

# Cognitive Science and Scientific Method

Overview and central concepts

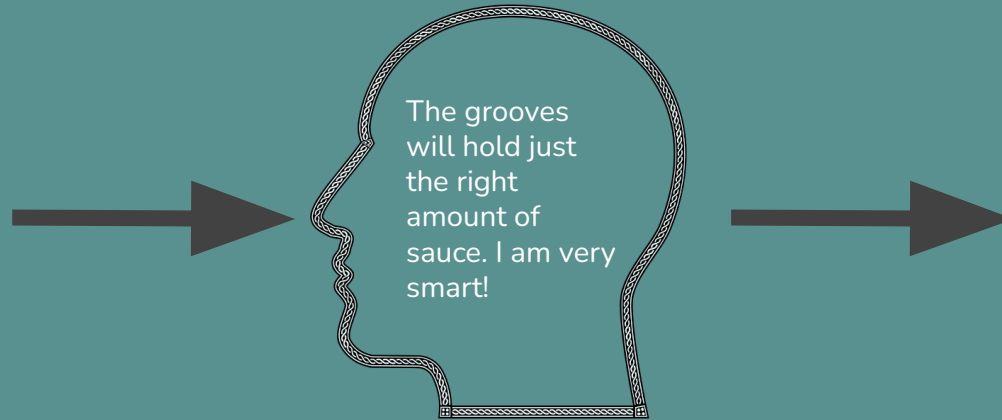


# What is Cognitive Science?

Cognitive Science studies the mental processes involved in:



Informational input  
(Perception)



Information processing  
(Cognition)



Behavioral output  
(Action)

# How does cognitive science relate to nearby disciplines?

Some speculations...



# Cognitive Science and Psychology

	Psychology	Cognitive Science
Subject Matter	-Biological intelligence -Focus on action	-Biological + artificial intelligence
Methods	-Behavioral experiments -Naturalistic observation	-Interdisciplinary (linguistics, philosophy, computer science, neuroscience, psychology)
Historical frameworks	Behaviorism	Computationalism

# Cognitive Science and Neuroscience

(Cognitive Science)



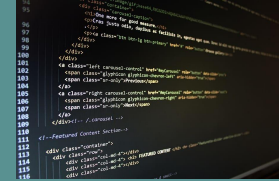
Identity?  
Functional realization?  
(Philosophy of Mind)



(Neuroscience)



(Computer Science)



(Electrical Engineering)



# Representation



# Propositions

'Jason went to the store'

'Jason fue a la tienda.'

'Jason đi đến cửa hàng rồi.'

## Propositions

express something  
about the world or  
*represent* things as  
being a certain way

*Jason went to the store.*

# Propositional Attitudes

attitude



proposition



I was angry that *Jason went to the store.*

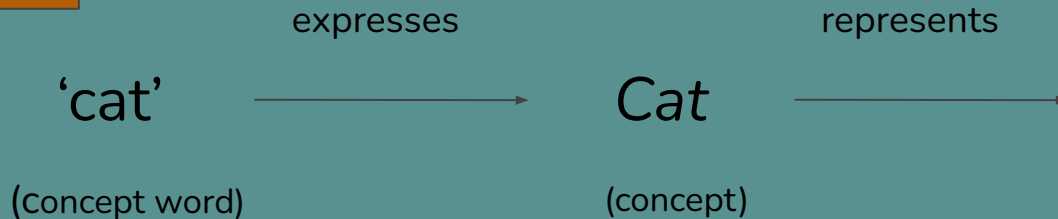
I hope that *Jason went to the store.*

I believe that *Jason went to the store.*



# Other Representational Entities: Concepts

**Propositional attitudes** are built up out of smaller **concepts**



# Other Representational Entities: Perceptions



causes



represents



# Representations as Theoretical Entities

Propositional attitudes, concepts, and perceptions are *unobservable*\* phenomena, but cognitive scientists posit them to explain *observable* phenomena, such as behavior and speech patterns.

Elementary particles are *unobservable* phenomena, but physicists posit them to explain *observable* phenomena, such as electromagnetism.

The Big Bang is an *unobservable* phenomena, but cosmologists posit it to explain *observable* phenomena, such as microwave background radiation.

\*Philosophers of science disagree about how to understand the observable/unobservable distinction or whether it is an important distinction at all.

