

Representation

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Given the historical readings, my goal is to address the questions: What do scientists mean when they say representation across time. I also want to briefly touch on the significance of representations for cognitive science.

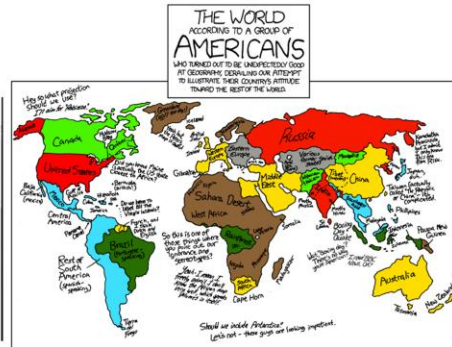
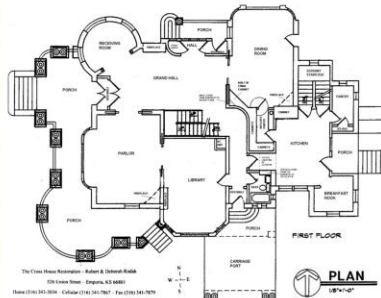
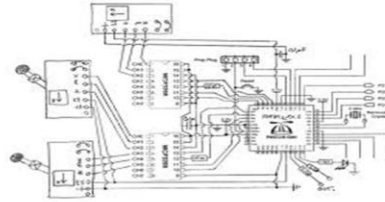
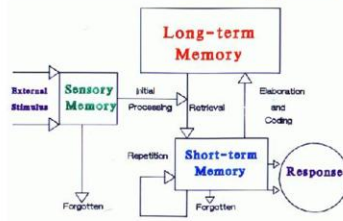
What do scientists mean when they say representation?

The top left diagram illustrates the flow of information through memory systems. It starts with 'External Stimulus' entering 'Sensory Memory'. From 'Sensory Memory', information can be 'Forgotten' or undergo 'Initial Processing' to move into 'Long-term Memory'. 'Long-term Memory' allows for 'Retrieval' back into 'Sensory Memory' or 'Elaboration and Coding' into 'Short-term Memory'. 'Short-term Memory' involves 'Repetition' to stay in the system or is 'Forgotten'. Finally, 'Short-term Memory' leads to a 'Response'.

The top right diagram is a complex electronic circuit board, likely a microcontroller or digital logic circuit, with numerous integrated circuits, resistors, and connecting wires.

The bottom left diagram is a detailed architectural floor plan of a building, labeled 'FIRST FLOOR'. It shows various rooms such as 'RECEPTION', 'OFFICE', 'LIBRARY', 'COURTYARD', and 'STAIRS'. A north arrow and a scale bar are included at the bottom.

The bottom right diagram is a world map titled 'THE WORLD ACCORDING TO A GROUP OF AMERICANS'. The map is color-coded and includes humorous annotations about different regions, such as 'This is the only religion that we call "Foreign Religion"', 'Russia is the only country that we call "Russia"', and 'South America (Latin America)'.



Ask a Structuralist . . .

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

or a Functionalist

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

Watson (1913)

To name a few: quality, extension, duration, intensity. But if you ask another order, clarity, etc.



Implications for Animal Studies

- 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



Watson (1913)

Basically we have removed internal mental representation from the domain of study!
Oh no, why am I standing here trying to talk to you about mental representations it's all over!

Epic Success!



***As long as you ignore ethical violations!**

Watson & Rayner (1920)

Little Albert (Watson & Rayner, 1920)

US → UR : loud noise → fear

NS → null : white rat → no response

US + NS → UR : white rat + loud noise → fear

Rinse and Repeat

CS → CR : white rat → fear



Operant Conditioning

Provided by a Random
Person on the Internet

Statistical Rigor!
Does a good job!

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.

If you haven't read the supplemental, that is a classic paper in language and cognitive science.

Caveat about Strawmen!

The arguments for Skinner's application to speech is well motivated when you look at the evidence he presents.

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)

Narrow (lawful): In the presence of a stimulus, a particular predictable response is realized.

Broad: Something in the environment caused the response.

The not obvious stimulus for operants is normally a reward?

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)

What is the controlling stimulus of my random cat facts?

It is easy to build a strawman and knock it down, but by limiting the evidence Skinner used to build his argument, it is clear that he overgeneralizes his hammer.

Verbal Behavior: Reinforcement



Chomsky (1959)

The application to speech was well motivated, the reinforcing quality of speech was its ability to affect changes in reality

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)

Putting Skinner and operant conditioning aside, the field believed that drive reduction could explain behavior (meaning no need for int rep)?

