

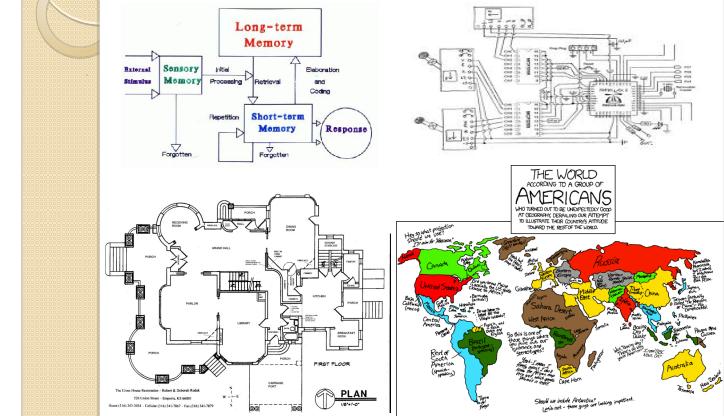
## Representation

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What do scientists mean when they say *representation*?



## Ask a Structuralist . . .

- There are a set number of elemental “**states of consciousness**” that can combine to explain consciousness.
- There are a set number of elemental “**processes of consciousness**” that can combine to explain consciousness.

## or a Functionalist

Watson (1913)

## Watson's Criticism of the Field

- Consciousness is the tool and the phenomena of study
- Data only has value as it licenses the analogy to human consciousness
- Non-replicability = Faulty Introspection

Watson (1913)

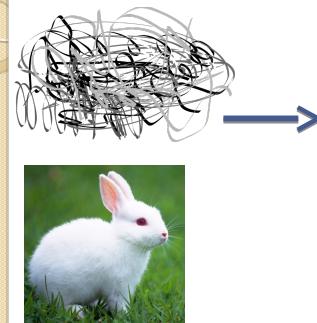
## The Response

- Redefine the domain of study.
- Instead of focusing on introspective attributes, elements, or processes,
- Focus on what can be seen
  - External Stimuli
  - Behavioral Responses

Stimulus → **MIND** → Response

Watson (1913)

## Epic Success!



\*As long as you ignore ethical violations!

Watson & Rayner (1920)

## Operant Conditioning

Provided by a Random Person on the Internet

## Terminology of Verbal Behavior

- **Controlling Stimulus** – something in the environment that controls the response
- **Operants** (Response) – “emitted responses, for which no obvious stimulus can be discovered.”

Chomsky  
(1959)

## Verbal Behavior: Reinforcement

- Reinforcement— the outcome of an operant leads to a reward, which increases the response strength.
- The problem is how to measure response strength?



Chomsky  
(1959)

## Where Skinner Went Wrong

- The behaviorist generalized their theory to a domain where it is very hard to reject the notion of internal representations: **Language**.
- Chomsky (1959) ceremoniously critiques this thesis.

## Does it generalize to language?

- “*A group of cats is called a ‘clowder’.*”
- Even if there was a controlling stimulus, how do we identify its response?
  - Answer: Post-hoc.
  - Displacement in language warrants internal representations

Chomsky  
(1959)

## Why the field could not explain Language

- Drive Reduction – Rewards relieve a need
- Language use can be drive reduction.
- To explain all language though, we may need to posit drives.

## The Curiosity Drive

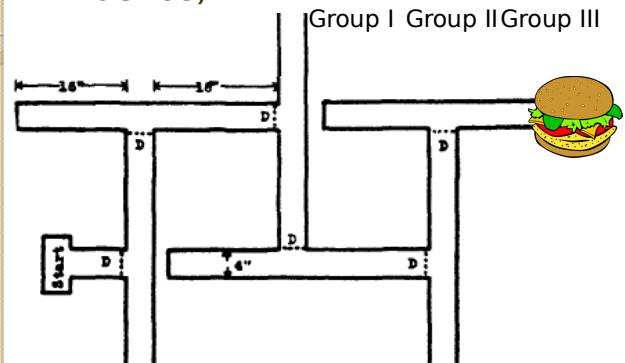
Chomsky  
(1959)

