Informatics 1 Cognitive Science

Lecture 2: Introduction to Cognitive Science

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Slide credits: Frank Mollica, Chris Lucas, Mirella Lapata

Overview

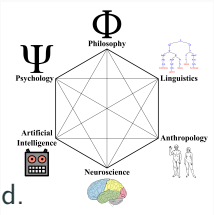
Cognitive Modelling

Cognitive Technology

Is Language a Cognitive Technology?

Recap

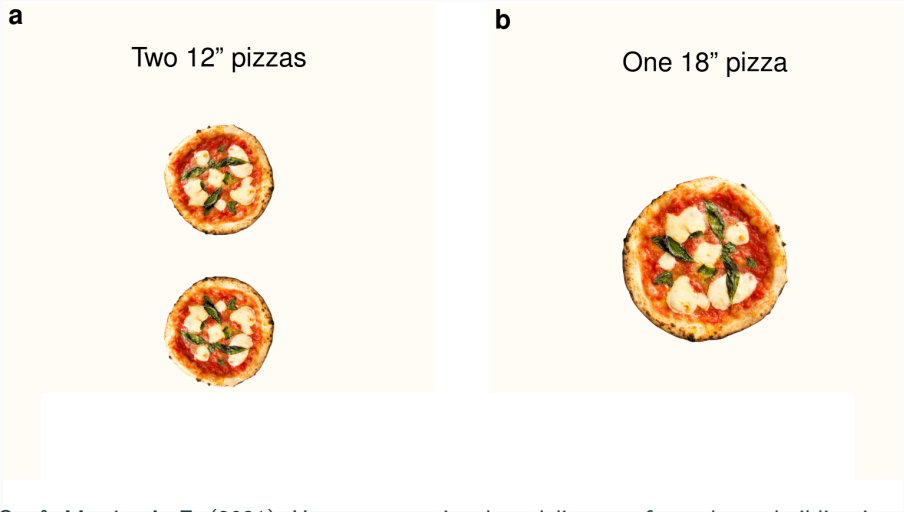
Central to cognitive science are mental representations and processes:



- A mental representation is a description of information in the mind.
- A mental process is a procedure for translating:
  - sensory information into representations;
  - representations into other representations; and
  - representations into actions/behavior.

Computational modeling can be used to *evaluate theories, generate new hypotheses, guide the collection of new data.*

Recap



Guest, O., & Martin, A. E. (2021). How computational modeling can force theory building in psychological science. Perspectives in Psychological Science 16(4), 789–802. Listen to the talk here.

Recap

a

Two 12” pizzas

$$\text{Area} = 2 \times \pi 6^2 = 226\,\text{in}^2$$

b

One 18” pizza

$$\text{Area} = \pi 9^2 = 254\,\text{in}^2$$

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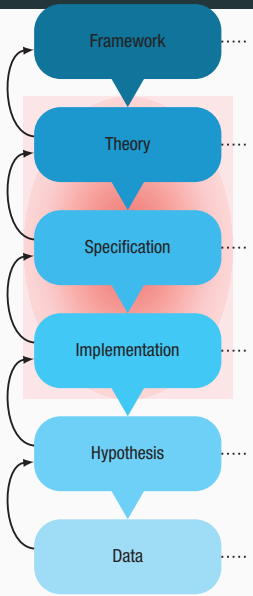
Cognitive Modelling

What is Cognitive Modelling?

Guest and Martin's taxonomy of cognitive modeling:



What is Cognitive Modelling?

Cognitive modeling is the process by which a verbal description is formalised to remove ambiguity, while also constraining the dimensions a theory can span.

Data are observations collected from the "real world" or from a computational model.

A hypothesis is a narrow testable statement. Hypotheses in psychology focus on properties of the world that can be measured and evaluated by collecting data and running inferential statistics. Any sentence that is directly testable by statistical means can be a hypothesis.

An implementation is an instantiation of a model created using anything from physical materials, e.g., a scale model or software.

What is Cognitive Modelling?

A specification is a formal description of a system to be implemented based on a theory. It provides a means of discriminating between theory-relevant claims and theory-irrelevant auxiliary assumptions. It constraints the space of possible computational models.

