

Cognitive Science and Artificial Intelligence

An interwoven approach

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What was studied

History of *cognitive science(s)*, compared and contrasted with the history of *artificial intelligence* and *computer science*. Main interest: are theories...

- **symbol**-oriented: localized representation, high level reasoning, distance from biology
- **connection**-oriented: distributed representation, interest in low level processing, perception, closely related to biology

Rationale behind research

Their shared histories have influenced one another many times.

- What is there to learn from Cognitive Sciences now?
- Are old paradigms relevant again?
- Which directions seem to hold the most promise?
- What's the current state of research?

Structure of the thesis

- Glossary: included to avoid *weighted* terms
- Historical section: developed in sections, highlights shifts in perspective
- Analysis:
 - Trends and movements
 - Symbols, subsymbols and hybrid approaches
- Appendix: introduction to neural networks moved here to keep text light

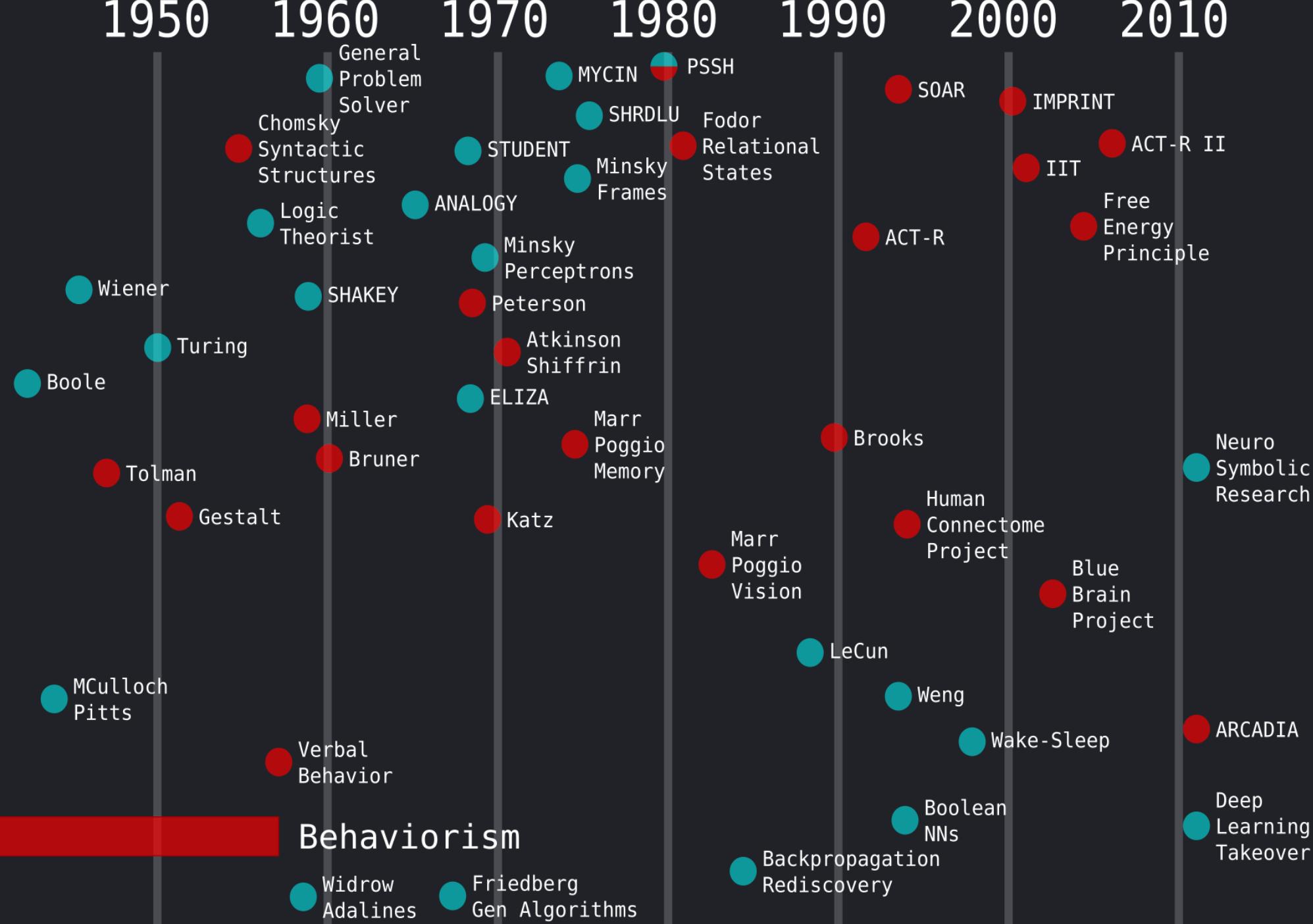
Structure of this presentation

Instead of sections, we'll go through some interesting points throughout the history.