## Edward Tolman "The Behaviorist"

- Two camps
  - Switchboard Operator (Reflex Chains)
    - ↑ ↓ ↑ ↓ ← → (B A ...)
  - Field Maps (Internal Representations)
    - Latent Learning (Positive Evidence)
    - Latent Learning (Negative Evidence)
    - Searching for the Stimulus
    - Spatial Orientation

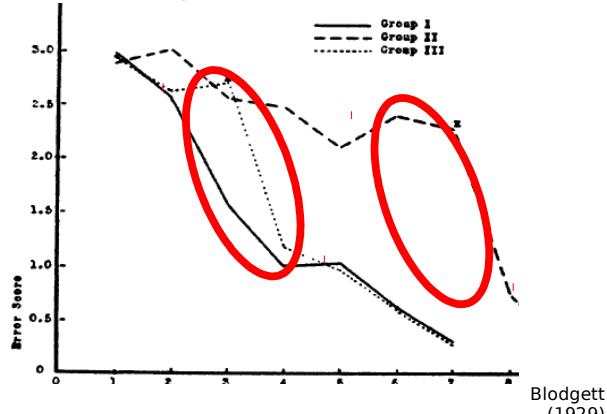
Tolman (1948)

## Latent Learning (Positive Evidence)

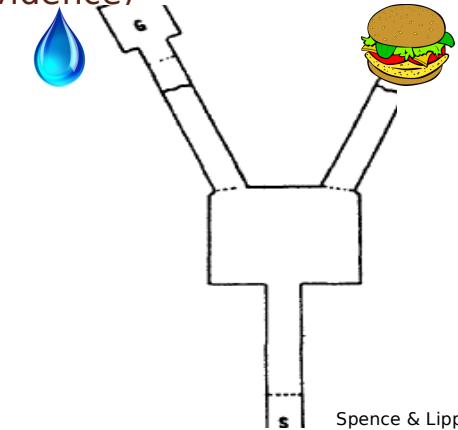


Blodgett (1929)

## Latent Learning (Positive Evidence)

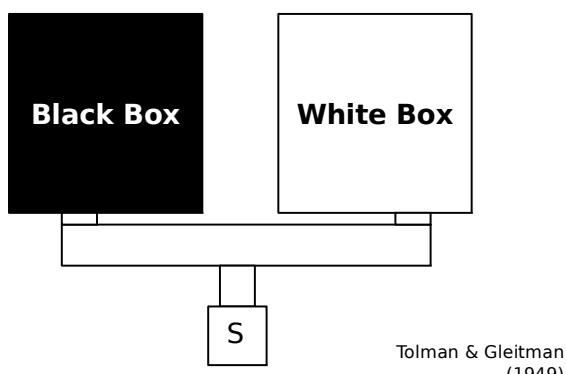


## Latent Learning (Positive Evidence)



Spence & Lippitt (19XX)

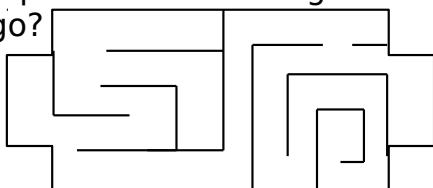
## Latent Learning (Negative Evidence)



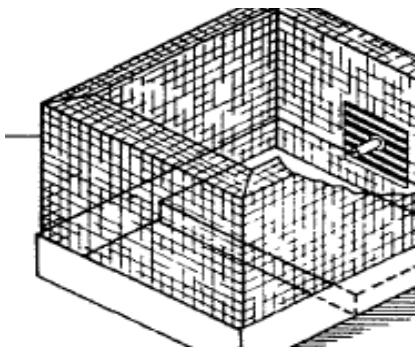
Tolman & Gleitman (1949)

## What does this tell us about Representations?

- Rats learn more than just the reflex chain!
- But how far does this field representation or cognitive map go?



