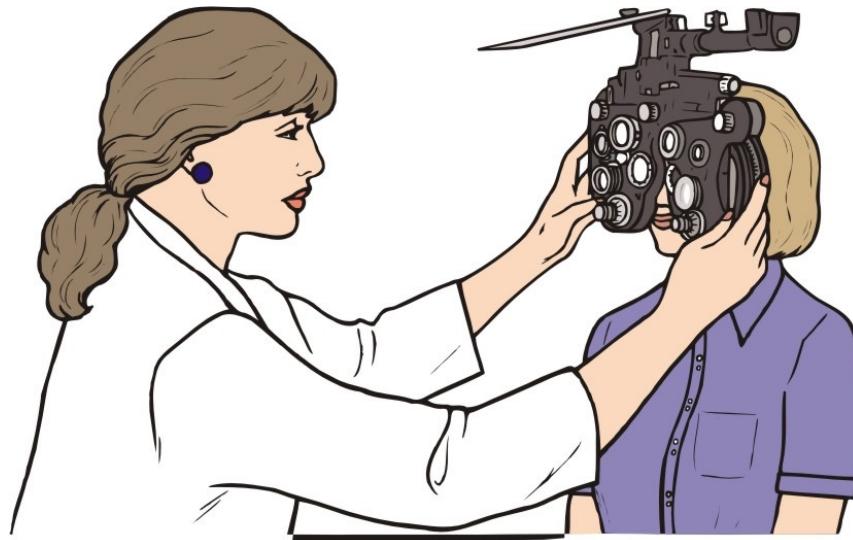
- Seeing this picture, what do you think of with the word “glasses”?



+ **glasses** = ?

Context and Meaning

- Seeing this picture, what do you think of with the word “glasses”?



+ **glasses** = ?

Signs: Context and Meaning

- Context determines how signs (especially symbolic signs) are interpreted
- Context: things, events, or space around a sign
 - It is the macro structure within which signs are interpreted
- Meaning of a sign is not in itself!
 - Depends on the surrounding system of signs of which it is a part

Semiotic Design Principle

When designing HCI artifacts,

**create a system of signs that all work
together**

to help with correct interpretation by users.

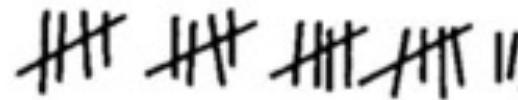
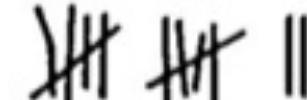
Representations

Representation

- Information is abstract and does not have concrete form
- Broadly speaking, a representation is:
 - external form of information
- We need to give a form (digital or physical) to the information we are trying to convey
- Uses and combines different “marks”, along with rules for interpreting them
 - language
 - mathematics
 - maps
 - diagrams
 - ...

Representing Numbers

- Are there differences in number systems?
 - Which is easier to compare size?
 - Which is easier to perform calculations such as addition or multiplication?

Tally Marks	 
Roman Numerals	XXIII XII
Arabic Numerals	23 12

Representing Numbers

- Tally marks & Roman numerals are additive
 - Difficult to read but size is perceived directly
- Arabic numerals are substitutive
 - Easier to read, cannot determine size perceptually

Representing Numbers

- With Arabic numerals we have to memorize the arithmetic table
 - 10 arbitrary symbols
 - place notation
 - carry from one column to another
- Roman numerals
 - 7 symbols
 - combine and reorder the symbols
 - apply simplification rules
- What about using Roman numerals for multiplication and division?