Then, we'll tackle symbols-subsymbols briefly.

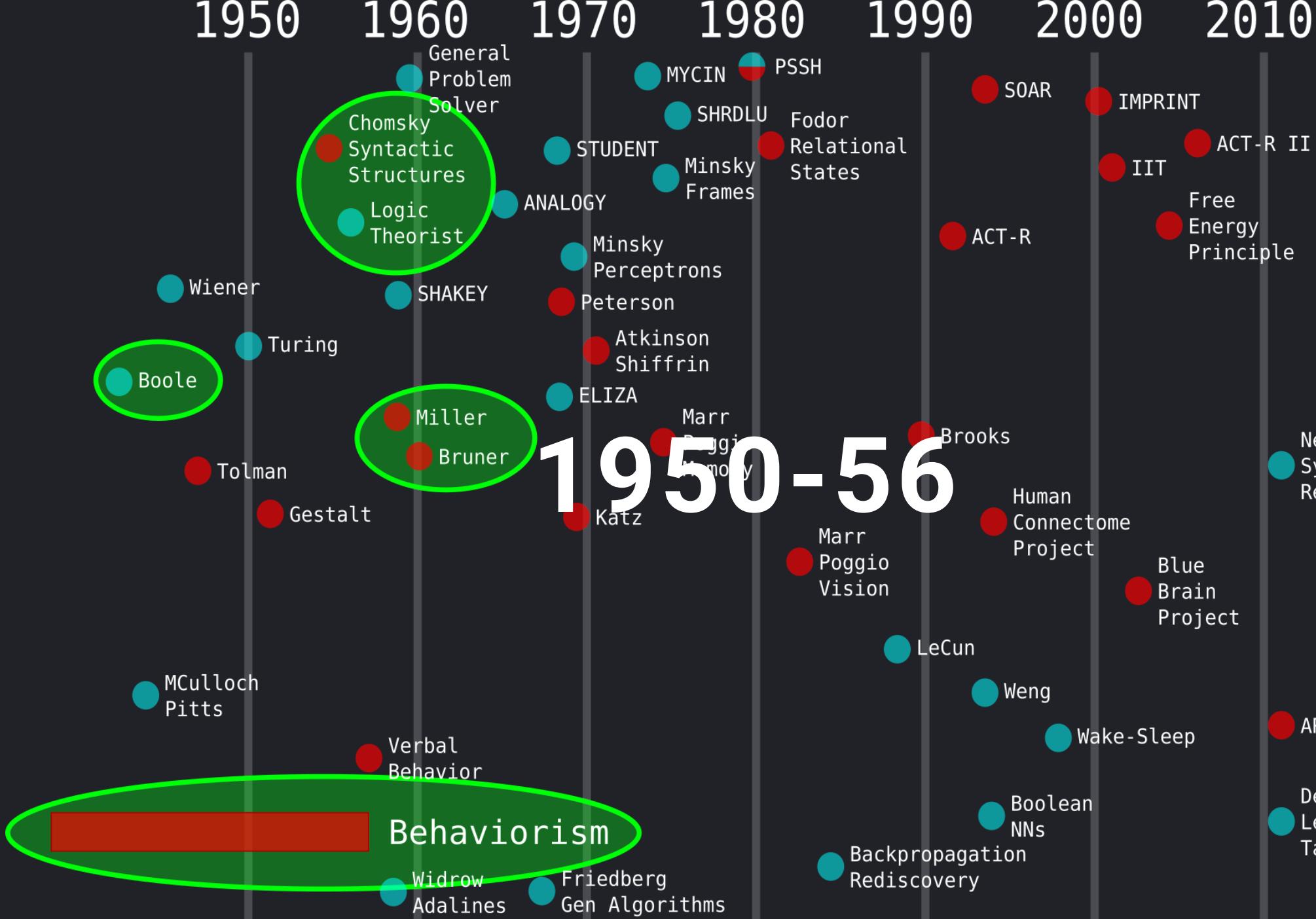
SYMBOLIC

CONNECTIONIST



SYMBOLIC

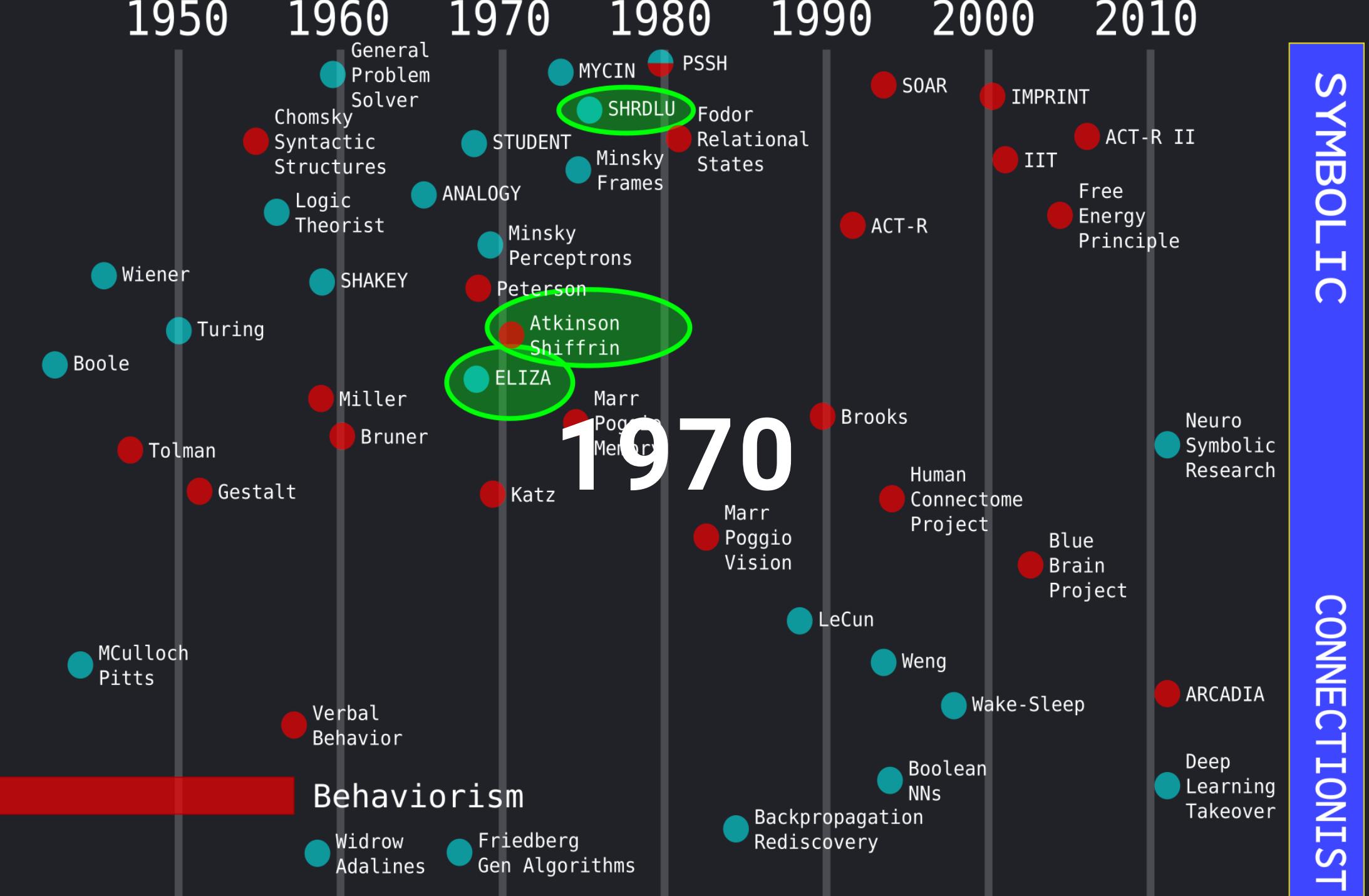
CONNECTIONIST



1950-56

Climate and pivotal year

- Boole
- Behaviorism (+past)
- Dartmouth College Workshop
- Miller "7", Bruner-Goodnow-Austin "A Study of Thinking"
- Chomsky 1957



