# The Physics of Intelligence

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Founder, CEO & Chief Scientist, Dyssonance AI

*The Science of Consciousness 2026, San Diego*

DYSSONANCE

Act I

# Information Is Not What We Thought

# Looking at AI Through a Physics Lens

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PHYSICS

*Sorbonne*
*BaBar / SLAC*

Understanding of
fundamental systems

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*Sorbonne*
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Understanding of fundamental systems

MACHINE LEARNING

*Walmart Labs*
*Atlassian*
*Figure Eight*

Building systems for the real world

# Looking at AI Through a Physics Lens

## PHYSICS

*Sorbonne*
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Understanding of fundamental systems

## MACHINE LEARNING

*Walmart Labs*
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*Figure Eight*

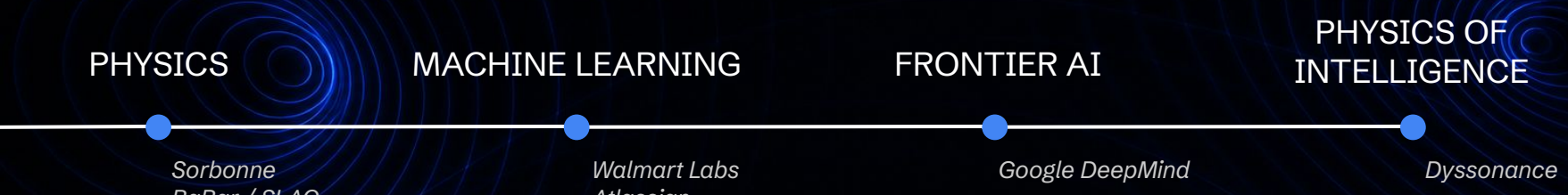
Building systems for the real world

## FRONTIER AI

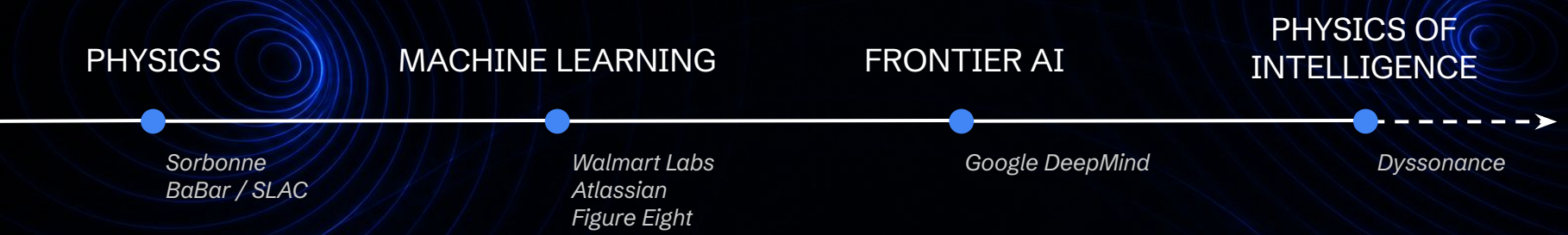
*Google DeepMind*

Discovering the limits of the paradigm

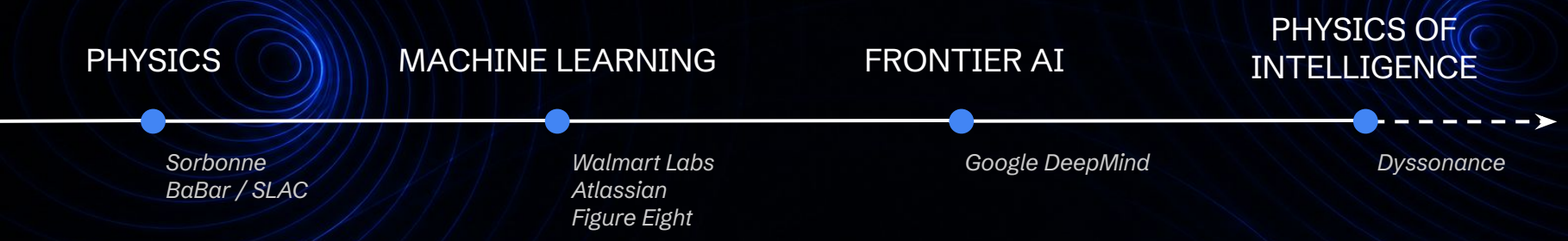
# Looking at AI Through a Physics Lens



# Looking at AI Through a Physics Lens



# Looking at AI Through a Physics Lens




ENABLE & ACCELERATE
RESEARCH + ENTERPRISE AI

data • infrastructure • systems

# What Wrestling With Data Taught Me

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DATA > MODEL

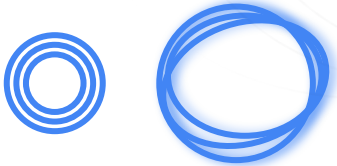


# What Wrestling With Data Taught Me

DATA > MODEL



QUALITY > SCALE

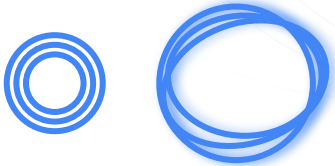


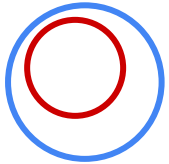
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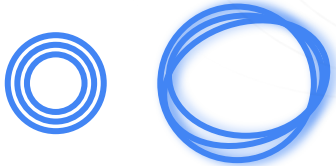
INFORMATION ≠ DATA

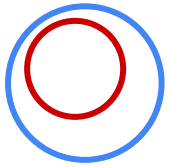
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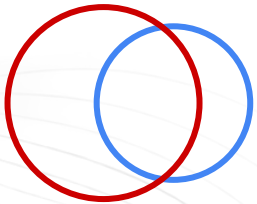


QUALITY > SCALE





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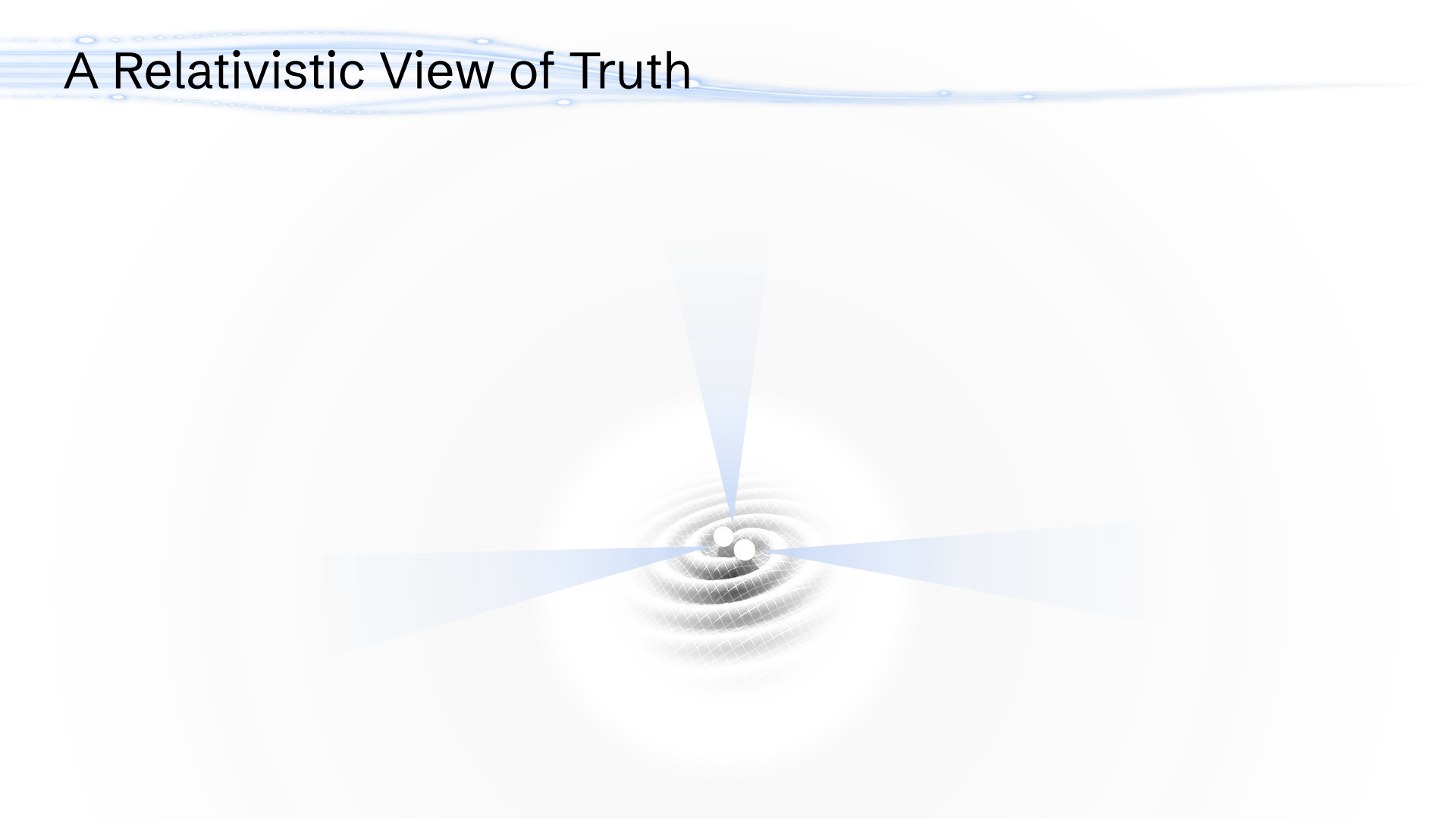
INFORMATION ⊄ DATA