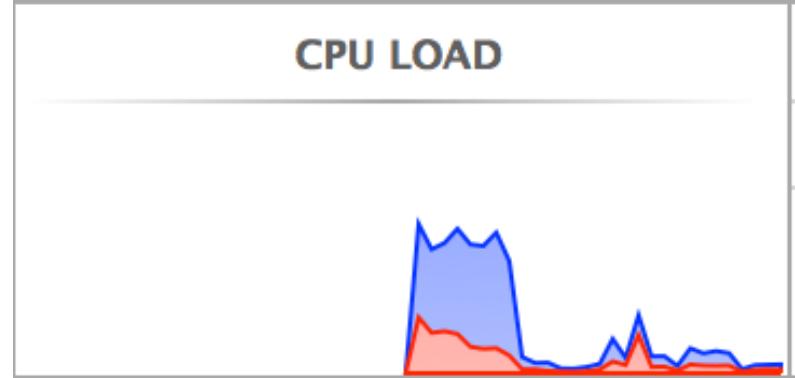
Representation design principle

- Different representations provide **trade-offs**
 - One aspect of a task can become easier while another becomes more difficult
- Tally marks are additive
 - Difficult to read but size perceived directly
- Arabic numerals are substitutive
 - Easier to read, cannot determine size perceptually

Representation must be appropriate for the task

Which is better?

System:	2.28 %
User:	2.09 %
Idle:	95.63 %



- Depends on the task
 - does user need to determine exact values?
 - does user need to see change over time?

Representation Effect

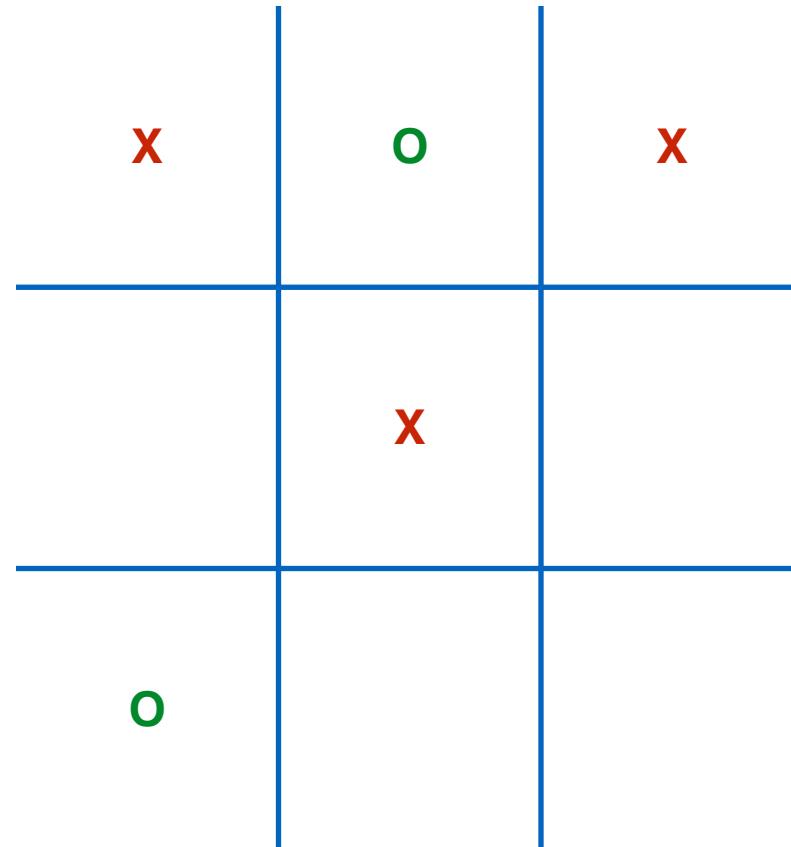
- Two representations may be informationally equivalent, but not equivalent in terms of cognitive effect/performance
 - Represent the same information
 - Differ in cognitive effort for perception and interpretation
- $IV + XI = 4 + 11$
 - Informationally equivalent, but not cognitively
- This is called the **representation effect**

Problem Representation

- Consider this simple game
- Two players: A and B
- There are 9 “pieces”: digits 1,2,3,4,5,6,7,8,9
- Each player takes a piece in turn, once a piece is taken, it cannot be taken again
- Winner is the first person who has 3 pieces that together add up to 15
 - A takes 8 then B takes 2
 - A takes 4 then B takes 3
 - A takes 5
 - What should B take next?