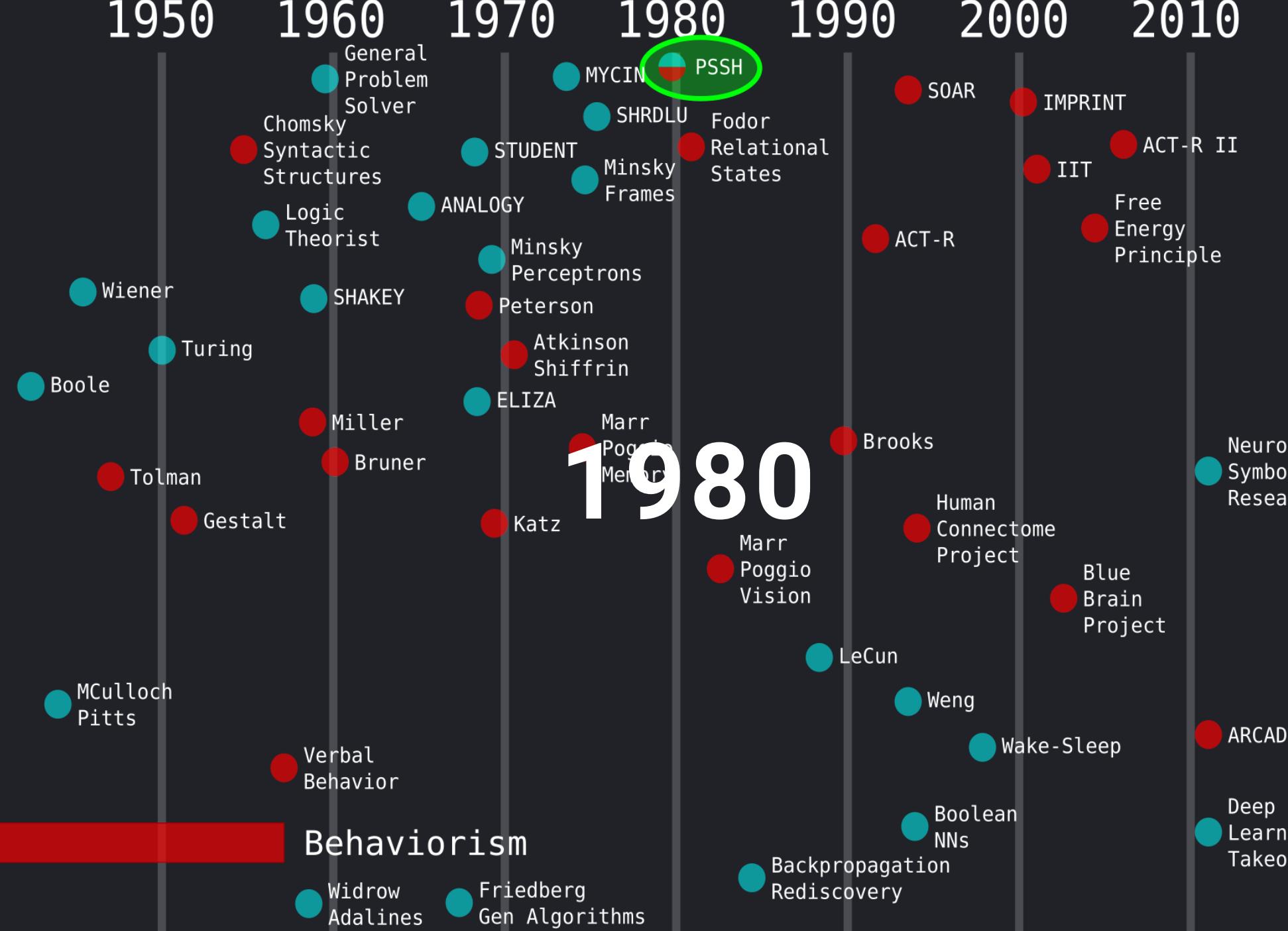
1970

Symbols

- SHRDLU
- ELIZA
- Atkinson Shiffrin memory model

SYMBOLIC

CONNECTIONIST