# A Relativistic View of Truth

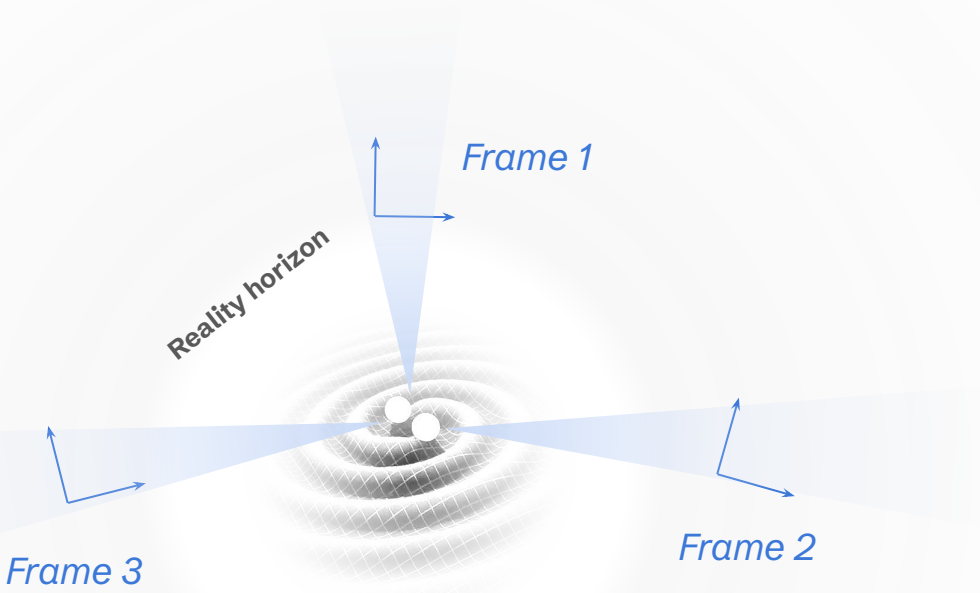
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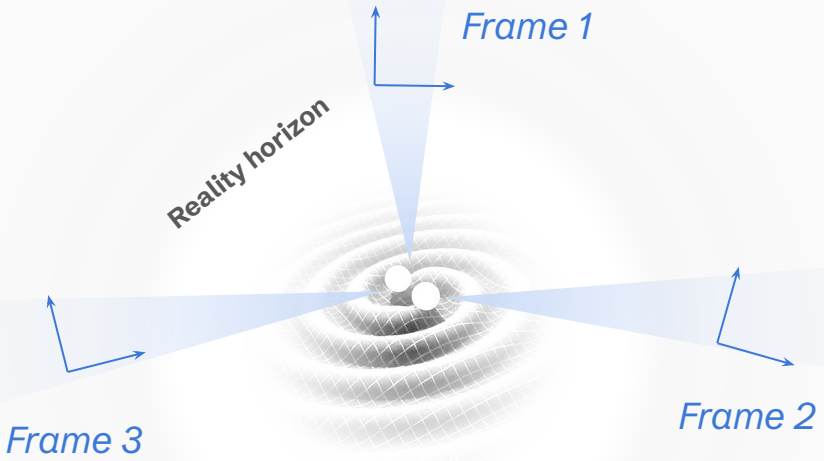
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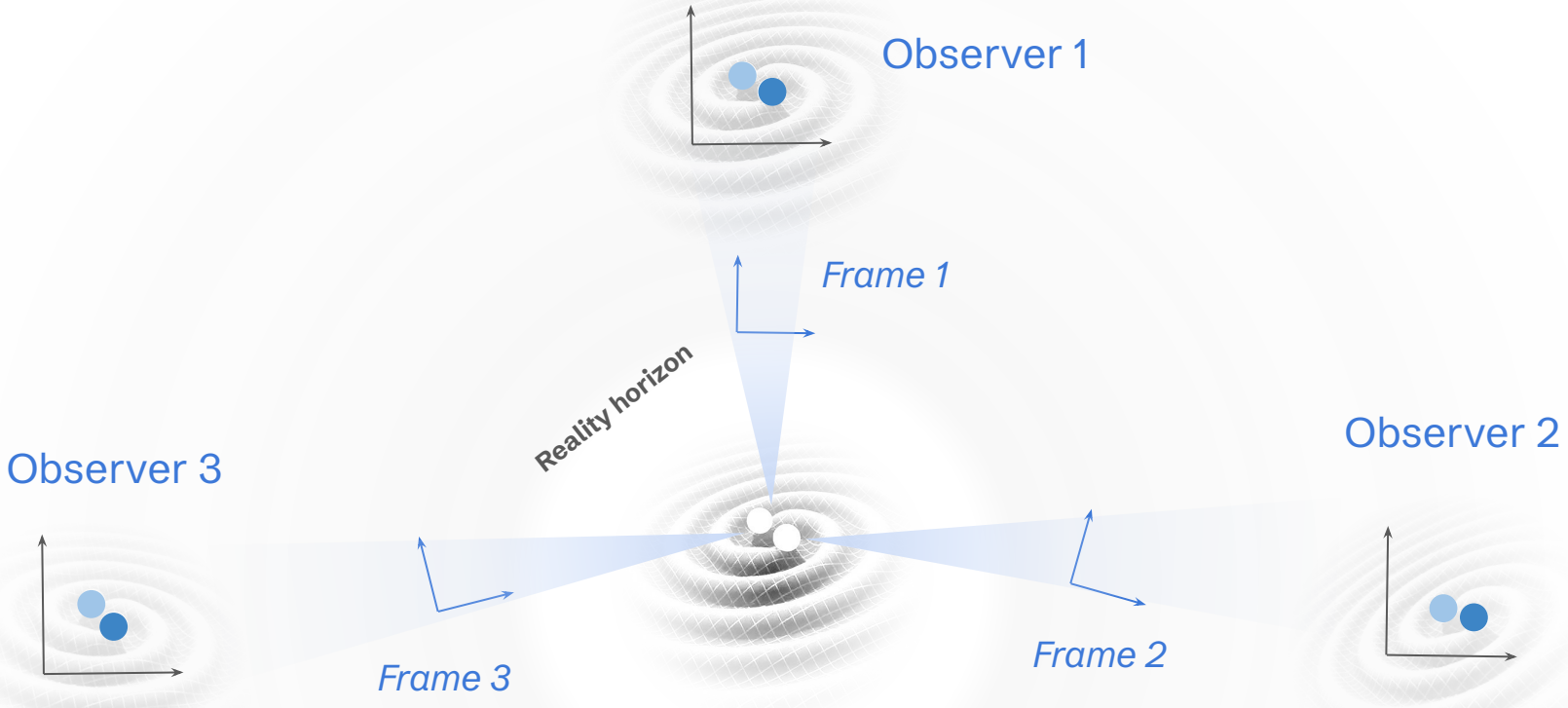
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# When Variance *Is* the Signal