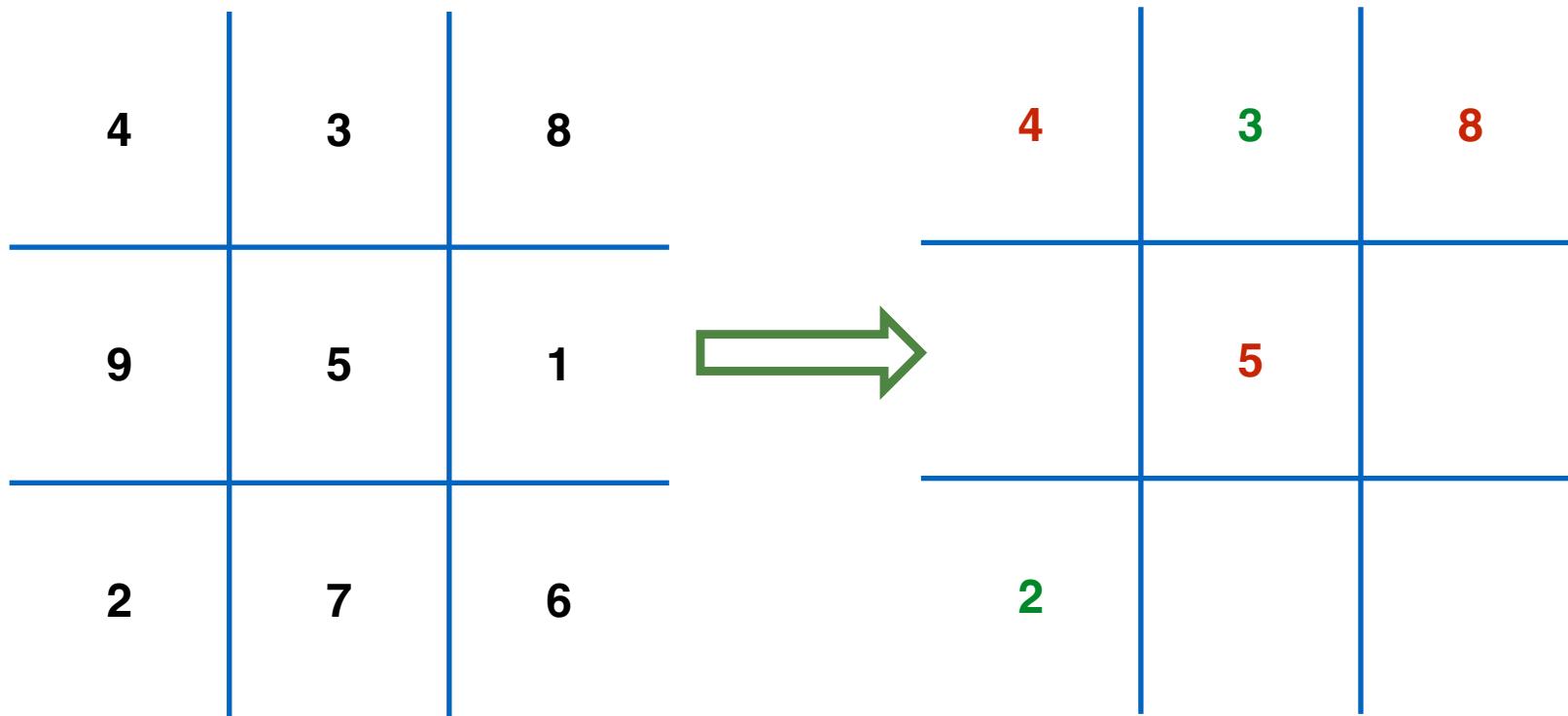
Another problem

- Anyone played this game before?
- What should “O”’s next move be?



Back to the first problem ...

- What should player B do now?