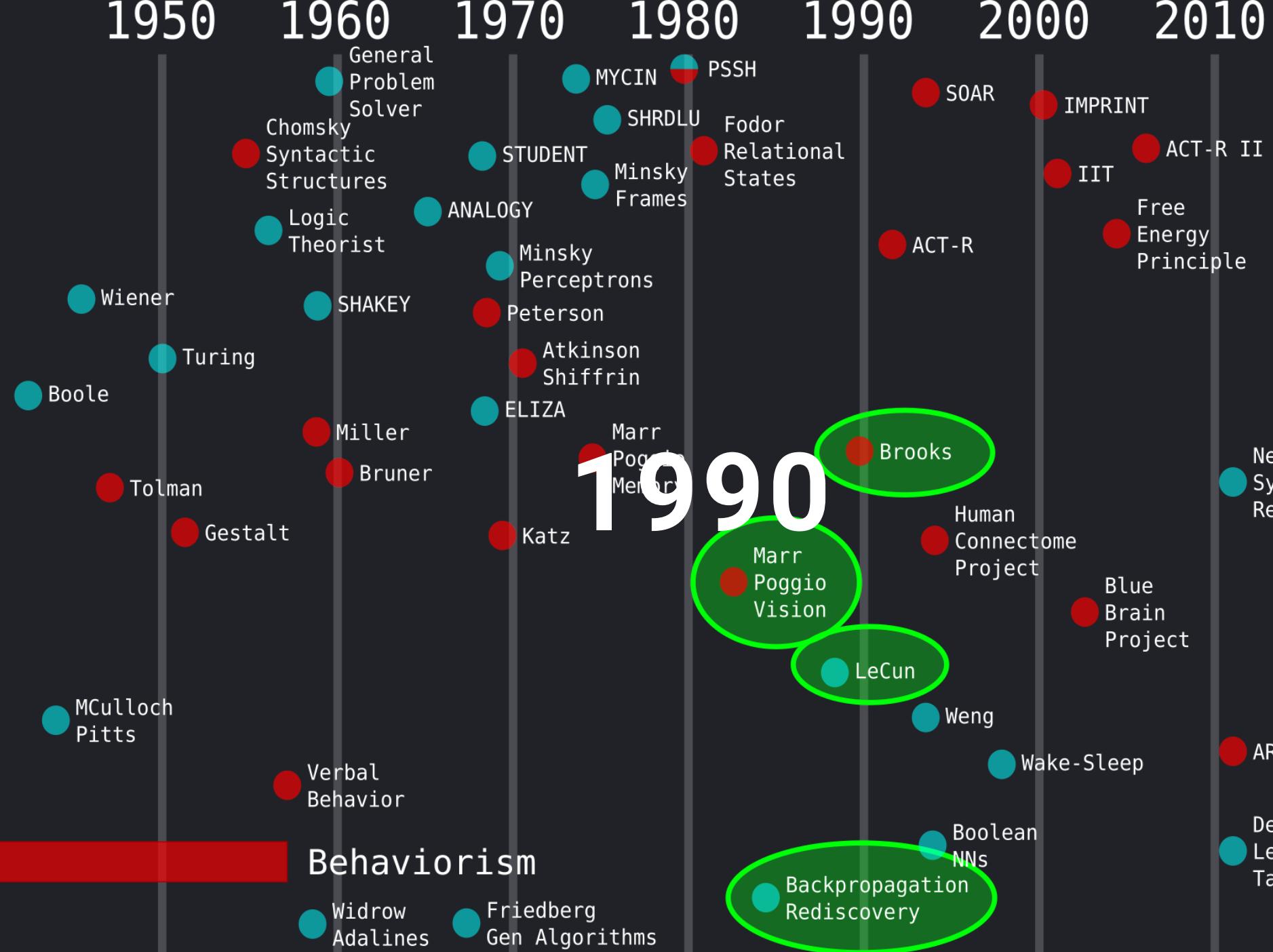
1980

Expert Systems

- 1976 PSSH
- Expert Systems (MYCIN, Dendral)
- Computational Theory of Mind

SYMBOLIC

CONNECTIONIST