# When Variance *Is* the Signal

Observer 1

$O_1$

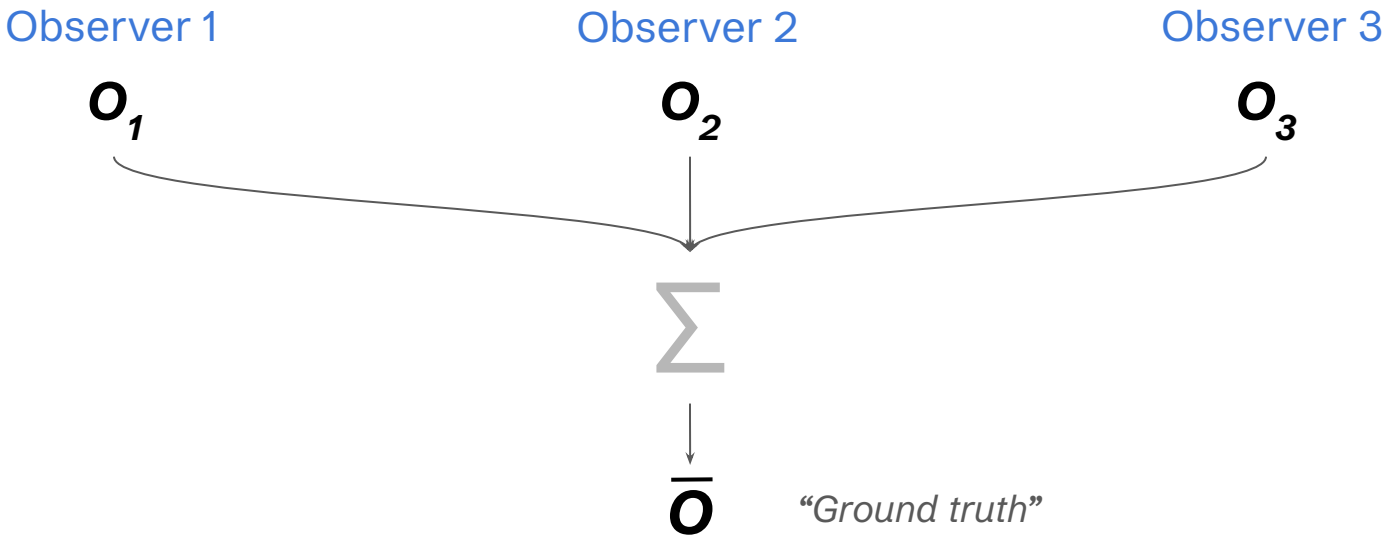
Observer 2

$O_2$

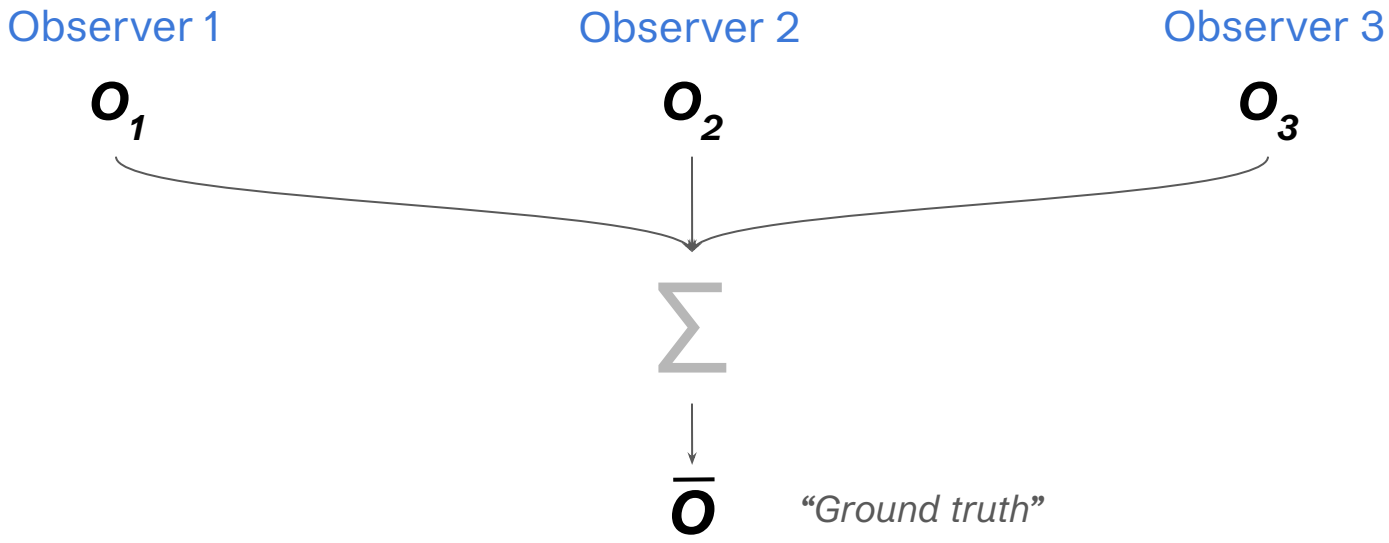
Observer 3

$O_3$

# When Variance *Is* the Signal



# When Variance *Is* the Signal




$S_1$ *Frame lost 1*

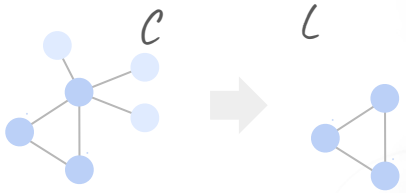
$S_2$ *Frame lost 2*

$S_3$ *Frame lost 3*

# That’s Why Language Is Lossy

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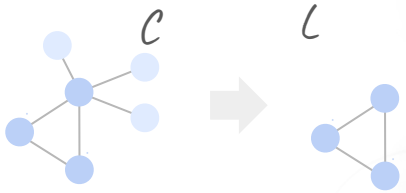
## Non-Survivability




$$C_i \xrightarrow{\pi_L} L_i$$

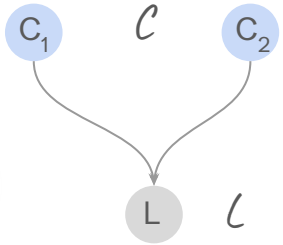
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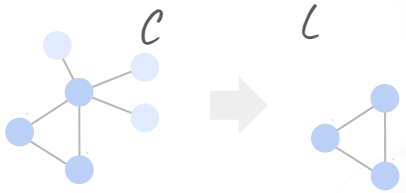
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$$C_1 \neq C_2$$
$$\wedge$$
$$L(C_1) = L(C_2)$$

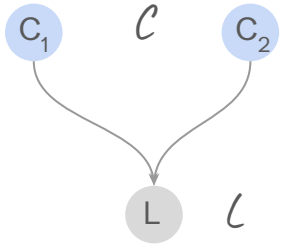
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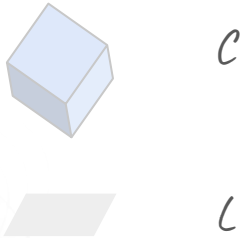

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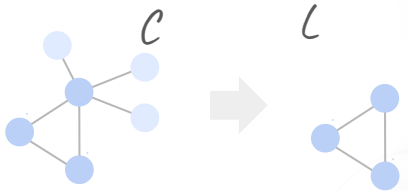
## Dimensional Collapse




$$C_1 \neq C_2$$
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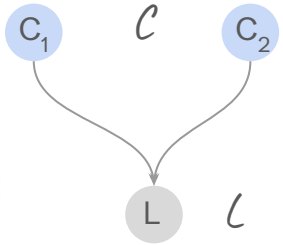
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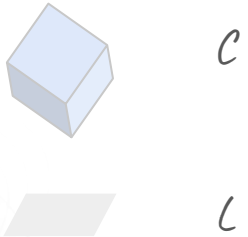

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$$\pi_L(C_1) = \pi_L(C_2)$$

$$\pi^{-1}(L) \text{ is not unique}$$

**Language is not an invertible function of thought.**

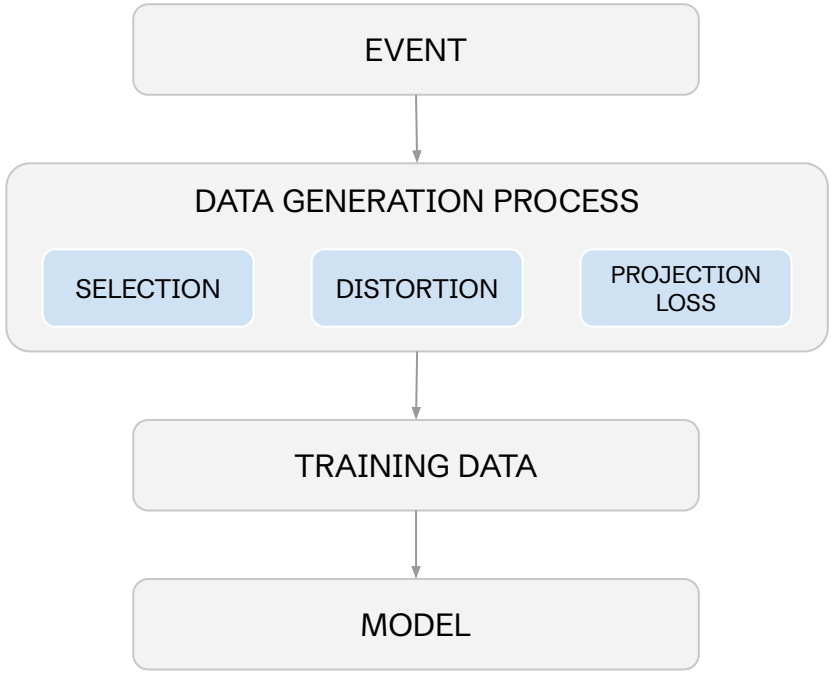
*We mistook an observable of cognition for the substrate of cognition.*