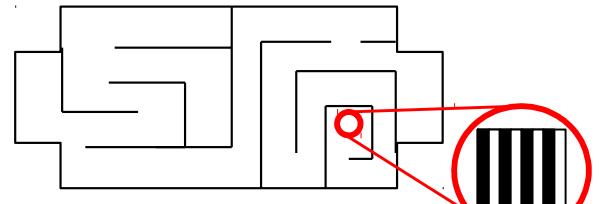
## Searching for the stimulus



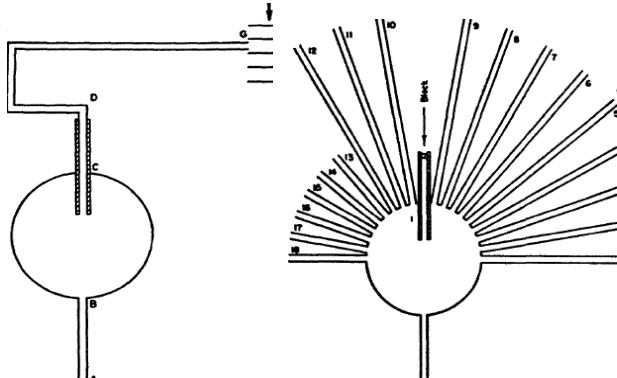
Hudson (19XX)

## What does this tell us about Representations?

- Rats look for stimuli to encode into their cognitive map!



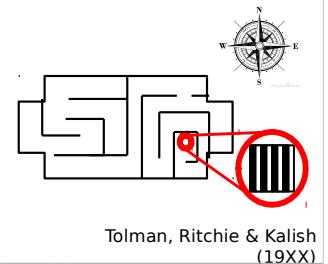
## Spatial Orientation



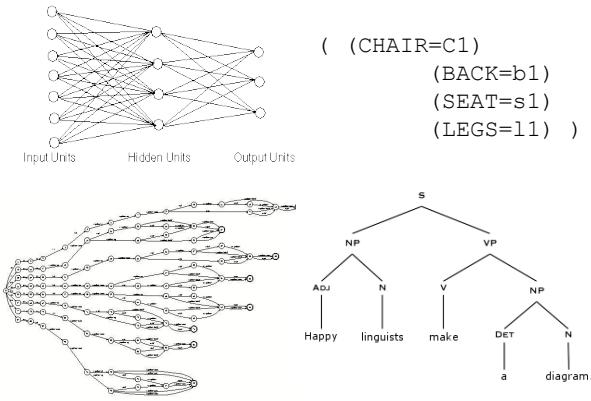
Tolman, Ritchie & Kalish (19XX)

## What does this tell us about Representations?

- Rats encode maps, relevant stimuli and spatial orientation.
- Cognitive Maps

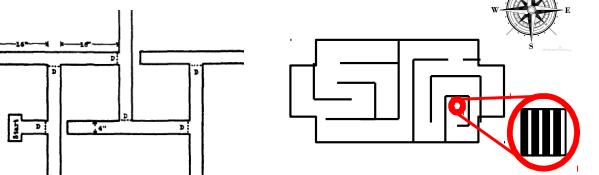


## The Cognitive Revolution

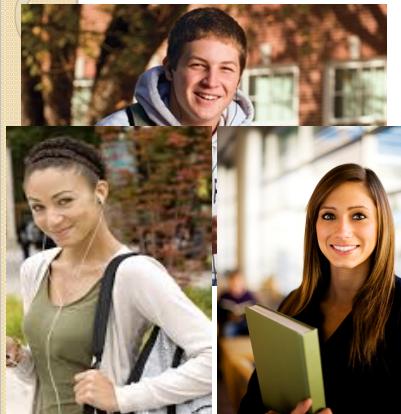


## Formalizing Representations

- **Domain** – World and the Representational Domain
  - **Content** – Features in the World encoded in Representational Domain
  - **Code** – Rules for relating features of the World and Content of the Representational Domain
  - **Medium** – Physical Instantiation of the Representation
  - **Dynamics** – How representations change
- Rothblat (1982)