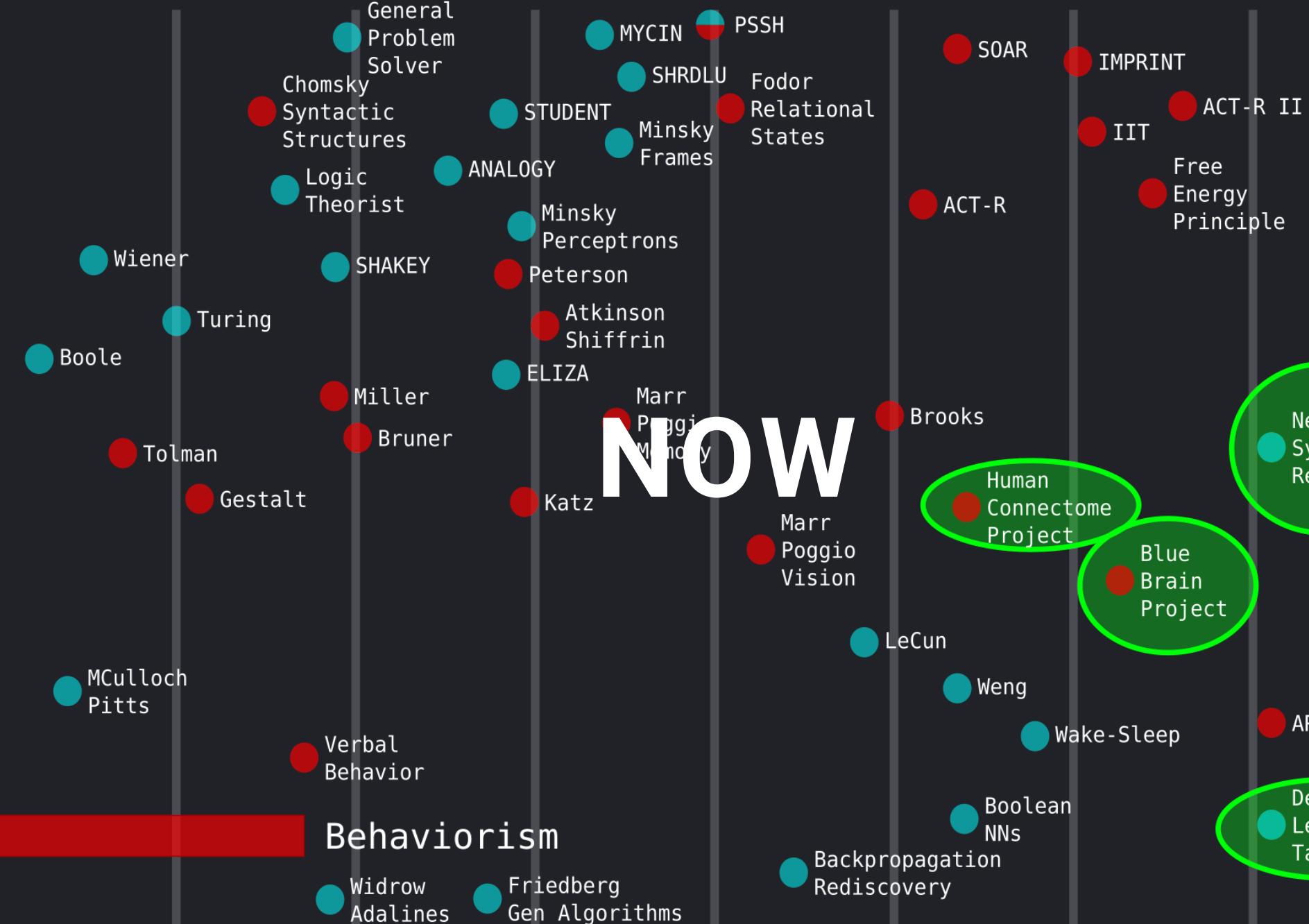


1990

Embodiment

- Brooks 1990
- Connectionism (LeCun, backpropagation)
- Computational Neuroscience, Modularism