Act II

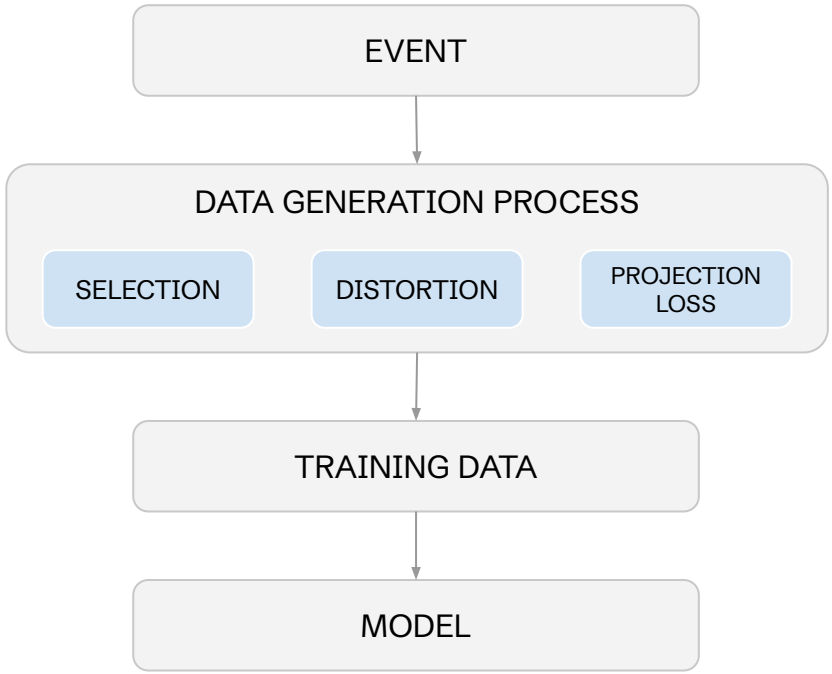
# We Built AI Backwards

# What Do We Even Mean by “Learning”?

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## Selection

Not everything becomes data

unexpressed experiences • non-recorded expressions • non-random misses

## Distortion

What becomes data may be altered

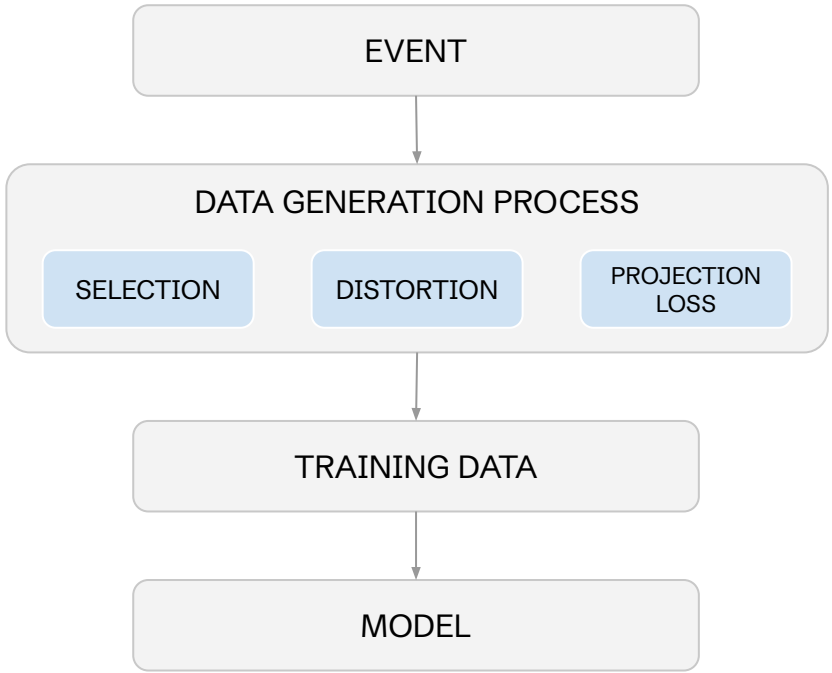
Misinterpretation • misrepresentation • memory error • incentives / rhetoric / social desirability

## Projection Loss

Even sincere expression is incomplete

language lossiness • cognition does not fully survive expression • the process is not invertible

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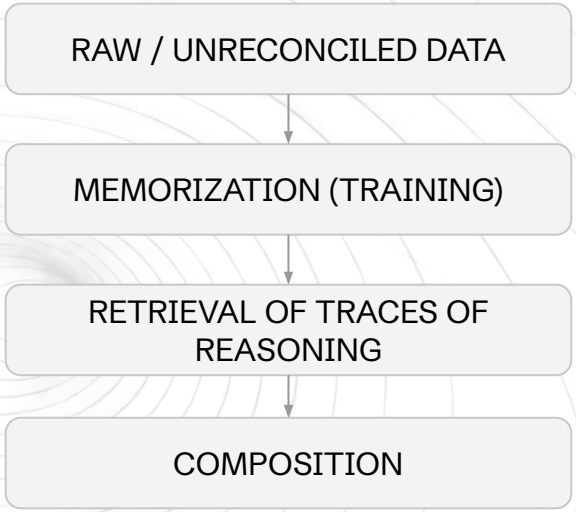
Learning the Data ≠ Understanding the Reality that Generated it

Memorization is not a substitute for learning

# Reasoning Shouldn’t Be Separate from Memory

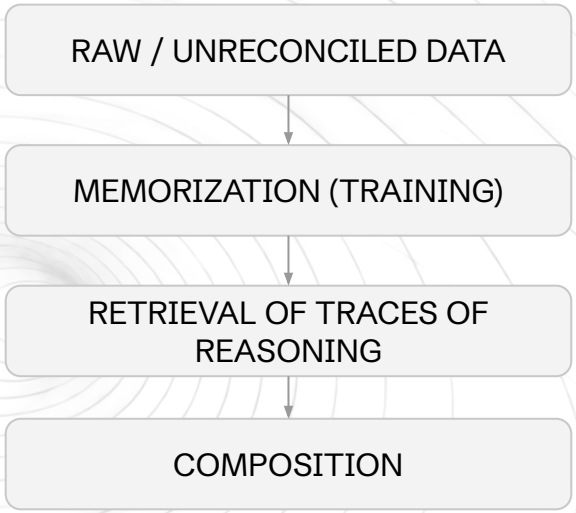
# Reasoning Shouldn’t Be Separate from Memory

## Reason Over Memory



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## Reason Over Memory




### Errors propagate

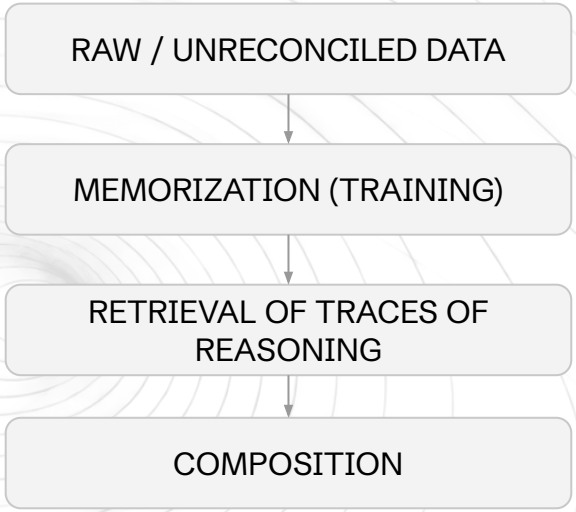
The reasoning substrate contains contradictions, ambiguity and low-quality traces.

### Computation restarts

Every new task has to retrieve and reconcile the raw material again.

# Reasoning Shouldn’t Be Separate from Memory

## Reason Over Memory



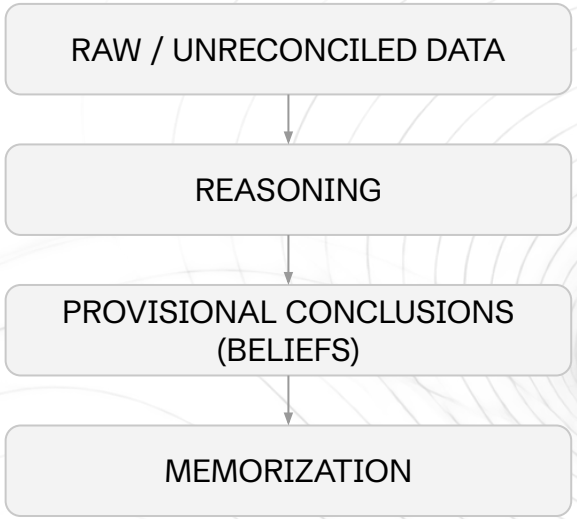

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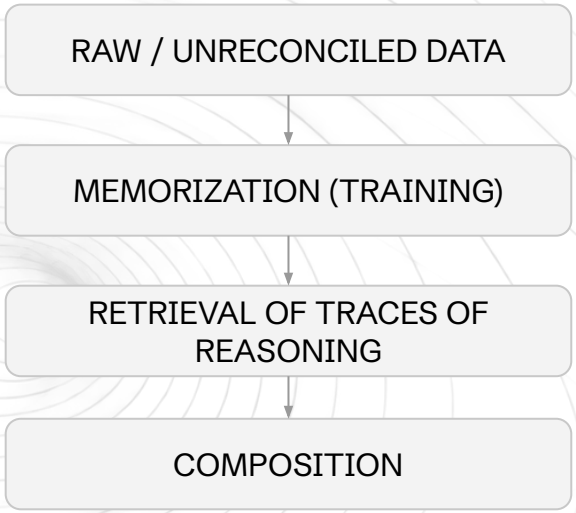
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## Remember the Output of Reasoning



# Reasoning Shouldn’t Be Separate from Memory

## Reason Over Memory



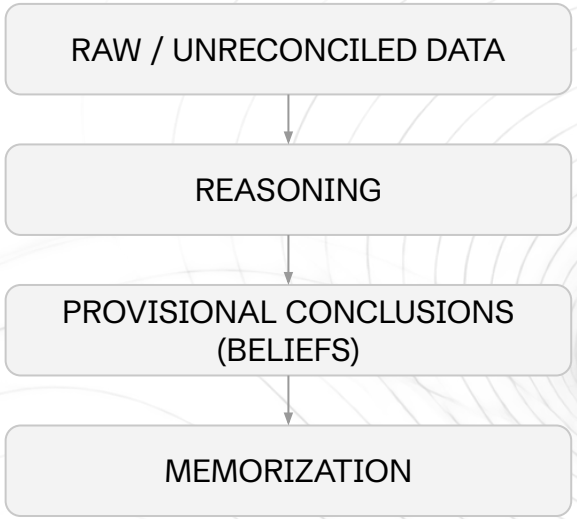

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The reasoning substrate contains contradictions, ambiguity and low-quality traces.

