

Temporal Abstraction for Knowledge Representation

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The Big Question

- grounding knowledge in experience
- building abstractions from experience

Working Bottom-Up

- **have** experience
- knowledge that describes and is defined by experience
- what can we say in the language of experience

New Tools

- options
 - temporal abstraction over actions
- predictions
 - temporal abstraction of observations
- temporal coherence
 - consistency over time in some state variable

Options

(Sutton, Precup, and Singh, 99)

- three parts:

- initiation set

\mathcal{I}

- policy

$\pi(\mathbf{x}, a)$

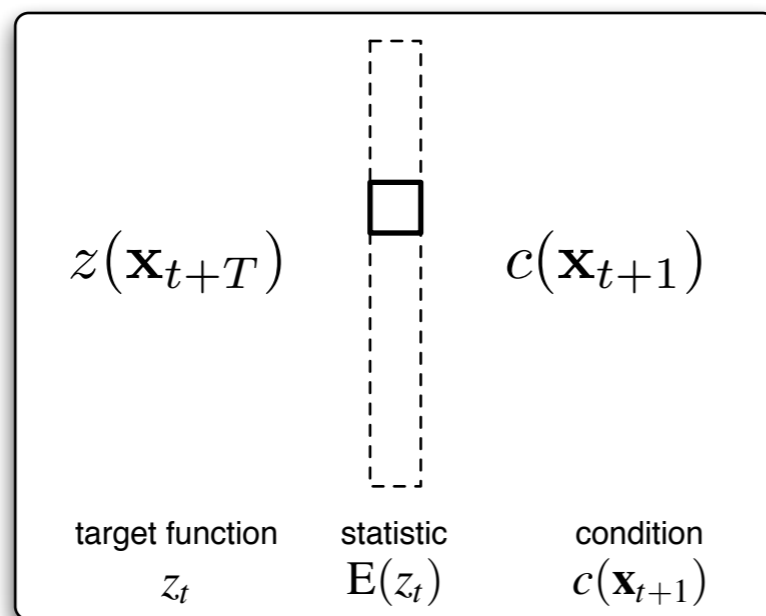
- termination condition

$\beta(\mathbf{x})$

Predictions

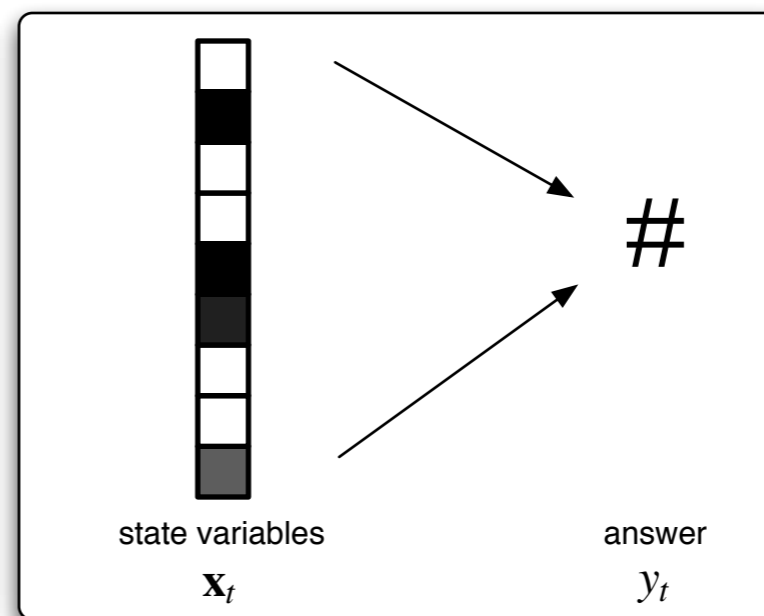
- question and answer

Question function



$$\mathcal{L}(f_t)$$

Answer function

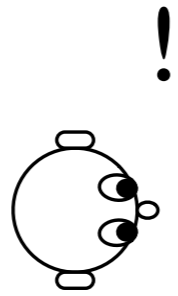


$$\sigma(\mathbf{w}_t, \mathbf{x}_t)$$

The Object Concept

- introduced by Piaget as a way of describing children's growing understanding of the physical world
- objectivist description: objects continue to exist whether or not they are observed

