

What is Cognitive Science?

- “Cognitive science has been viewed as the study of the natural domain of cognition...
- where the latter includes prototypical phenomena of perception, problem-solving, reasoning, learning, memory, and so on.”

How to make a field in science

1. Round up some phenomena that seem related.
2. Find some principles that unify the phenomena or that explain patterns and regularities
3. Use those principles to put boundaries on the domain of inquiry. Specify what is in and what is out.
4. Figure out how the stuff in the domain works

Reason respecting behavior

- Info processing psychology – knowledge, goals, plans, means
- Language (formal linguistics)
- Theorem proving
- Chess and other games

The attribution problem in Cognitive Science

- We can't see the processes we care the most about, so we must infer them from observable behavior.
- But how can we infer the invisible?
- Well, ...what is visible?
- Reason-respecting behavior.
- How can we account for that?

Formal Systems

- We know of another system that produces reason-respecting sequences.
- It's LOGIC
- FORMal, get it?
- Strings of symbols
- Rules for manipulating strings of symbols
- *“If you take care of the syntax, the semantics will take care of itself.”* (Haugeland, 1981)

The classical view of computing and cognition (PSSH)

- Symbols and expressions
- Meanings are composed of meaning elements
- Formal operations transform expressions
- Three distinct levels
 - knowledge/computational
 - (what does it do?)
 - symbol/representational
 - (how is the doing organized?)
 - biology/implementation
 - (what stuff does it?)

Formal Systems have a history

Early Accounting Systems



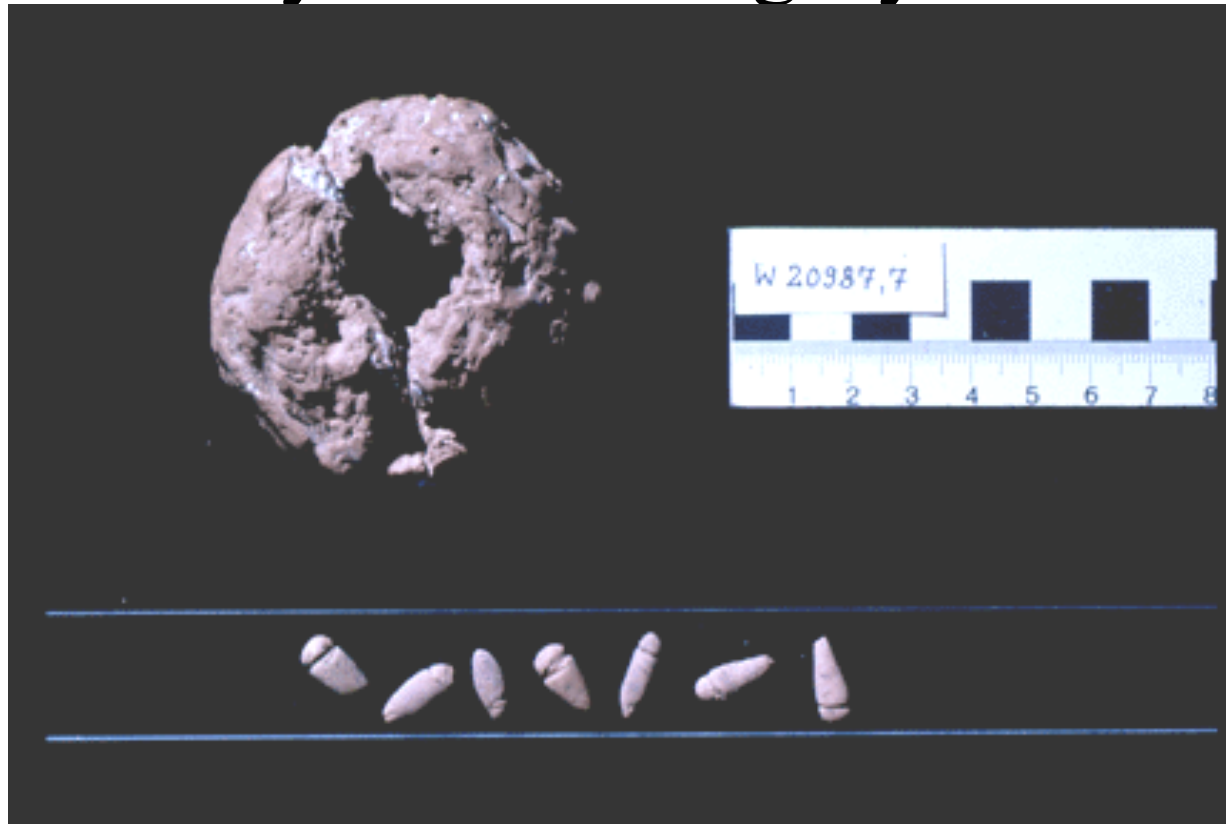
Six ovoid tokens representing an account of six units of oil

Early Accounting Systems



Plain tokens. Mesopotamia, 4000 B.C.