# What should we think about theoretical entities?

**Scientific Realism** - We should believe in the theoretical entities posited by our best scientific theories.



**Scientific Instrumentalism** (aka Constructive Empiricism) - Science is only in the business of systematizing and explaining observable phenomena. We should only believe what our best scientific theories say about the observable. We should be agnostic about whether the theoretical entities posited by our best scientific theories really exist.



# Mental Representations Are Not That Weird!

They include beliefs, hopes, fears, and experiences of seeing dogs, hearing music, and tasting fruit. You already believe in them!



# Mental Representations Are Not That Weird! (Pt 2)

## Propositional Attitudes

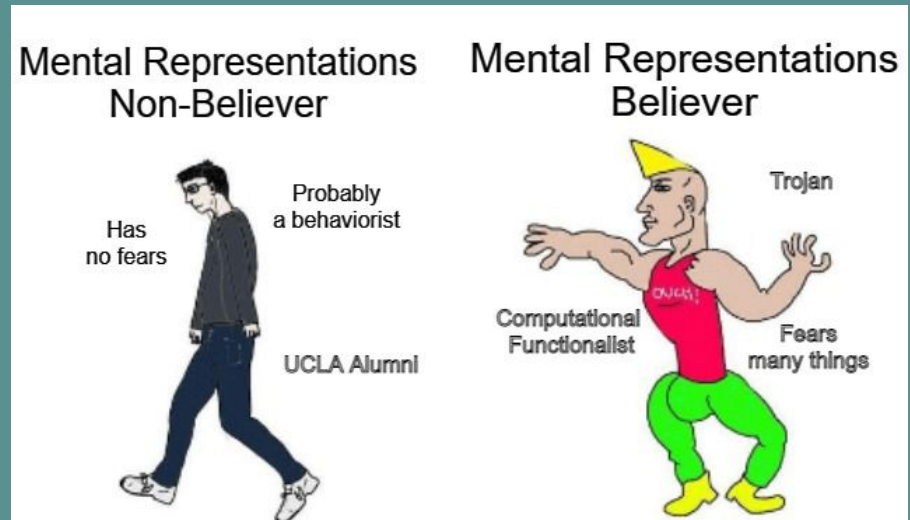
The hope that Jason went to the store *represents* Jason going to the store, and consists of an attitude of hope towards that representation.

The belief that Jason went to the store *represents* Jason going to the store, and consists of an attitude of belief towards that representation.

## Perceptions

The experience of tasting fruit *represents* that fruit, and does so in a particular way (e.g. as being sweet and juicy).

The experience of seeing dogs *represents* those dogs, and does so in a particular way (e.g. as being fluffy and fast).

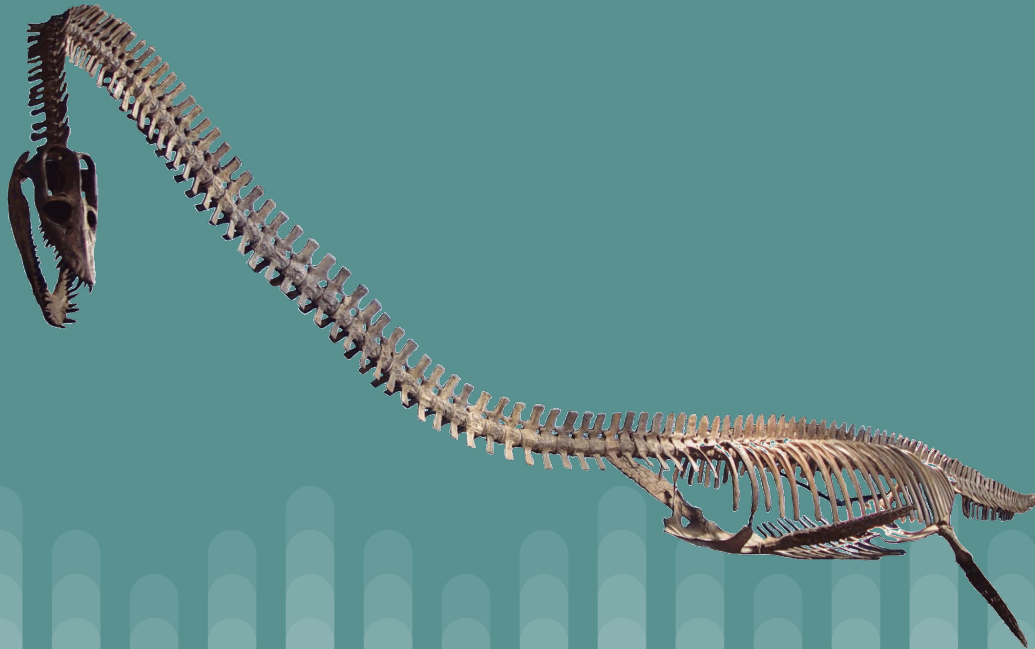


# Scientific Method



# Observation

Plesiosaurs had really long necks.