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Every new task has to retrieve and reconcile the raw material again.

## Remember the Output of Reasoning




### Better substrate

Future reasoning starts from reconciled conclusions, not raw contradictions.

### Cumulative reasoning

the system builds on prior computation instead of restarting.

# Data Needs to Be Compiled, Not Just Memorized

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DATA

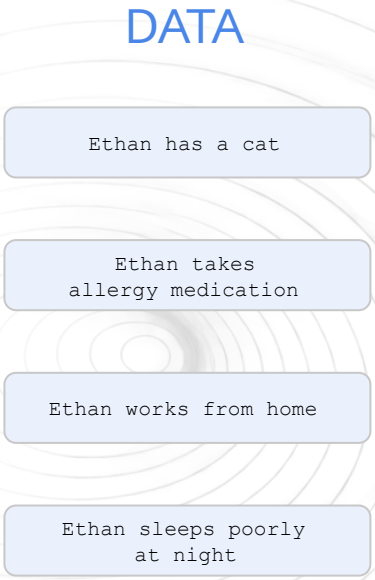
Ethan has a cat

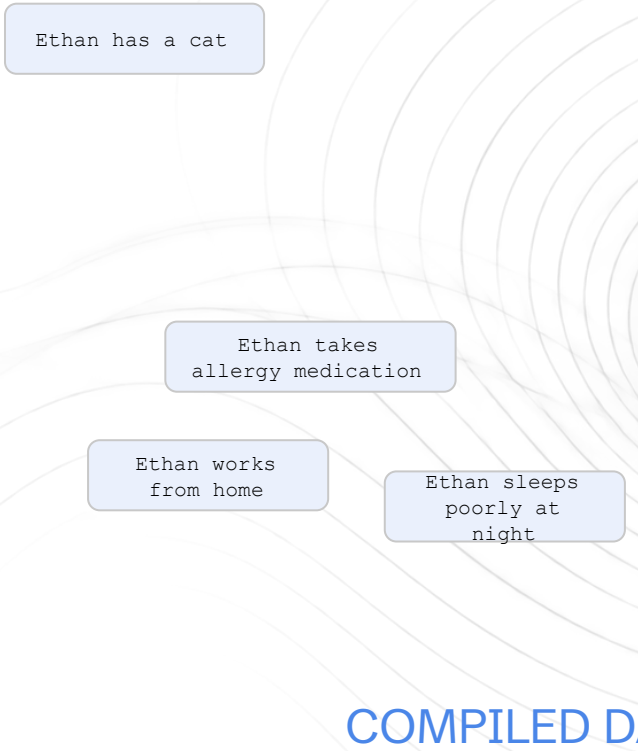
Ethan takes allergy medication

Ethan works from home

Ethan sleeps poorly at night

# Data Needs to Be Compiled, Not Just Memorized

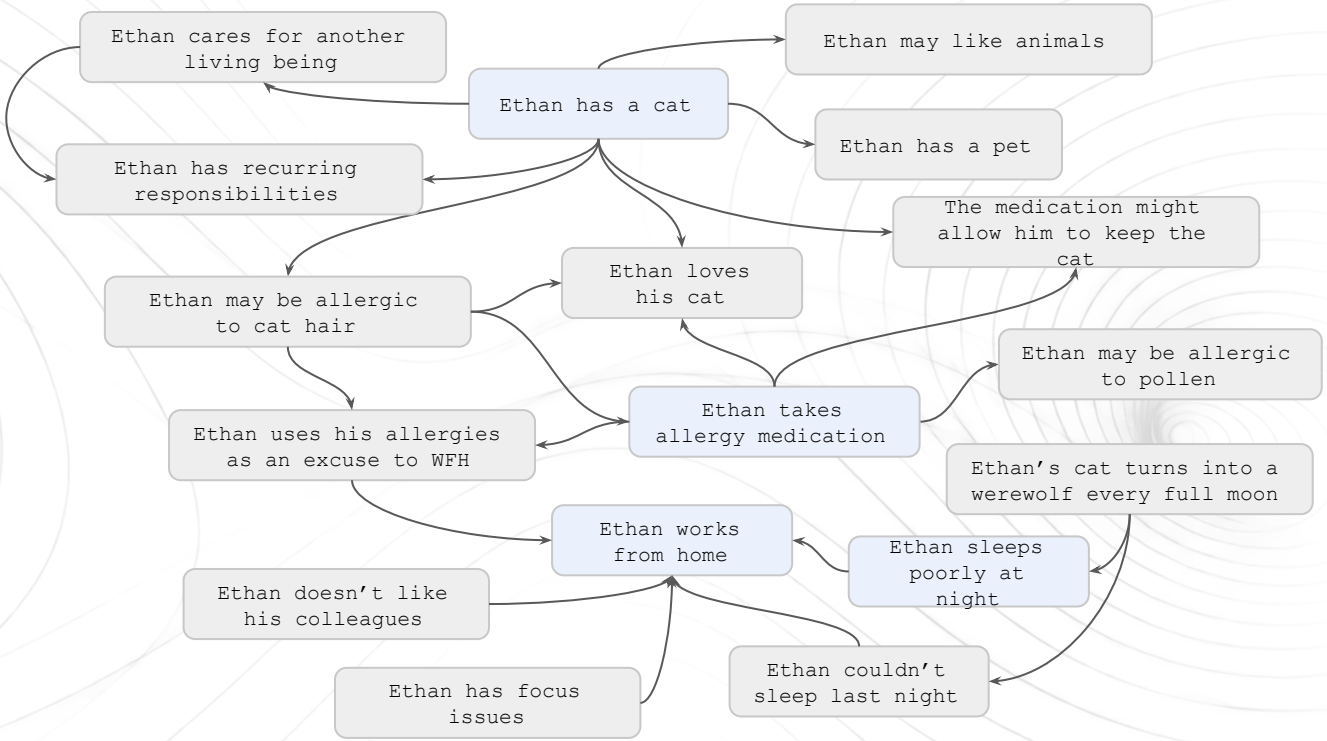


# Data Needs to Be Compiled, Not Just Memorized

## DATA

- Ethan has a cat
- Ethan takes allergy medication
- Ethan works from home
- Ethan sleeps poorly at night