Early Accounting Systems



An envelope and its contents representing 7 units of oil

Early Accounting Systems



An envelope, its contents of tokens, and corresponding markings. 3300 B.C.

Early Accounting Systems



Complex tokens. Sheep, oil, metal, garment.
3300 B.C.

Early Accounting Systems



Impressed tablet showing an account of grain. 3100 B.C.

Early Accounting Systems



Pictographic tablet showing 33 units of oil. 3100 B.C.

Properties of Spoken and Written Language

- Spoken
 - Ephemeral
 - Dynamic
 - Auditory (sound)
 - Structure in time
- Written
 - Semi-permanent
 - Static
 - Visual (sight)
 - Structure in space

decontextualization

decontextualization

weave or
surrounds

with

relation to

not

to make or take

the act

Binary addition as a formal system

$T ::= o|x|To|Tx$ (where $::=$ means “is defined to be” and “|” means “or”)

The semantic function can then be defined recursively as follows, using the definition of the strings provided above:

(1) $SF(o) = 0$ (*the semantic interpretation of “o” is the number zero*)

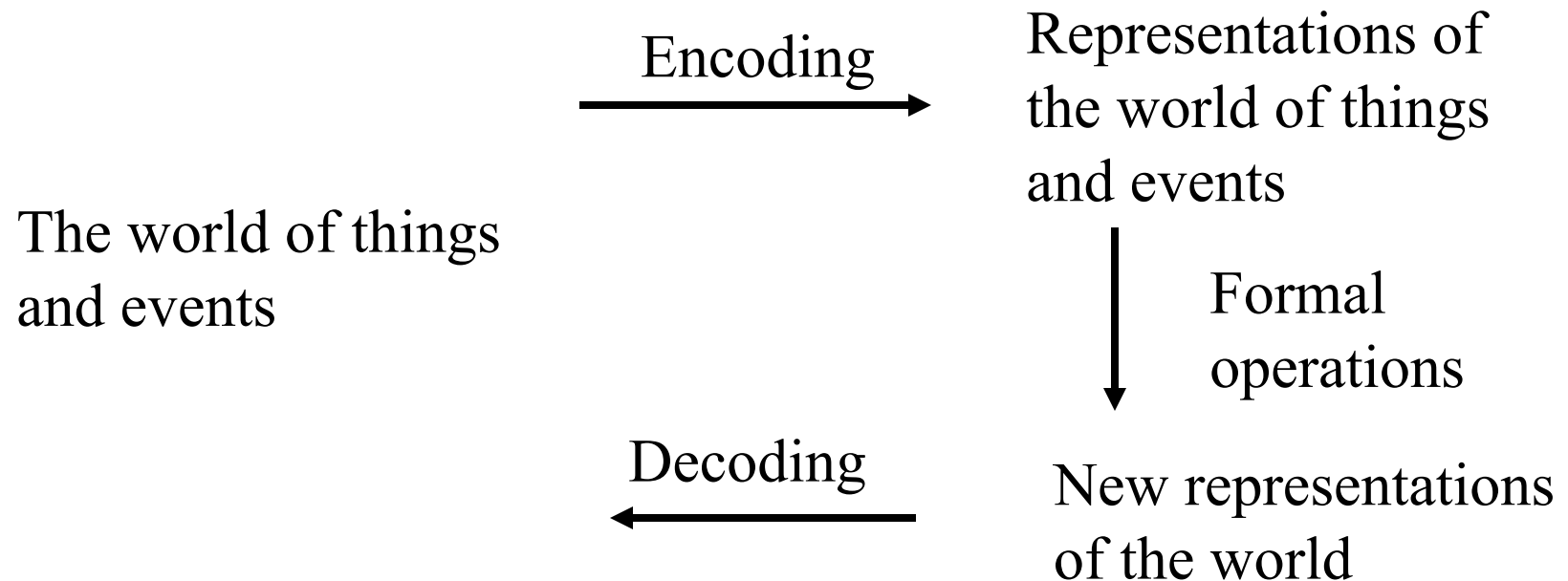
(2) $SF(x) = 1$ (*the semantic interpretation of “x” is the number one*)

(3) $SF(To) = 2 * SF(T)$ (*the semantic interpretation of a string T followed by “o” is two times the semantic interpretation of T alone*)

(4) $SF(Tx) = 2 * SF(T) + 1$

(the semantic interpretation of a string T followed by “x” is twice the semantic interpretation of T alone plus one).

The Secret of Our Success



The Secret of Our Success

The world of things
and events

Encoding



$$t = 0$$

$$x = 0$$

$$a = g = 9.8\text{m/sec}^2$$

$$v = gt$$

$$x = 1/2gt^2$$



Falling object

Falls 490m in
10 seconds

Decoding



$$t = 10 \text{ sec.}$$

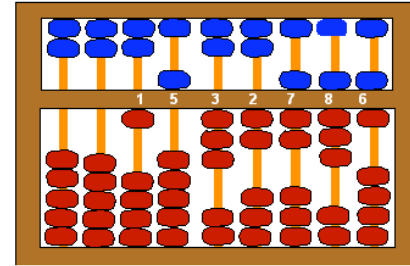
$$x = 1/2 g 100$$

$$= 50g \text{ meters}$$

Getting symbols to behave in a way that fits the world

- Why does this turn out to be possible?
- Why is the world a place that can be modeled by mathematics?
- No one knows, but it DOES work!