Problem Representation

- 15-puzzle and tic-tac-toe are isomorphic problems
 - Deep structure is the same; deep solution is the same; superficial aspects are different
 - When their **structures** are **represented properly**, the solution becomes apparent
- Design Lesson
 - **Representations affect how we solve problems and change the nature of our tasks and activities**
 - Without the grid, it was a memory game, but
 - With the grid, it became a territorial conflict game

“Problem solving may be the quintessential expression of human thinking. **It is required whenever there is a goal** to reach and attainment of that goal is not possible either by direct action or by retrieving a sequence of previously learned steps from memory.”

-- Committee on the Status, Contributions, and Future Directions of Discipline-Based Education Research

“Solving a problem simply means representing it so as to make the solution transparent.”

-- Herbert Simon

Representation and Cognition

- Remember distributed cognition?
- Memory, thought, and reasoning are constrained without external representational aids
 - e.g., calculator, paper and pencil, books, ...
- Representations are tools for and extensions of the mind
 - There is a primal unity of representation and what is represented, as far as human cognition is concerned
 - This is what makes representations so powerful
- We think with and through representations
 - Think of language, numbers,...

Internal and External Representations

- Internal: in the head
 - e.g., mental models



influence & reciprocity

- External: in the world
 - e.g., bar charts

Representation design principles

- Good representations aid thinking
 - e.g., help to solve a problem, to understand something, to make decisions, ...
- Bad representations can:
 - constrain thinking
 - increase cognitive load
 - lead to construction of erroneous mental models
 - lead to errors of perception and action
 - ...

Representation design framework

- How should we design representations?
- Which representation to use depends on:
 1. Users' tasks
 - e.g., comparing size or adding or ...
 2. Underlying problem/data/information
 - e.g., is it quantitative, categorical, ...?
 3. Perceptual & cognitive capabilities/limitations
 - Older people, children, university researchers, ...
 4. Context of use
 - Game, productivity tool, educational, ...
 - Culture

Representation and Cognition

- Two major tasks for many users:
 - **Finding** relevant information easily and quickly
 - **Interpreting** and computing desired conclusions

Representation and Cognition

- Remember the two modes of cognition?
- Different representations can engender these
 - **Reflective**: requiring mental effort to make sense of
 - **Experiential**: easily perceived and interpreted

Representation example

- Which is the best flight from Vancouver to Montreal in terms of
 - Length of flight, number of stop-overs, ...

		Depart	Arrival
AC 117	Vancouver – Calgary	7:00	9:00
Cdn 321	Vancouver – Calgary	9:00	12:00
Cdn 355	Calgary – Montreal	13:30	19:30
AC 123	Calgary – Toronto	12:30	16:30
AC 123	Toronto – Montreal	16:45	17:30

*time zone: +1 van-cal, +2 cal-tor, mtl

- This is **Reflective Design**
 - Needs **thinking and comparison**
 - Inappropriate for this task

Another example

- Consider the following representation:

Inderal	1 tablet 3 times a day
Lanoxin	1 tablet every a.m.
Carafate	1 tablet before meals and at bedtime
Zantac	1 tablet every 12 hours (twice a day)
Quinaglute	1 tablet 4 times a day

- It's lunchtime, which pills should the elderly person take?
- The elderly leaves the house in the afternoon and won't return until the next morning. How many pills of each kind should he/she take?

Another example

	Breakfast	Lunch	Dinner	Bedtime
Lanoxin	x			
Inderal	x	x	x	
Quinaglute	x	x	x	x
Carafate	x	x	x	x
Zantac		x		x

- It's lunchtime, which pills should I take?
- I leave the house in the afternoon and won't return until the next morning. How many pills of each kind should I take?
- This matrix aids both search and computation

Another Task

- Count the number of buffalos
 - How would you represent the information for this task?



|||| ||||

Buffalo

|||| ||||

Buffalo / kids

||||

Adults

||||

Kids

8

4

Fidelity principle

- Remember fidelity from the model/prototype lecture?
 - This is another example of it
- Not always desirable to have a high degree of representational fidelity
- Represent information that is **relevant** to the **current task**

Representational Fidelity

- In many cases, decreasing fidelity means you can increase density
 - More information can be packed in
- However—the more abstract and convention-based a representation is, the more information should be given to aid in interpretation
 - Think about mathematical symbols
 - Why are they so difficult to learn?
 - Why are they so powerful?