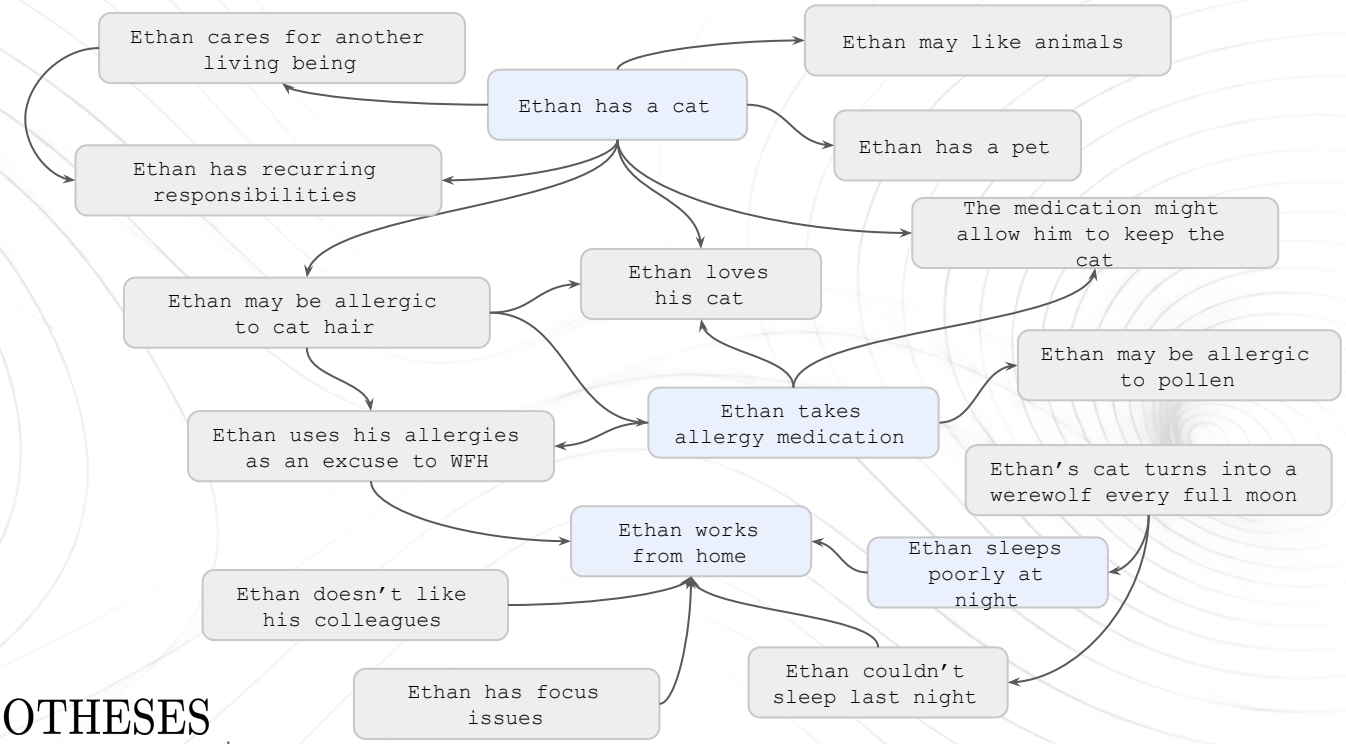



## COMPILED DATA

# Data Needs to Be Compiled, Not Just Memorized

## DATA

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DATA $\xrightarrow{\text{REASONING}}$ HYPOTHESES

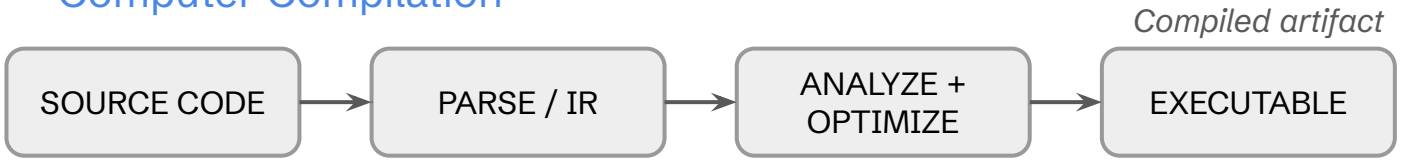
INTERPRETATION

COMPILED DATA

# Reasoning Requires Statefulness

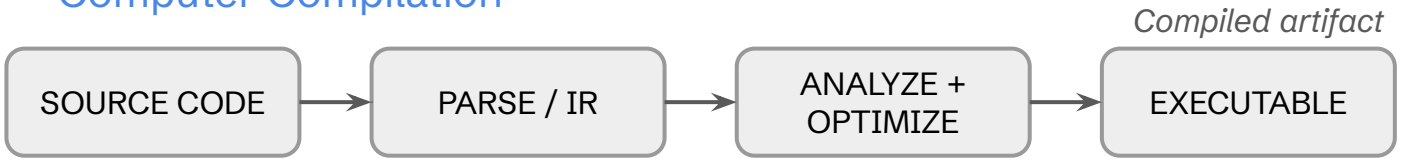
# Reasoning Requires Statefulness

## Computer Compilation

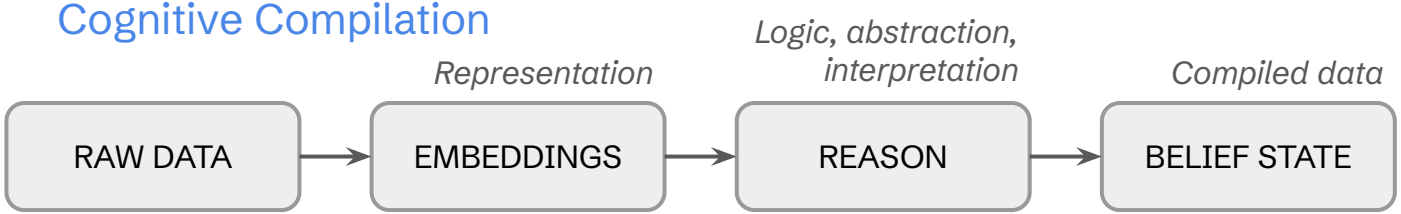


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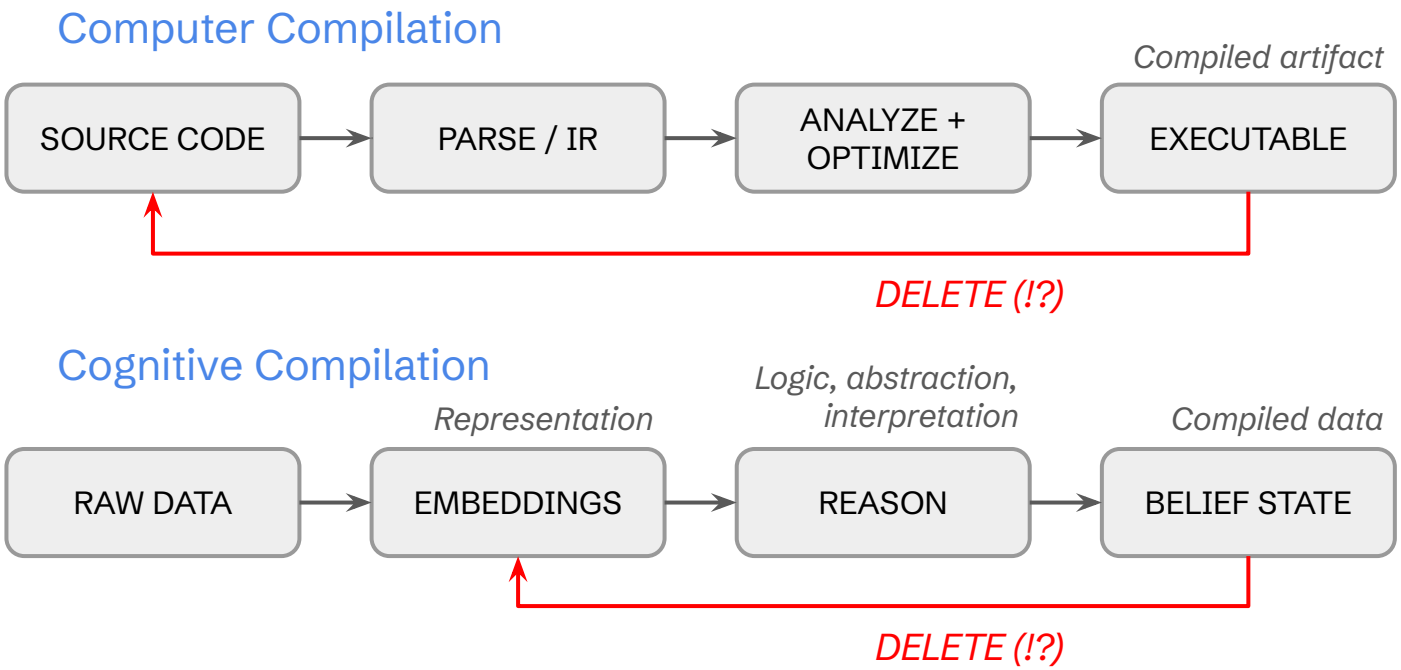
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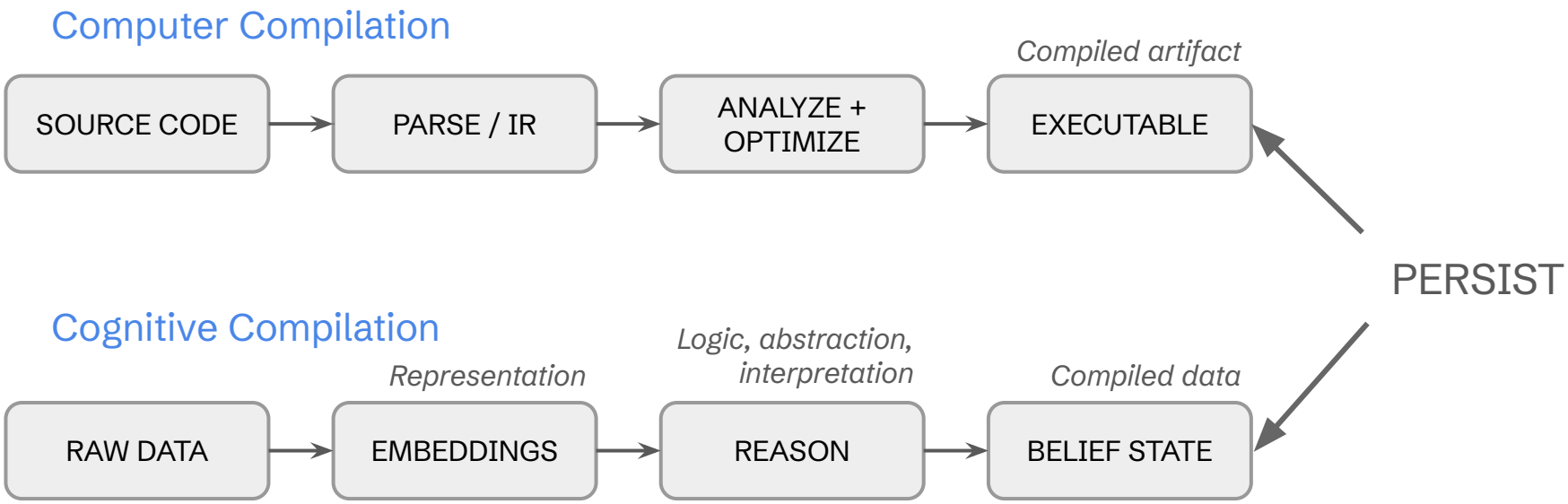