1950 1960 1970 1980 1990 2000 2010



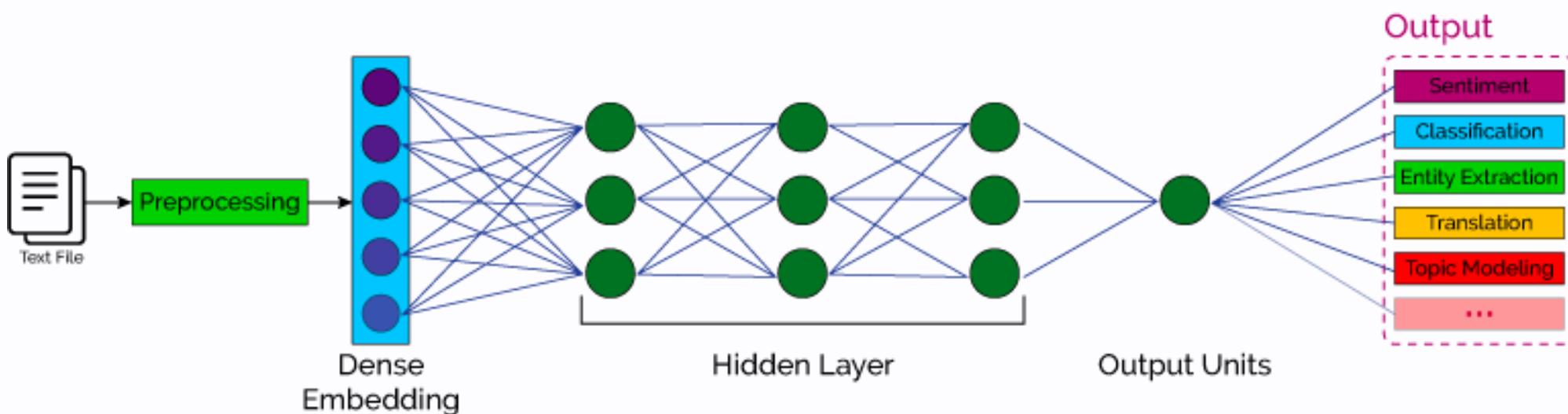
"NOW"

- Deep learning:
 - Image processing
 - Natural Language Processing
- Neuro-symbolic Reasoning
- Human Connectome, Human brain project

Symbolic-neuro integration

Symbolic - neuro - symbolic

- normal neural networks
- standard approach



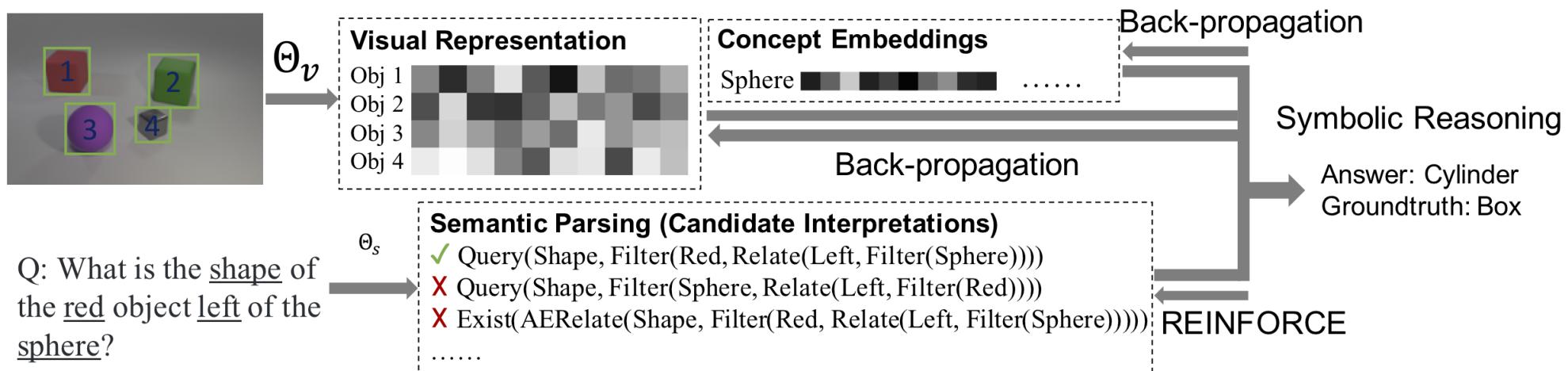
Symbolic[Neuro]

- Monte Carlo Tree Search + NN for state estimation
- Self driving cars
- Great success in game-playing