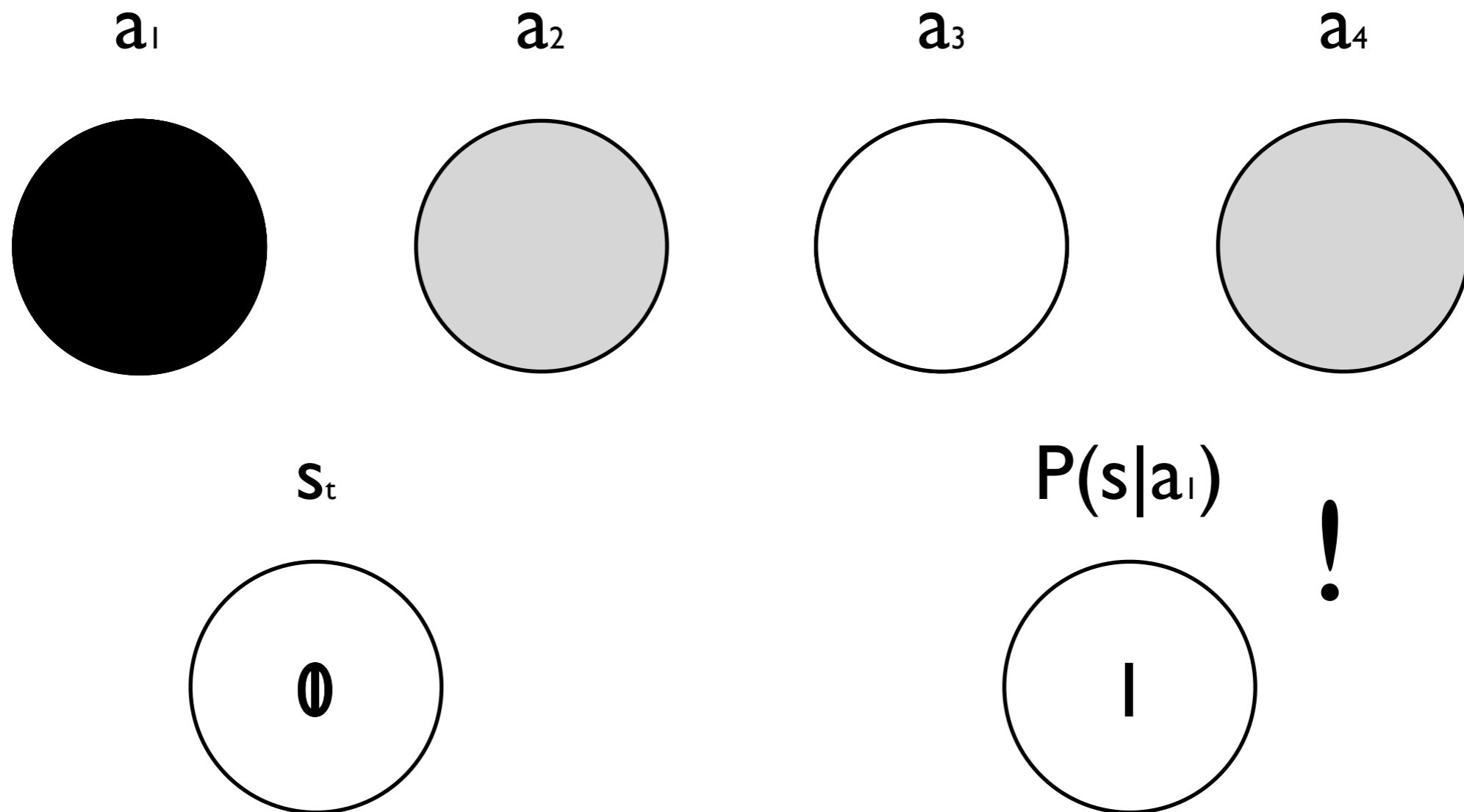
Persistence



Knowledge of Persistence

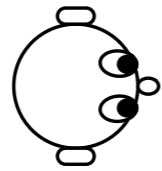
- Objectivist view:
 - Objects continue to exist when you look away.
- Empirical view:
 - A prediction conditioned on looking back has a high degree of temporal coherence.

Empirical Representation Persistence



Permanence

!