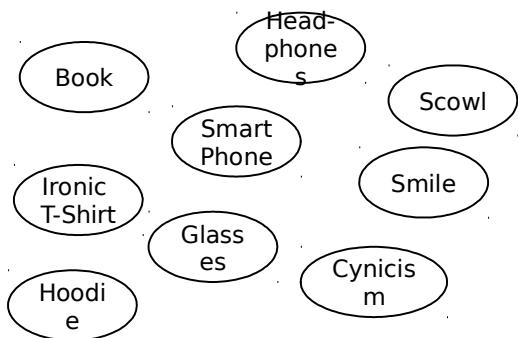


## Case Study: Distributed Network Model of Semantic Memory



- **Domain:** Identifying fake college students
- **Content:** Book, backpack, smile, headphones, smart phone, hoodie
- **Code:** Salient features get represented
- **Medium:** <unspecified>

## Case Study: Distributed Network Model of Semantic Memory



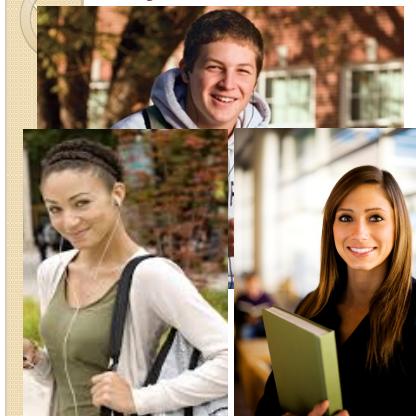
Plaut & Booth (2000)

## Criticisms of Amodal Models

- They are not **grounded** representations
- There is no straightforward biologically plausible coding mechanism
- Explanatory Power is post-hoc
- Not parsimonious
- Models do not generate hypotheses

Barsalou (1999)

## Case Study: Perceptual Symbol Systems



- **Domain:** Identifying fake college students
- **Content:** Same as before
- **Code:** Selective attention picks out features
- **Medium:** Areas of the brain corresponding to perception and motion
- **Dynamics:** Features are converted into simulators

Barsalou (1999)

## Case Study: Perceptual Symbol Systems

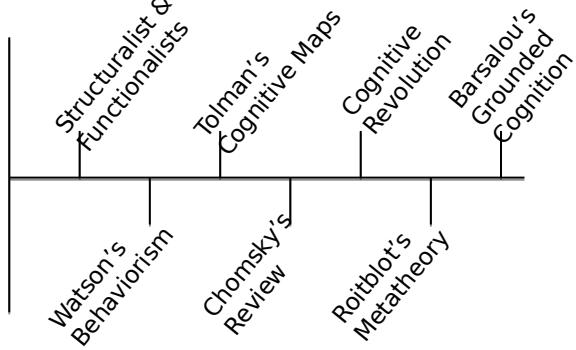


## Why are representations useful?

- Cognitive scientists propose representation at both the computational and algorithmic level of explanation (Marr, 1982) with the intent that neuroscientists will eventually be able to provide explanations at the implementational level.

## Conclusions

- What is a representation?



## Conclusions

- Structuralists & Functionalist
  - There are a set number of elemental “**states / processes** of consciousness” that can combine to explain consciousness.
- Watson’s Behaviorism
  - Complete **rejection** of internal mental representations
  - Introduced meaningful applications of psychology to the world.

## Conclusions

- Tolman’s Cognitive Maps
  - Rats have internal mental representations, or **cognitive maps** that include relevant stimuli and are not fixed in spatial orientation.
- Skinner’s Verbal Behavior & Chomsky’s Review
  - While Skinner’s generalization of operant conditioning to language has modest evidence, language cannot be completely explained without internal mental representations.

## Conclusions

- The Cognitive Revolution
  - Multiple models, or representational systems, were created based on analogies made to programming languages, linguistics, and formal logic.
  - Most of these models are amodal.

## Conclusions

- Roitblot’s Metatheory of Representation
  - Domain- the world and the task to be modeled
  - Content- the features of the world represented in the model
  - Code- the rules to go from features in the world to features in the model and vice versa
  - Medium- the physical instantiation of the model
  - Dynamics- how representations change over time

## Conclusions

- Barsalou’s Embodied Cognition
  - Amodal models typically do not specify their medium.
  - Amodal models do not always specify biologically plausible methods of encoding representations
  - The Embodied Cognition Hypothesis specifies medium and biological encoding as the perceptual system.

## Conclusions

- Why have representations?
  - Representations bridge the gap between Cognitive Science and Neuroscience