Depictive vs Descriptive

- Depictive / analogical representation
 - Meanings are supposed to be conveyed through their visual form
 - e.g., photographs, drawings, maps
- Descriptive / propositional representation
 - Meanings are conveyed through conventions and rules for interpreting notational symbols
 - e.g., natural language, mathematics, computer language

Any connection to semiotics?

Depictive vs Descriptive



The British Isles are a group of islands off the northwest coast of continental Europe that include the islands of Great Britain and Ireland and over six thousand smaller islands. There are two sovereign states located on the islands: the United Kingdom of Great Britain and Northern Ireland (commonly known as the United Kingdom) and Ireland (also described as the Republic of Ireland). The British Isles also include three dependencies of the British Crown: the Isle of Man and, by tradition, the Bailiwick of Jersey and the Bailiwick of Guernsey in the Channel Islands, although the latter are not physically a part of the island group.

Principle: Pictorial Superiority Effect

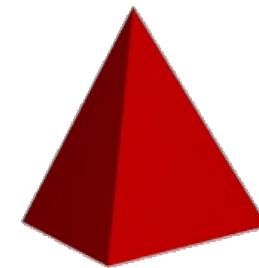
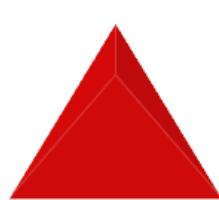
- Memory for depictive representations is superior to memory for descriptive ones
- Visual abilities develop prior to linguistic abilities
 - Higher mental bandwidth for visual images
 - Visual images communicate information in parallel
 - Text, for example, communicates it sequentially instead

Remember: There are trade-offs.

No one representation is perfect for all tasks, users, and contexts.

Static vs Interactive

- Static
 - No change
 - Conveys syntax, structure, and surface semantics
- Dynamic/interactive
 - Added temporal dimension
 - May change form
 - Conveys deeper semantics, process, motion, ...