Bottom Line: Behaviorism cannot explain language. We need internal mental representations. And this was being acknowledged by certain “behaviorists”

Edward Tolman “The Behaviorist”

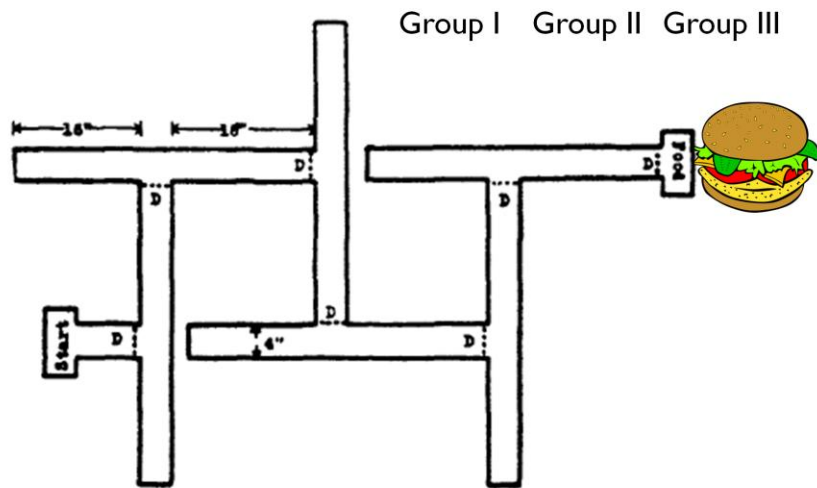
- Two camps
 - Switchboard Operator (Reflex Chains)
 - $\uparrow \downarrow \uparrow \downarrow \leftarrow \rightarrow \leftarrow \rightarrow$ (BA ...)
 - Field Maps (Internal Representations)
 - Latent Learning (Positive Evidence)
 - Latent Learning (Negative Evidence)
 - Searching for the Stimulus
 - Spatial Orientation

Tolman (1948)

Positive Evidence means learning to reach X.

Negative Evidence means learning to avoid X.

Latent Learning (Positive Evidence)



Blodgett (1929)

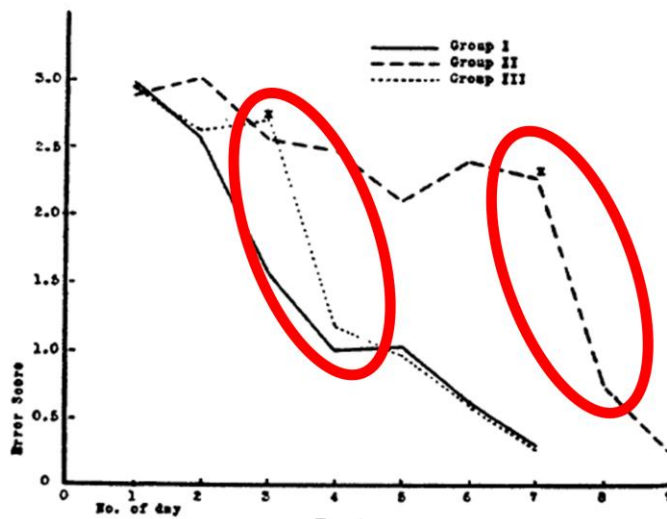
One trial per day

Group I (Control) → Food @ goal every day

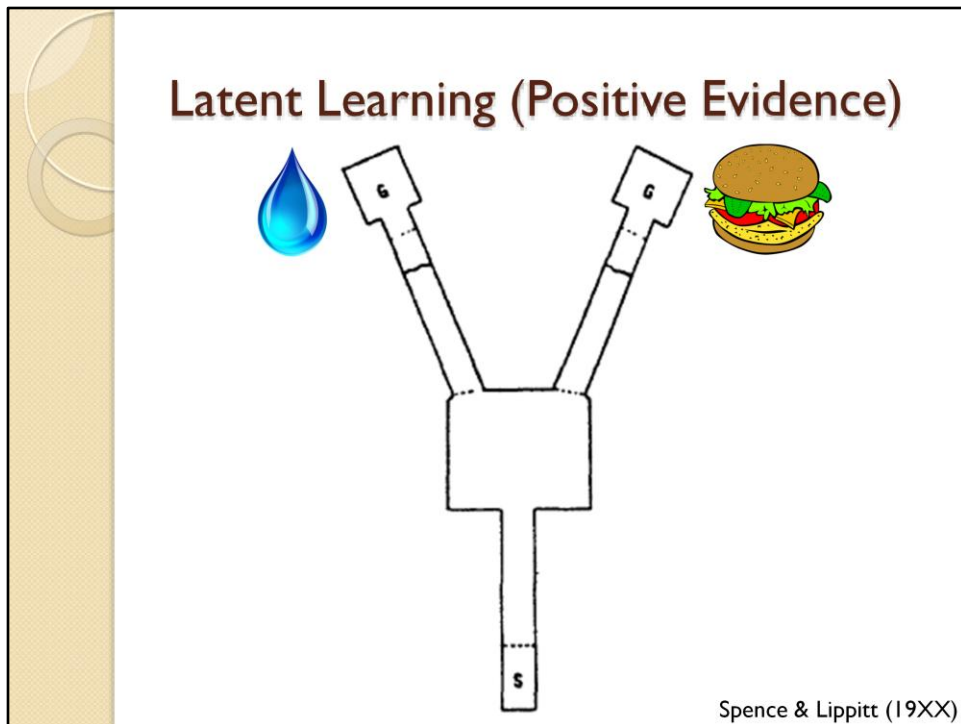
Group II (7 days) → Fed in cage for 6 days, food @ goal on day 7