Consider the abacus



Here patterns of beads represent numbers. People learn rules for transforming these patterns of beads in such a way that the semantic interpretation of before-and after pairs corresponds to a useful mathematical function. But there is nothing intrinsically mathematical about the rules themselves: they are just rules for moving beads around. What makes the rules useful for doing mathematics is that we are assured of a certain continuing correspondence between the formal or syntactic patterns of beads and mathematical objects (such as numbers).

The Turing Machine

- An imaginary (theoretical) device.
- It works by manipulating meaningless symbols.
- It can compute the answer to any sufficiently well-specified problem.
- Digital computers are not imaginary, and they can be equivalent to a Turing machine.

The three big pieces of early Cognitive Science

1. Formal Systems
2. Meaningful computation by mindlessly following rules
3. Mechanized symbol manipulation

Mindware as reason-respecting Software

- In a formal system, state plus operator implies a new state,
- States of mind could lead to other states of mind in ways that follow rules.
- It is the program that matters.
- The machine it runs on is “a mere implementational detail.”

Physical Symbol System Hypothesis

- Symbolic Codes
- Cognition happens at the level of deliberative thought – symbol or representational level
- Intelligence, wherever it is found, will be found to be a physical symbol system.

Reverse Engineering

- Pick something that people do that is smart.
- Figure out how to do that same thing on a computer.
- Then look at the program in the computer. It should tell you something about the nature of the task and the things the person must do in order to perform the task.

And it works!

- This is exciting!
- Just document the I/O relations,
- build a program that can do the job (the *sufficiency* criterion),
- and then look inside to see how it does it.
- Wow!

Can we get symbols to work in a way that fits the brain?

- An empirical hypothesis: Physical symbol system hypothesis.

Thinking Meat?!

How can we get Reason-respecting
behavior out of a lump of flesh?

Could the brain be a meat computer?

- The program (the rules) run by the brain must be a formal system
- Brain states must correspond to symbols or propositions in a formal language.
- Functional equivalence of your brain states to mine – Not identity.
- Brain states must cause other brain states in just the right “reason-respecting” way.

The meat wouldn't matter

- If we knew the program, we could run it on any suitable computer.
- Then we would have an artificial human mind!
- And we already know how to do this.

Ok, But....

- The time course of real-world action
- There are many levels of software. Are there also levels of mindware?
- Are games good representatives of cognitive tasks?
- Is the Turing test a good representative?

OK, But...(continued)

- Engineering A/I vs Research A/I
- Consciousness (the C word) and qualia
- Language and Searle's Chinese Room

Searle's Chinese Room

- A person (you?) in a room with a slot in the door.
 - Book of rules
 - Box of symbols
- Chinese people outside push strings of symbols through the slot
- You use the rules to make new strings and push them out the slot.
- Do you speak chinese? Does the room?

Why not formal symbols?

- What symbolic computers do well and what people do well.
- Nature doesn't work like that.
- The metaphor is vague.
- Every device, considered at different levels, could be a model of many different things.

Questions remain

- If the PSSH does not describe what the brain does, what explanation do you offer instead? What's the alternative?
- If the brain doesn't do PSSH,
 - What does the brain do?
 - And what does PSSH?
 - (because banishing PSSH from the brain doesn't make it go away.)

Is the Meat Magic?

- The answer depends on whether or not we think consciousness is simply a matter of information processing.

Two aspects of mindfulness ?

- Reason respecting flow of thoughts
- Everything else
 - Qualia
 - Affect/emotion
 - Embodiment

Are these really different aspects?

Examining assumptions

- What was modeled? “Every such operation consists of some change of the physical system consisting of the **computer** and **his** tape.”
Turing, 1937
- Are the levels really separable?
- Are embodied meanings compositional?
- Explore: is an abacus a computer? No.
- Is the navigation team a computer? Yes. Notice how well the account works for a socio-cultural system.

Still doing science – bounding the field

- Once upon a time, PSSH was the only game in town (if we all do that how will an alternative ever come along?)
- Co-constitution of theory and phenomena for which the theory will be responsible. Eg. Turing test

Why the UCSD department of cognitive science does not study cognitive science.

It would be both surprising and troublesome if too many of what we pretheoretically took to be clear cases of cognition ended up being omitted in the process. But it would also not be entirely surprising if some of our favorite candidate “cognitive” phenomena got left out. For example, it could turn out that consciousness is not something that can be given a computational account. Similarly, certain kinds of statistical learning, aspects of ontogenetic development, the effect of moods and emotions, and many other important and interesting phenomena could simply end up not being amenable to a computational account. P40