## Cognitive Compilation



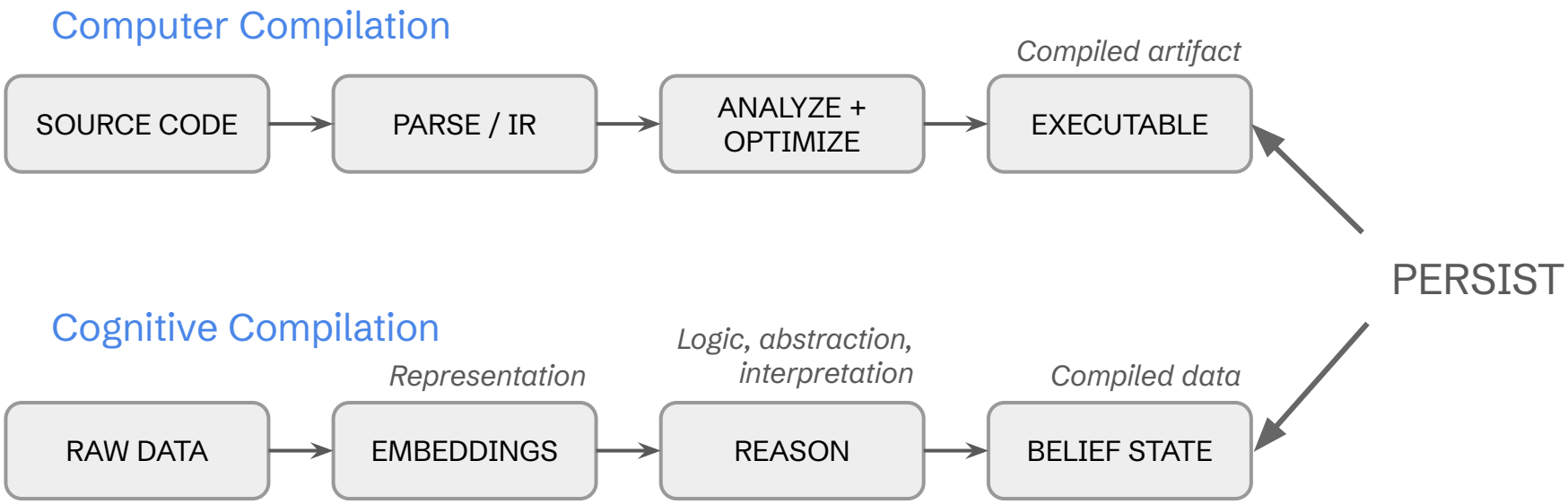
# Reasoning Requires Statefulness



# Reasoning Requires Statefulness



# Reasoning Requires Statefulness




Representations preserve transformed inputs.
State preserves the outputs of reasoning.

Reasoning is cumulative only if its output persists.

Act III

# Why Intelligence Is a Physics Problem

# Information Is Not Passive

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## Passive Quanta of Information




- Stored
- Represented

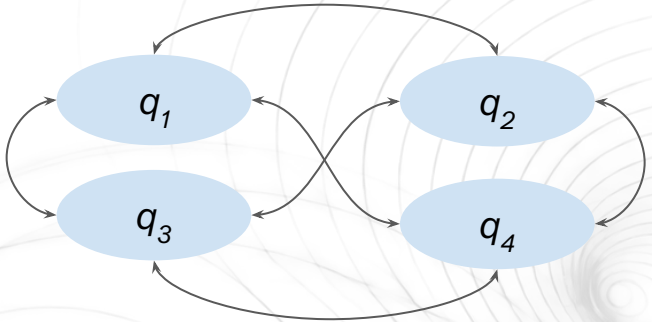
# Information Is Not Passive

## Passive Quanta of Information




- Stored
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## Active Quanta of Information




- Interacting
- State-Changing

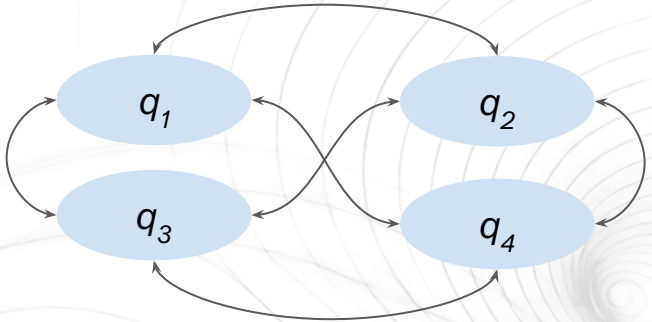
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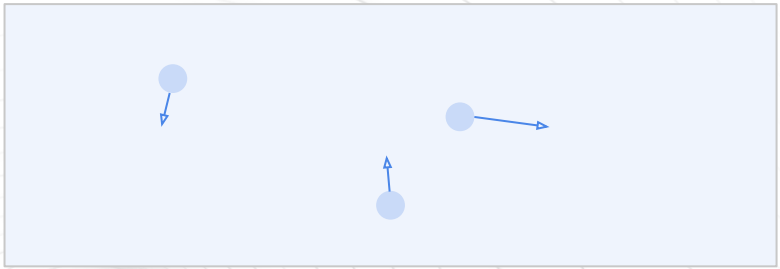

- Interacting
- State-Changing

If Information Acts on Information, Information Has Dynamics

# Causality Emerges from Informational Interaction

# Causality Emerges from Informational Interaction

## Sparse Regime



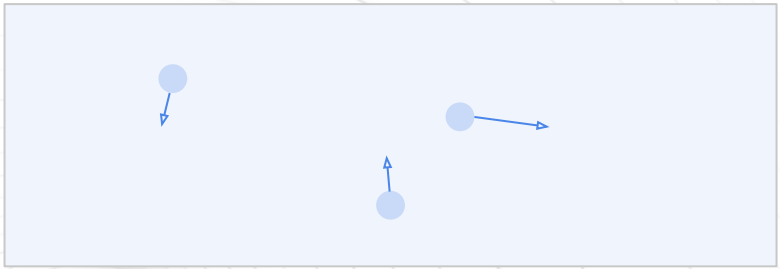
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**Ignoring interactions is a fair approximation.**

Few particles, few collisions, approximately independent behavior.

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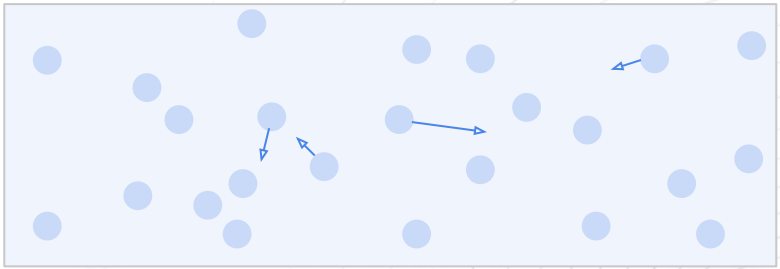


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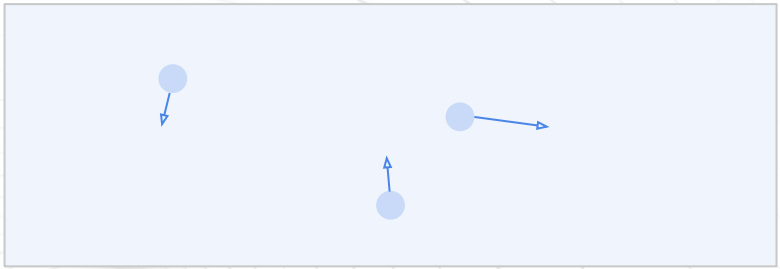
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**Scale changes the regime →** More information in the same representational neighborhood makes interactions increasingly difficult to ignore.