Group III (3 days) → Fed in cage for 2 days, food @ goal on day 3

Latent Learning (Positive Evidence)

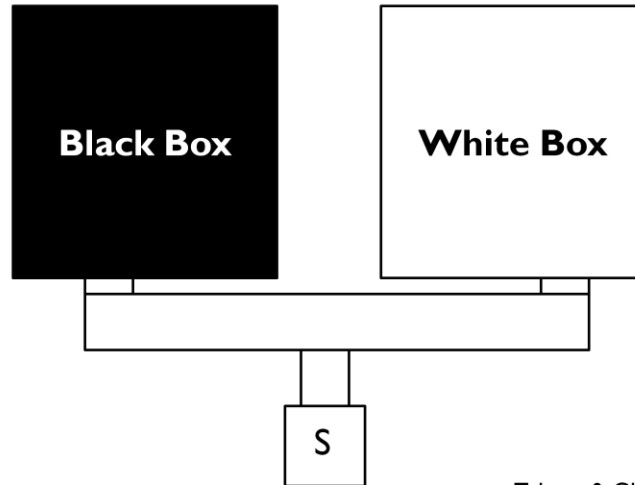


Blodgett (1929)



Always satiated before entry to maze. Reward for maze was friend time.
Trained for a week, 4 trials per day. Food and water were counterbalanced but more frequently in one location than the other.

Latent Learning (Negative Evidence)



Tolman & Gleitman (1949)

Forced exploration of both boxes

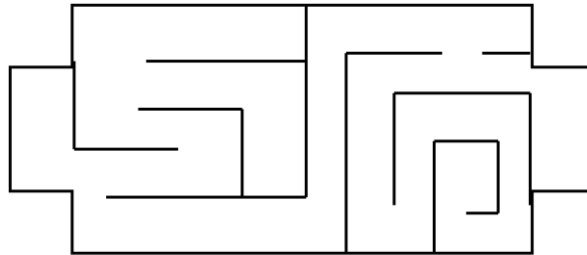
In the detached goal box, animals were shocked

Placed in the maze, most went to the non-aversive box.

Starved One mouse made the wrong decision, realized it before the box, squealed, became visibly distressed and eventually ran back the other way

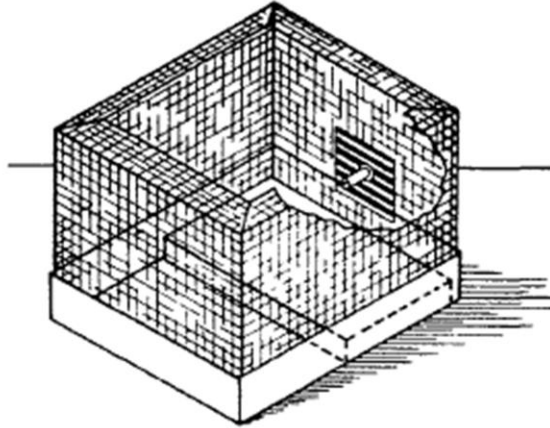
What does this tell us about Representations?

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



Maybe, it might just be that the rats learned several reflex chains
Do we encode stimulus in the environments?
How deeply do we encode these stimuli
Stay tuned . . .

Searching for the stimulus



Hudson (19XX)

Single Trial Avoidance.