# Question

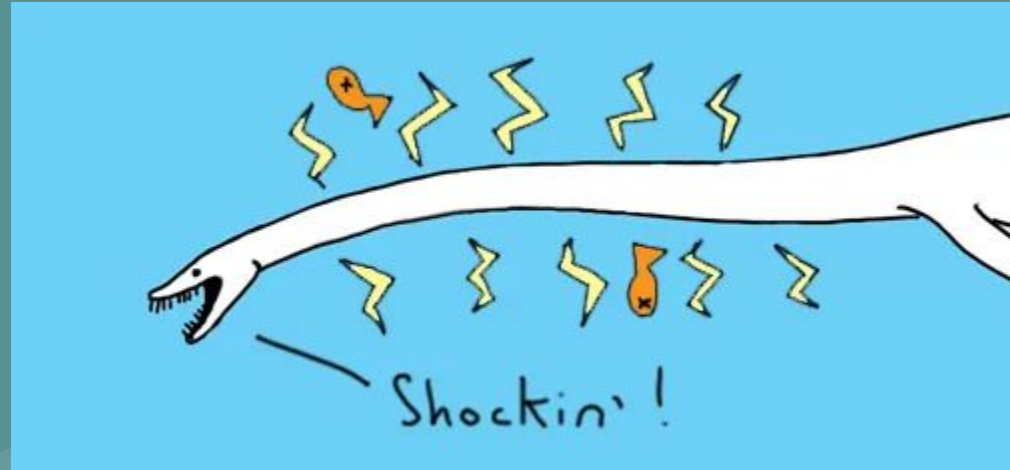
Why did plesiosaurs have such long necks?



# Hypothesis

The long necks were electrogenic organs (as in some eels).

A scientific **hypothesis** answers a **question** that was prompted by an **observation**.



# Prediction

If we scan the interior cavity of a plesiosaur skull, some parts should be disproportionately large, in order to house enlarged brain structures for processing electrical signals.

A scientific **hypothesis** should (together with some auxiliary assumptions) entail some testable **predictions**.



# Experiment

Let's CT scan some plesiosaur skulls!

The **experiment** is a test of the **prediction**.

**YAY  
SCIENCE**

# Verification / Falsification

If our scans do not detect anything anomalous, then our **prediction** is *falsified*.



If our scans do detect something anomalous, then our **prediction** is *verified*.



Does this mean the **hypothesis** is verified/falsified? ...

# Duhem-Quine Thesis

A **hypothesis** entails **predictions** only together with certain background assumptions. A scientist may react to a false prediction by modifying these assumptions, instead of abandoning the hypothesis.

No

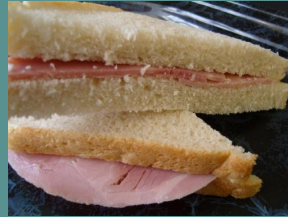


# Scientific Explanation



# What makes a good *scientific* explanation?

Why is there a sandwich?



Because I put it there.



causal explanation

Because there is meat  
between slices of bread.



metaphysical explanation



# What makes a good *scientific* explanation? (Pt 2)

**Deductive-nomological model:** scientific explanations deduce the explanandum from premises involving scientific laws\*

1. All water freezes below 32 F. ← scientific law
2. This sample is water.
3. This sample freezes below 32F. ← explanandum (what's being explained)

# What makes a good *scientific* explanation? (Pt 3)

**Causal model:** scientific explanations are causal explanations

# What makes a *good* scientific explanation?

Explanandum: My phone falls when I release it.

Explanation A: All objects are governed by gravity.

VS

Explanation B: There are 20 invisible gnomes living on my hand. When I release my phone, they drag it to the ground.

# Virtues of Scientific Explanations

**Simplicity** – how many entities, how many kinds of entities, how many assumptions

**Explanatory power** – how much is explained, are different kinds of phenomena explained, are the predictions novel

**Coherence** – how well does the explanation cohere with other facts and scientific theories