Neuro; Symbolic

From neuro perception to symbolic reasoning
(Neuro Symbolic Concept Learner)



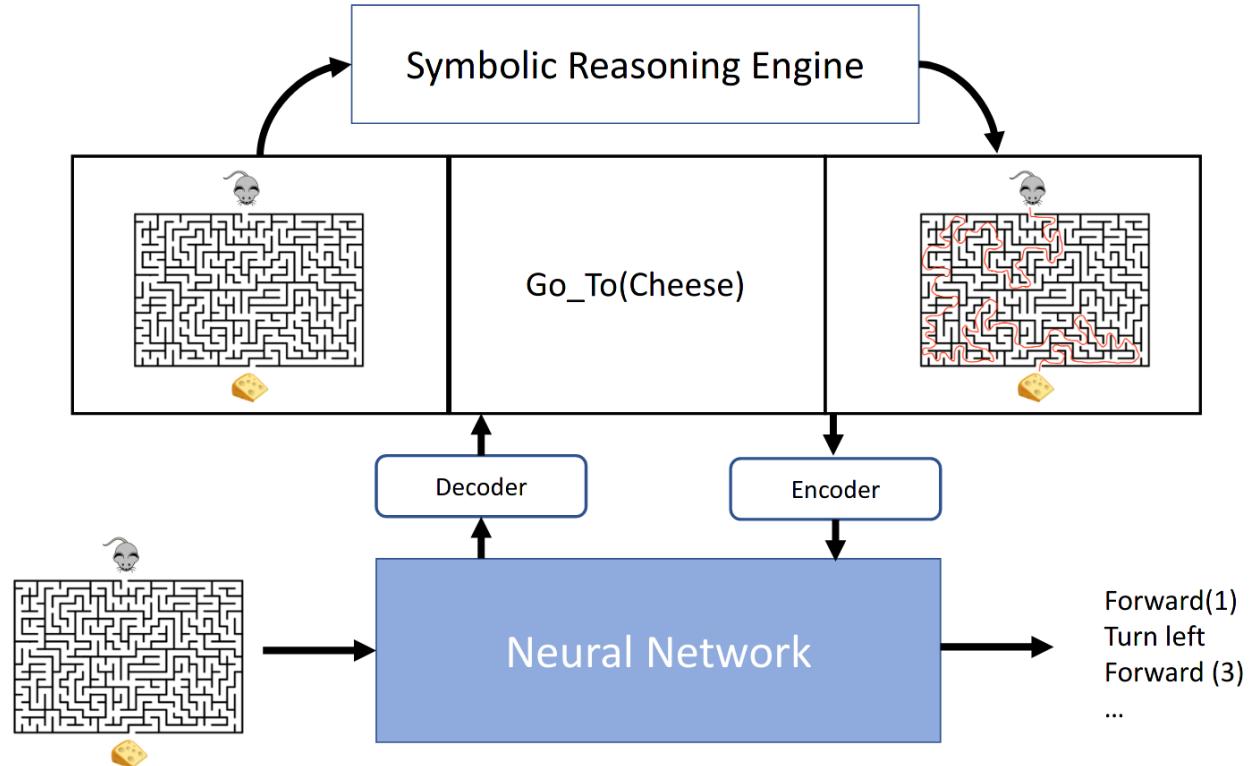
Neuro: Symbolic \rightarrow Neuro

- Training converts symbolic rules to training pairs
- No correctness guarantee
- E.g: Deep Learning for Symbolic Mathematics

Neuro_Symbolic

- Using symbolic rules as guidelines or *templates* for connectionist structures
- Logic Tensor Networks:
 - formulas -> fuzzy logical reasoning
 - object features -> error minimization
 - all in Neural Network

Neuro [Symbolic]



Kautz ends on these hypothetical models, which would be able to encode and decode into and from a **symbolic** reasoning engine

Conclusion

In this presentation, we went over some relevant passages of the thesis. After some history, we went over the difference between symbol and subsymbol-representations, and ways to integrate them.

Sources not included in thesis bibliography:

- Kautz slides
- Logic Tensor Networks
- Deep Learning for Symbolic Mathematics
- images: NN, AlphaGO, NSCL

Please find all other historical sources in the thesis
bibliography

Thanks!