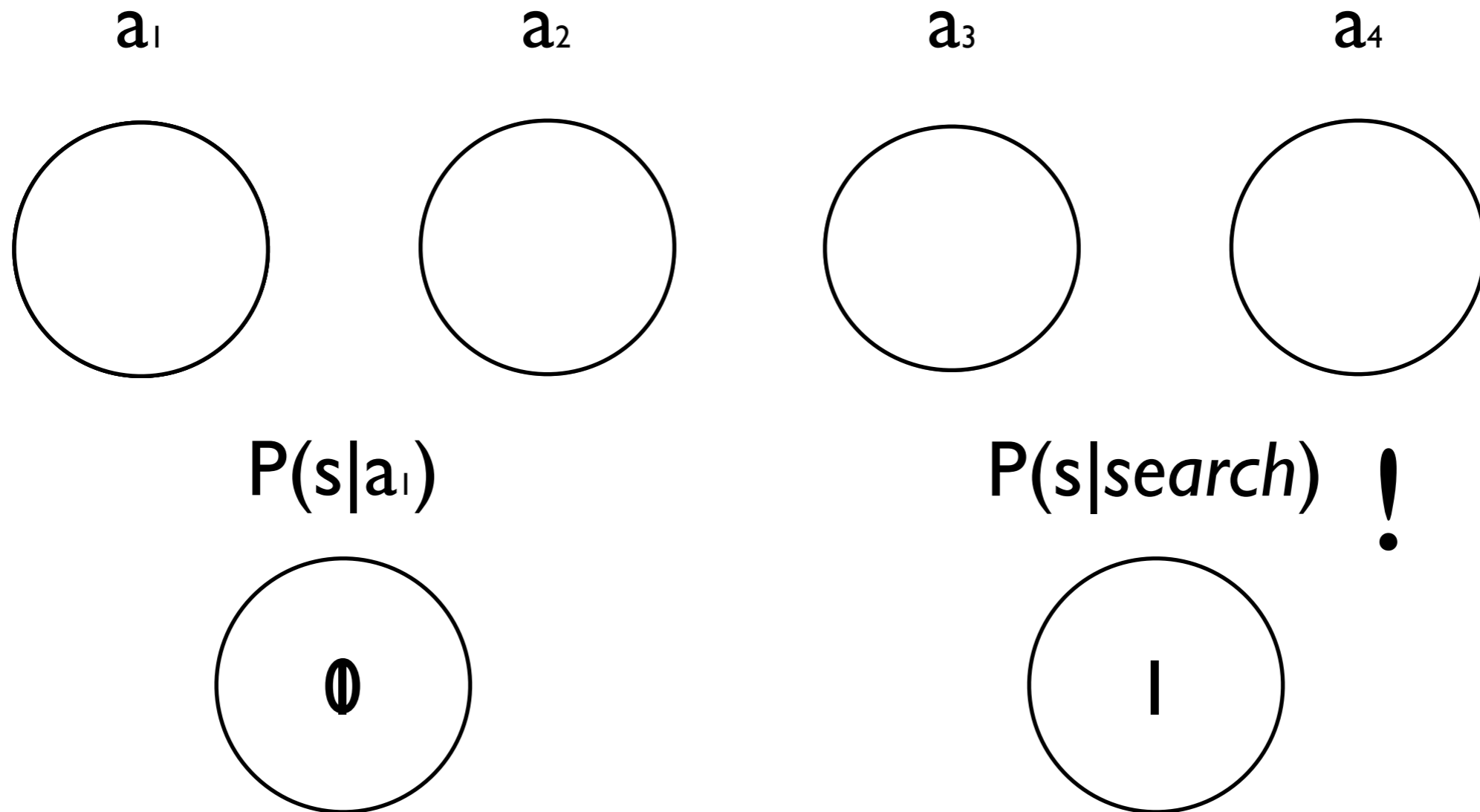
Knowledge of Object Permanence

- Objectivist view:
 - Objects continue to exist even when they are hidden by other objects.
- Empirical view:
 - A prediction conditioned on an appropriate option has a high degree of temporal coherence

Empirical Representation of Permanence

- Search option
 - \mathcal{I} anytime
 - π chose next action
 - β once every action has been chosen

Empirical Representation of Permanence



Conclusion

- experience-grounded abstractions possible
- can have surprisingly abstract concepts
 - predictions
 - options

Questions?