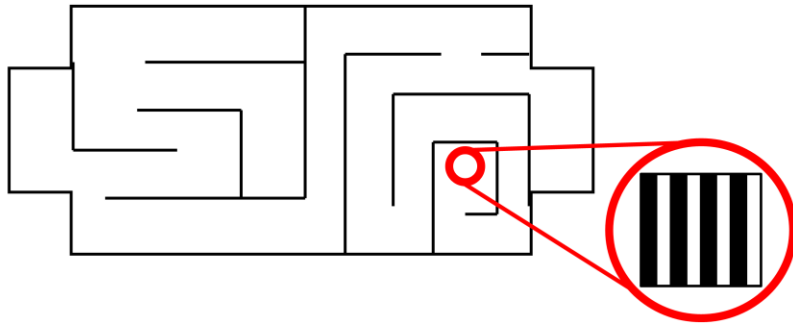
Eat from pattern food → Shock → Avoidance

What they are avoiding?

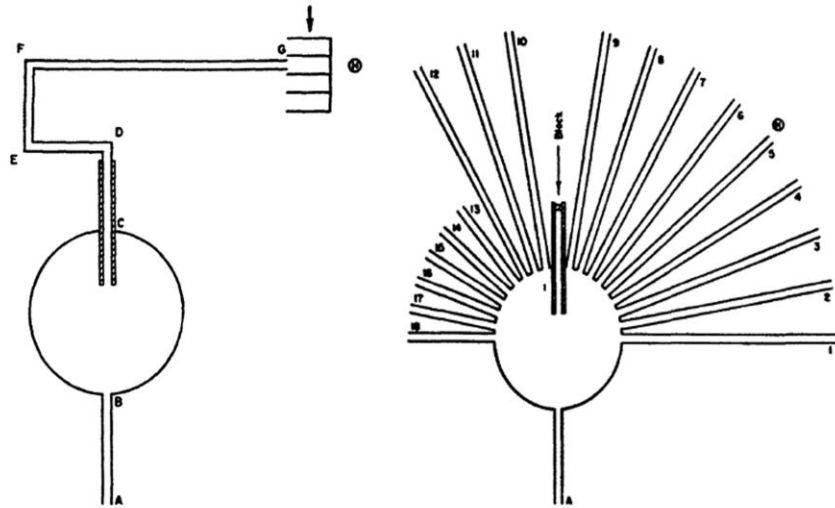
Eat → Shock → Blackout + Pattern (disappear) → No Avoidance

What does this tell us about Representations?

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



Spatial Orientation

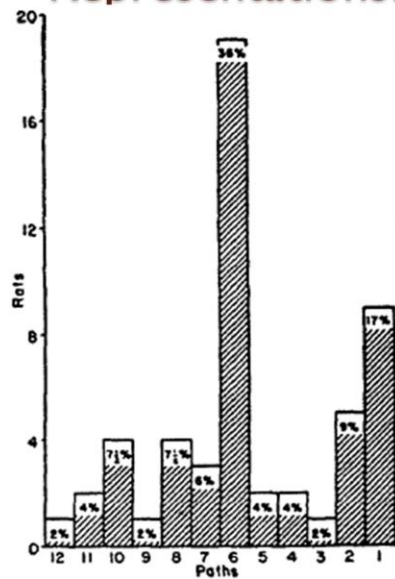


Tolman, Ritchie & Kalish (19XX)

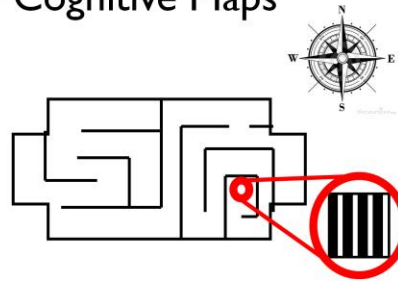
Trained 4 nights, 3 trials per night on the left maze and food was rewarded
Then let loose into the mohawk maze. Walked a few inches and doubled back
decided on 1 path.

Histo

What does this tell us about Representations?

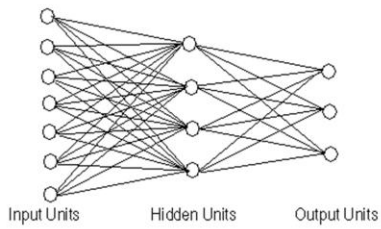


- Rats encode maps, relevant stimuli and spatial orientation.
- Cognitive Maps

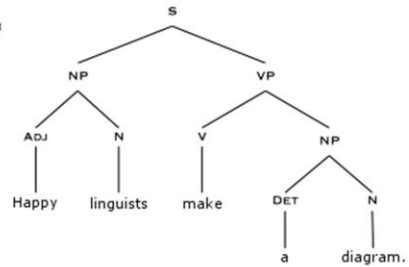
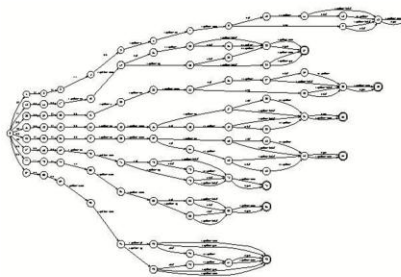