Types of Representations

**(e.g., in the context of
games)**

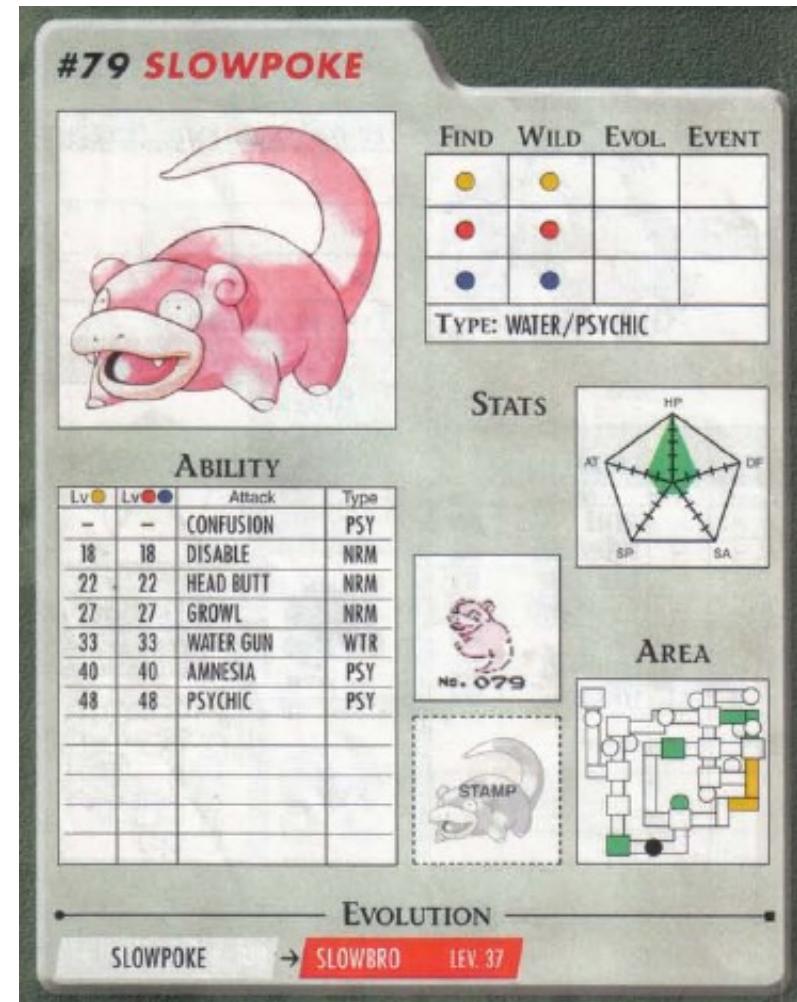
Representation system

- An HCI artifact (e.g., game) is made of a set (collection) of representations (signs) that together form the entities of the artifact
- There are different types of representations
- Individually, each representation encodes a different entity, its attributes, or its relations to other entities
- Collectively, the representations encode and reflect the current state of the artifact



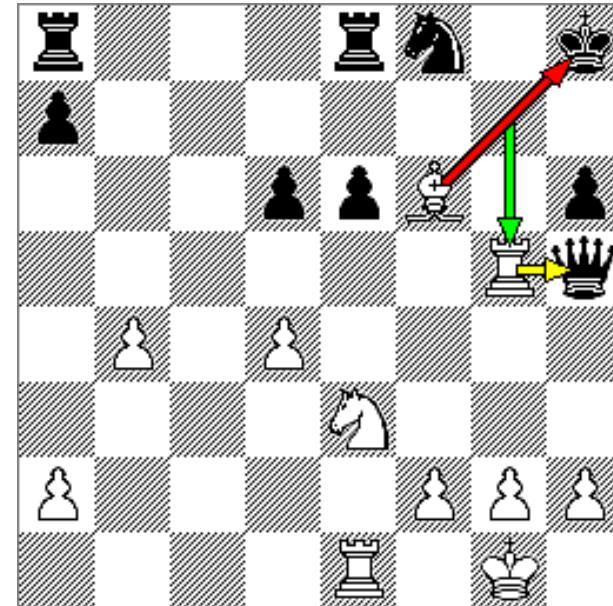
Lemmings

Representations in games



Internal relations

- What are the current states of these games? In other words, what are their internal relationships?

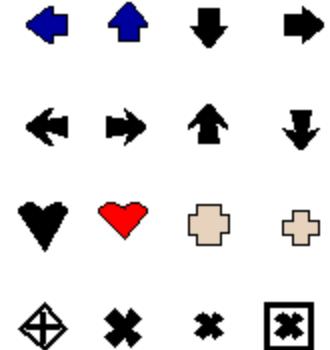


Some categories of representations

- Symbols
- Icons or glyphs
- Pictures / images
- Text or language
- Plots
- Maps
- Diagrams
- Tables

Symbols

- Are small images
- Are most basic representations
- Encode
 - Person
 - Quantity
 - Individuality
 - Existence