A theory is a scientific proposition—described by natural language, mathematics, logic, diagrams—that introduces causal relations with the aim of describing, explaining, or predicting a set of phenomena.

A framework is a conceptual system of building blocks for creating simulations of complex psychological systems. A framework is typically described using natural language or diagrams.

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Let's look at an example for language aquisition (more in week 2).

What is Cognitive Modelling?

Data

"I eated the cheerios."

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Hypothesis

The child will say "eated" more than "ate."

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def past_tense(verb): return verb + 'ed'
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Theory

Words and Rules

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Theory

Words and Rules

Framework

Sympol Manipulation vs. Neural Networks

What is Cognitive Modelling?

Framework

Productivity & Reuse vs Connectionism

Theory

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Productivity & Reuse vs Connectionism

Theory

Words and Rules

Specification

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Implementation

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def past_tense(verb): return verb + 'ed'
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Hypothesis

The child will say "seeed" more than "saw."

The child will say "helped" more than "helpen."

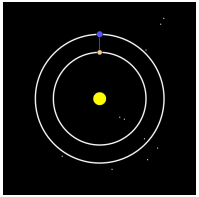
What is Cognitive Modelling?

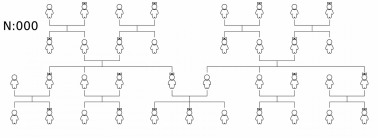
Time for a short quiz on Wooclap!

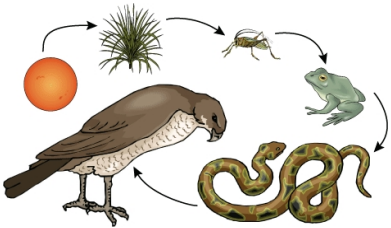
https://app.wooclap.com/REGEPQ

Cognitive Technology

What is a Cognitive Technology?







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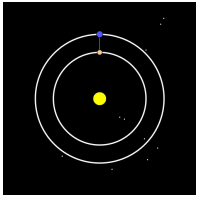
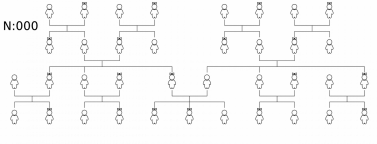
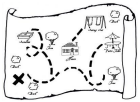
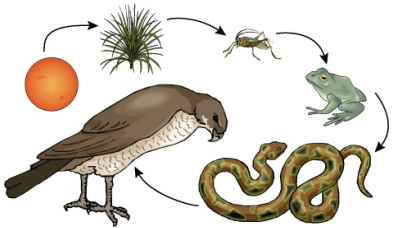




Language





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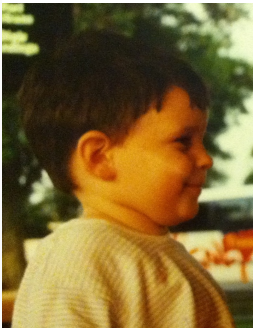
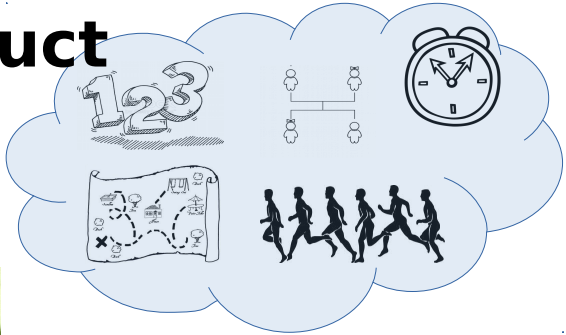
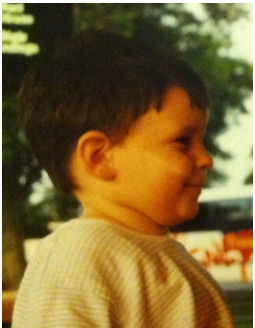


What is a Cognitive Technology?