Tolman, Ritchie & Kalish (19XX)

The Cognitive Revolution

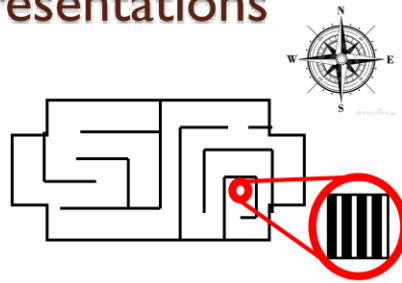
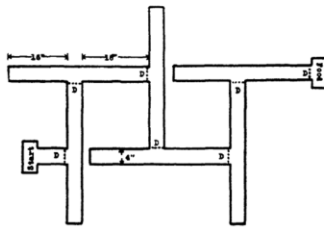


((CHAIR=C1)
(BACK=b1)
(SEAT=s1)
(LEGS=l1))



Connectionist Models
Feature Lists
Finite State Automata
Syntactic Tree Parsing

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

Roitblat (1982)

Domain – World and the Representational Domain, but the representational domain is not the full picture of the world. It is delimited by things such as task or features. Why would we want to store the color of the maze? Why might we have wanted to store the illumination of the maze? Based on task, different things are considered in our representational structure.

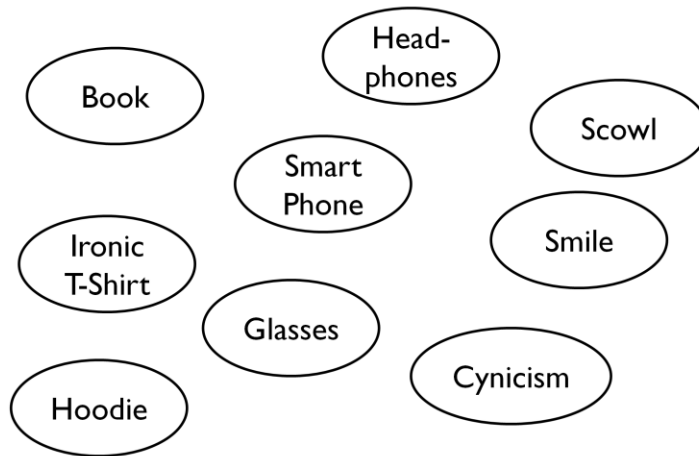
Content – The features of the represented world that are preserved in representation and any dependencies or information that can be derived from it.

Case Study: Feature Based 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: Feature Based Model of Semantic Memory



McRae, de Sa, Seidenberg (1997) ; Tyler & Moss (2001)

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)

Caveat – Strawman coming up!

This is actually oversimplification (assumed the brain and Hebbian learning) but that is how most strawmen are formed in the introduction of a paper.
Issue of Medium

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)

Not a recording system but an actual conceptual system

Case Study: Perceptual Symbol



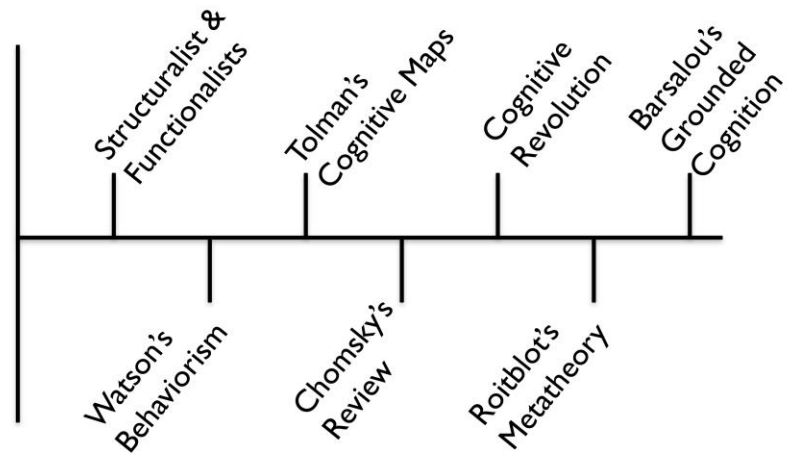
Why are representations useful?

- 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.

Having representations and proposing changes in representations via mental processes informs the questions that cognitive neuroscientists ask.

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.

Summarizing with the weaker hypothesis



Conclusions

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