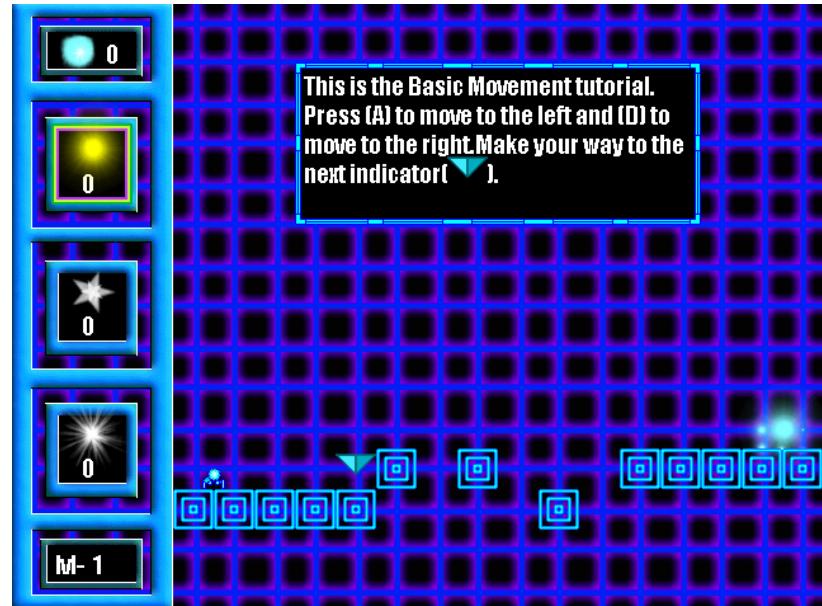
Icons

- Are miniaturized images
- Encode
 - Small amounts of information
 - More information than symbols
- Are similar to symbols in purpose
- Mostly used for buttons, objects, or simple stats



Pictures

- Are larger images
- Usually used as background
- Can be realistic or abstract
- Usually non-functional, but can affect experience and feeling

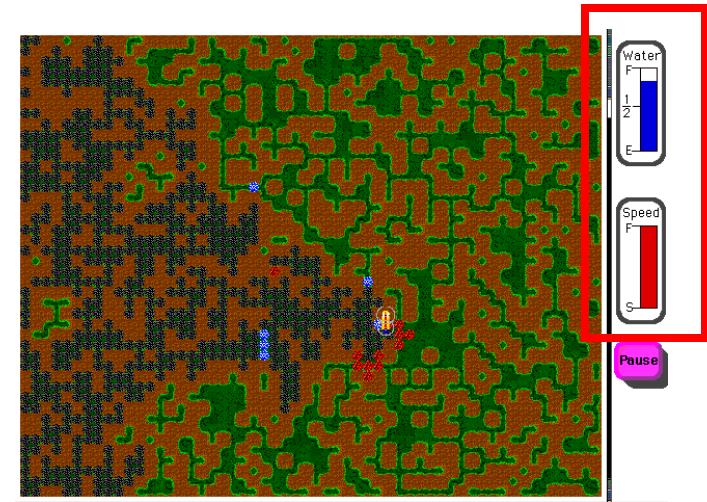


Text or language

- Is good for encoding discursive information
- People mentally process this type of representation more linearly than in parallel
- Encodes
 - Scores
 - Instructions
 - Stats
 - ...

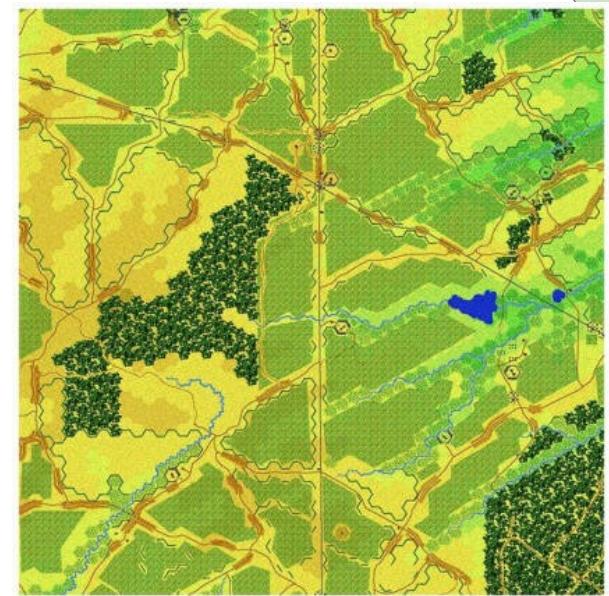
Plots

- Are graphs that show quantitative data
 - Value of data in time
 - Distribution of data
 - Change of value over time