“Three koalas”

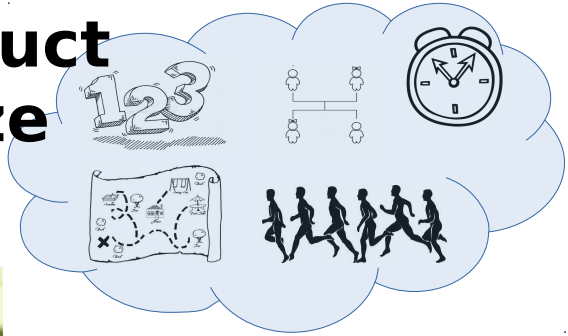
Construct





“Three koalas”

Construct
Utilize



What is a Cognitive Technology?

We humans have created not just physical machines . . . but also mental machines; mechanisms of thought, embodied in our nervous systems, that enable our minds to go further, faster, and in different directions than the minds of any other animals . . . They are "gadgets," rather than "instincts" because, like many physical devices, they are products of cultural rather than genetic evolution. New cognitive mechanisms—different ways of thinking—have emerged, not by genetic mutation, but by innovations in cognitive development. (Heyes, 2019, p. 1)

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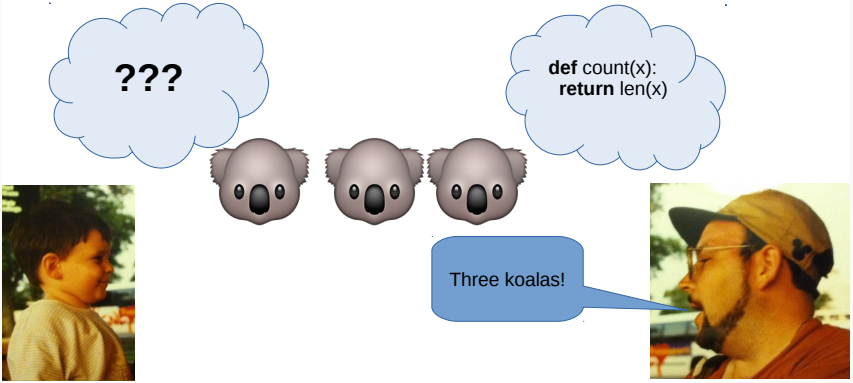

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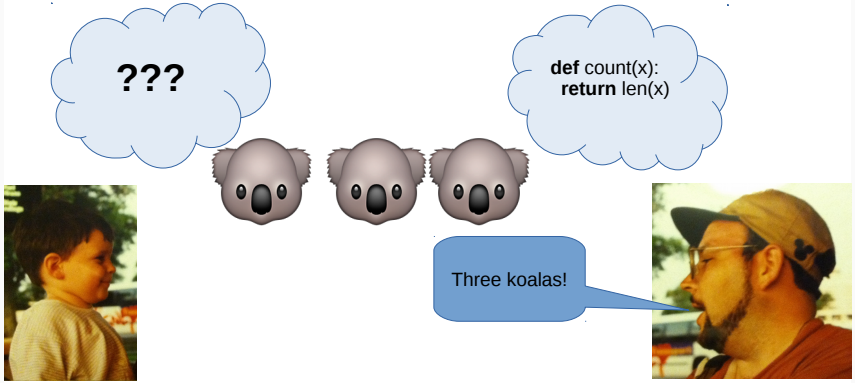

- Cognitive technology: the representations and processes
- Cognitive artifact: the linguistic signal
- Environment: the koalas and the teacher

What is a Cognitive Technology?

Time for another short quiz on Wooclap!

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Some Questions

- How much of learning is driven by the environment vs. innate capacities?
- Do we use the same, domain-general, learning mechanisms across all cognition or do we have domain-specific learning mechanisms?
- Is the innate capacities uniquely human or shared across species?

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We will come back to these questions over the next two weeks!

Is Language a Cognitive Technology?