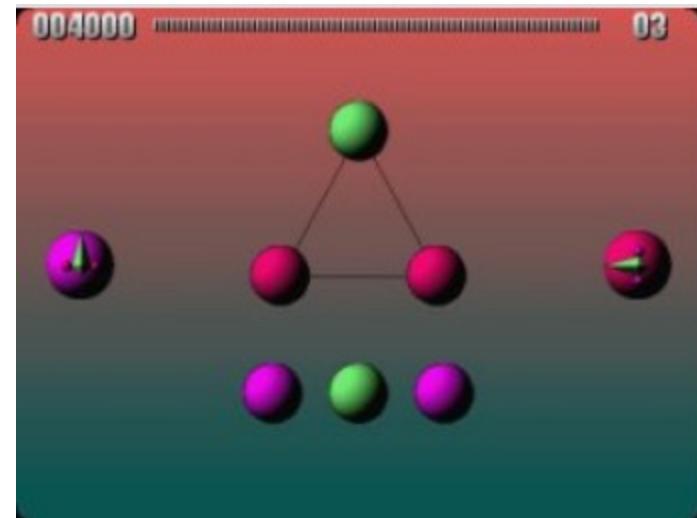
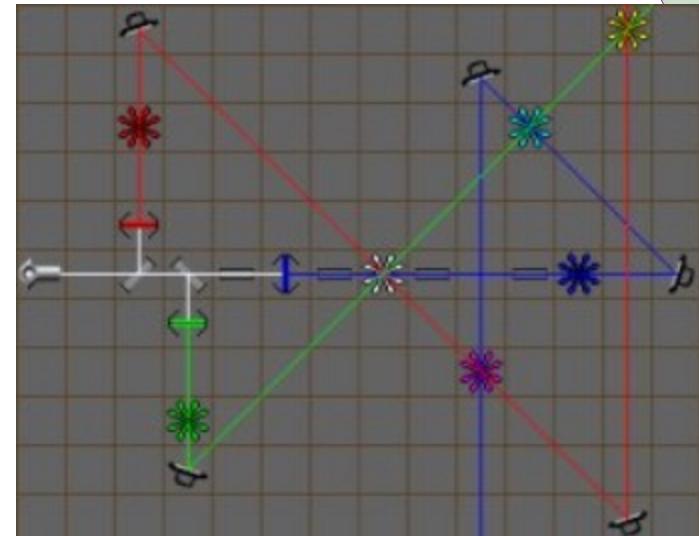
Maps

- Encode
 - Spatial information
 - Can be 1d, 2d, 3d
 - Real or virtual and abstract
 - Location
 - Directional relations



Diagrams

- Encode non-quantitative
 - Relationships
 - Connections
 - Movements
- There are many, many kinds



Tables

- Are cell-based containers
- Are good for indexed information



#79 SLOWPOKE

FIND WILD EVOL. EVENT

●	●		
●	●		
●	●		

TYPE: WATER/PSYCHIC

STATS

Lv	Lv	Attack	Type
-	-	CONFUSION	PSY
18	18	DISABLE	NRM
22	22	HEAD BUTT	NRM
27	27	GROWL	NRM
33	33	WATER GUN	WTR
40	40	AMNESIA	PSY
48	48	PSYCHIC	PSY

ABILITY

Evolution: SLOWPOKE → SLOWBRO LEV. 37

AREA

Stamp No. 079

jose - Brett

Datei Bearbeiten Partie Fenster Hilfe

14.11.2003

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Representations: A final word

- Remember:

Representations can be embedded. You can construct complex representations by EMBEDDING the previous representations in each other, such as having a table whose cells are made of diagrams whose nodes are made of plots whose elements are made of icons whose ...

Summary

- Semiotics – study of signs and meaning
 - Sign, Object, Interpreter, Context
 - Three types of signs
- Representations embody information
 - Act as signs on the visual interface
 - Representation chosen affects how we think with it
 - Need to be chosen for task and context
 - can be more reflective or experiential
 - high fidelity may not matter
 - Descriptive vs depictive
 - Pictorial superiority effect
 - Example of representations in games, as HCI artifacts