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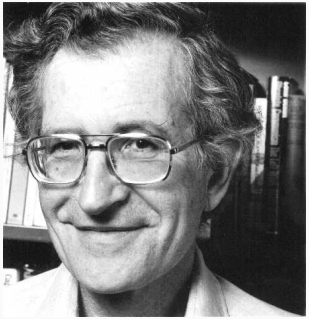

A human language is a system of remarkable complexity. To come to know a human language would be an extraordinary intellectual achievement for a creature not specifically designed to accomplish this task. A normal child acquires this knowledge on relatively slight exposure and without specific training. He can then quite effortlessly make use of an intricate structure of specific rules and guiding principles to convey his thoughts and feelings to others, arousing in them novel ideas and subtle perceptions and judgments. (Chomsky, 1975, p. 4)

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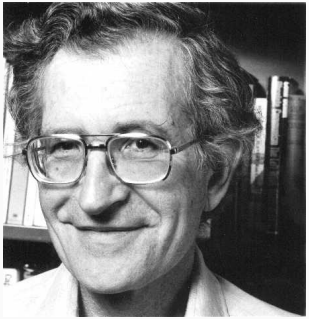

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A few potential sources of evidence to consider:

- Genetic and neuroscientific evidence
- Animal communication
- Linguistic universals and diversity
- Acquisition: critical periods

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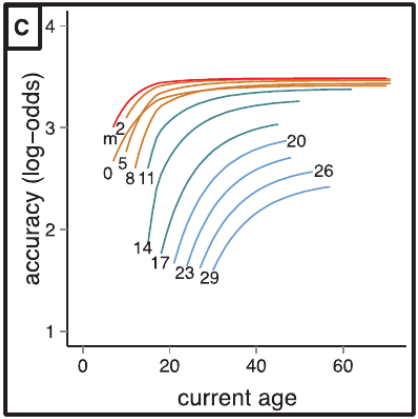
Is Language a Cognitive Technology?

There is a critical period in development during which a language can be acquired like a native speaker.

- child vs. adult language learning
- native vs. non-native speakers
- age of immigration and language ability
- arrive before age 6 $\rightarrow$ generally pass as native speakers
- arrive after puberty $\rightarrow$ generally do not pass as native speakers
- Evidence: "feral children", "wolf children", "attic children"
- Wild boy of Aveyron, *L'enfant sauvage* by François Truffaut

Is Language a Cognitive Technology?



Red: monolinguals; orange: age of exposure: 0–9 years old;

green: AoE 10–19; blue: AoE 20–30.

A critical period for second language acquisition: Evidence from 2/3 million English speakers, J.K. Hartshorne, J.B. Tenenbaum, S. Pinker. Cognition 177 (2018), 263–277.

Is Language a Cognitive Technology?

Let's see how well our WooClap survey on language acquisition accords with Hartshorne et al.'s study!

Is Language a Cognitive Technology?

Genie

- Was tied to her potty chair for 13 years by her dad
- Only words she knew: *stop it* and *no more*
- Could she manage to learn language?

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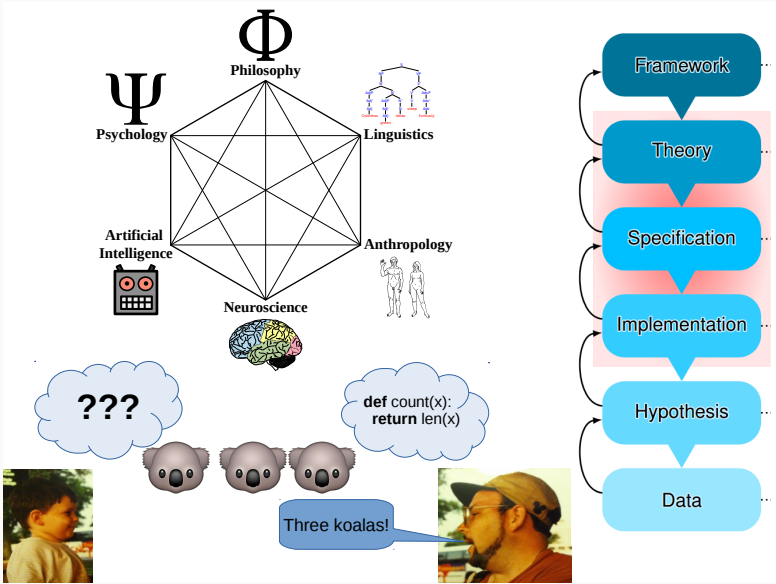
- Genie learned many words but not syntax!
- Amount of language learned after critical period seems limited.
- Difficult to disentangle linguistic from other forms of deprivation.

Summary


Philosophy
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