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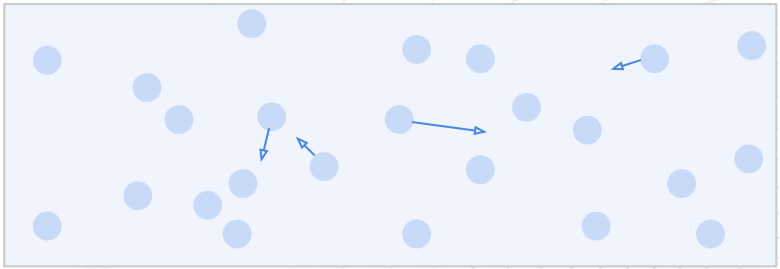


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The AI Regime

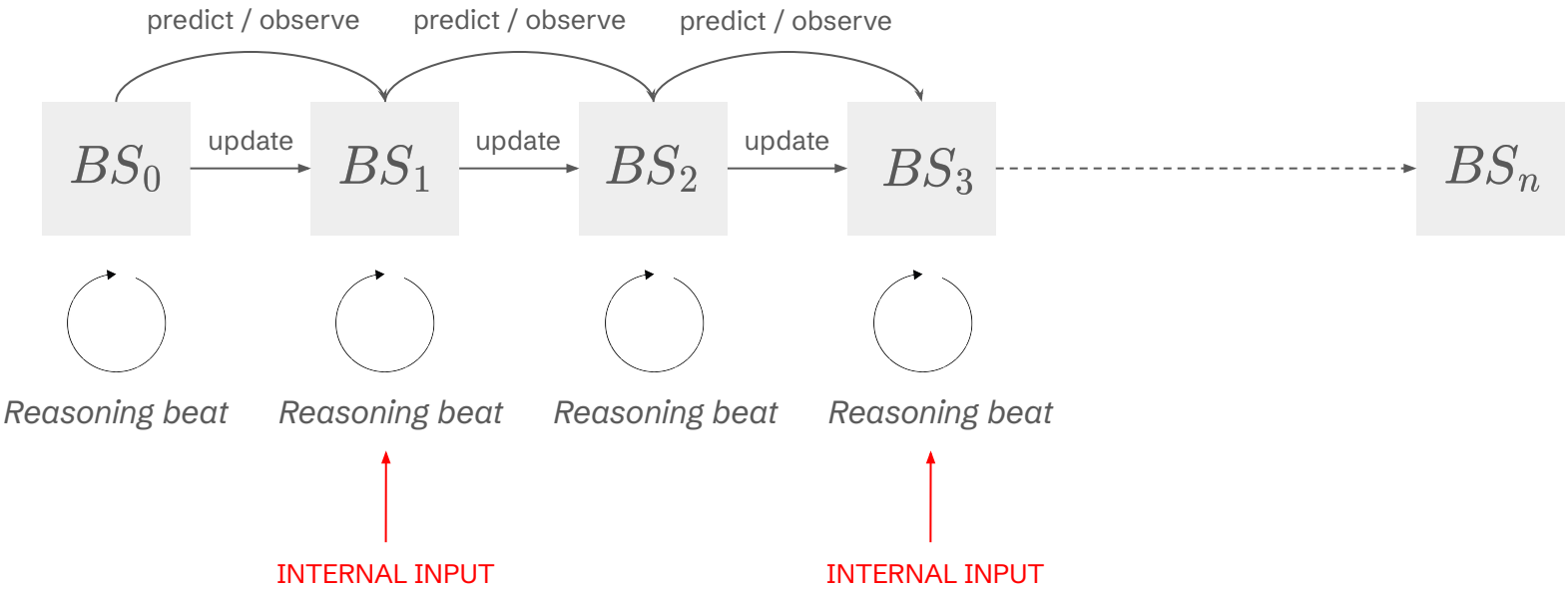
Data Volume ≠ Information Density → Density is relative to the representation space

# Cognition Is State Evolution

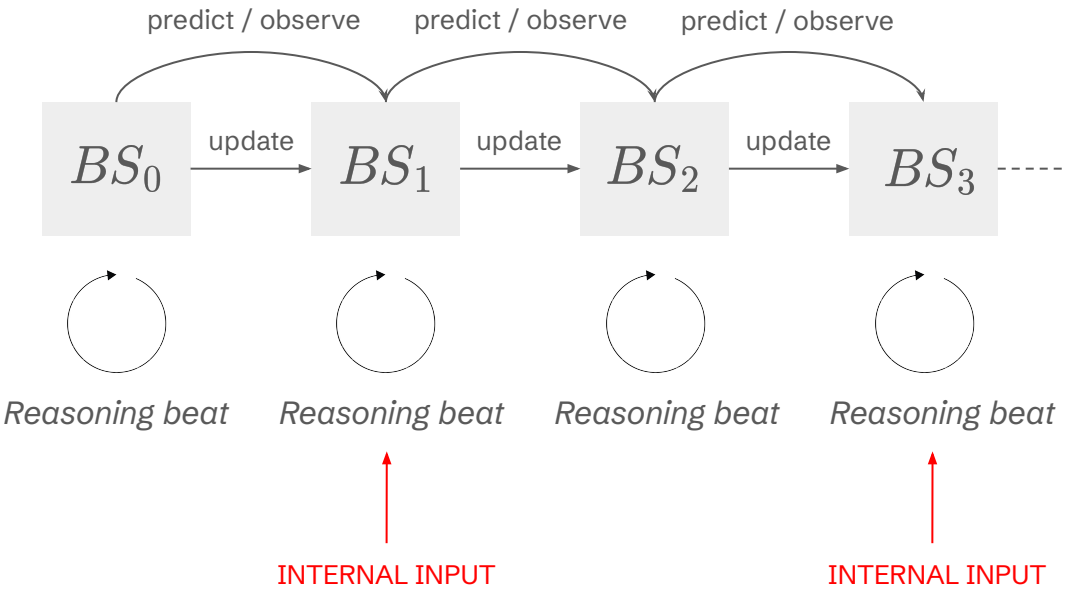
# Cognition Is State Evolution

$$BS_0$$

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## AXIOMS OF STATE EVOLUTION

### PROVISIONALITY

A state represents the best current interpretation, not truth.

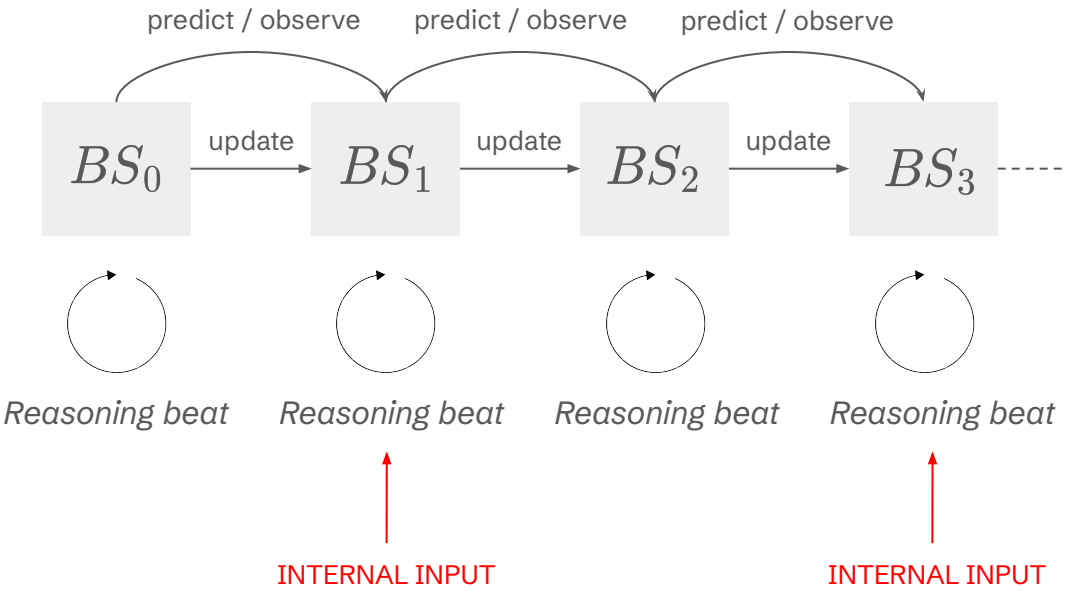
### PERSISTENCE

The output of reasoning survives the reasoning beat.

### REVISION

New evidence modifies existing interpretation; it does not restart cognition.

# Cognition Is State Evolution




Cognition keeps evolving…
even when nothing new comes in.

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# And This Is Physics, Not Computer Science...

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Computer Science

Physics

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MODEL

## Computer Science

$$x \xrightarrow{f_\theta} y$$

Models the output

Goal: learn the mapping

## Physics

$$S_t \xrightarrow{\mathcal{D}} S_{t+1}$$

Models the system

Goal: explain the dynamics

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| | Computer Science | Physics |
|---|---|---|
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| EVOLUTION | $x \to f(x) \to y$<br>Evolution is executed | $S_0 \to S_1 \to S_2 \to \cdots$<br>Evolution is intrinsic |

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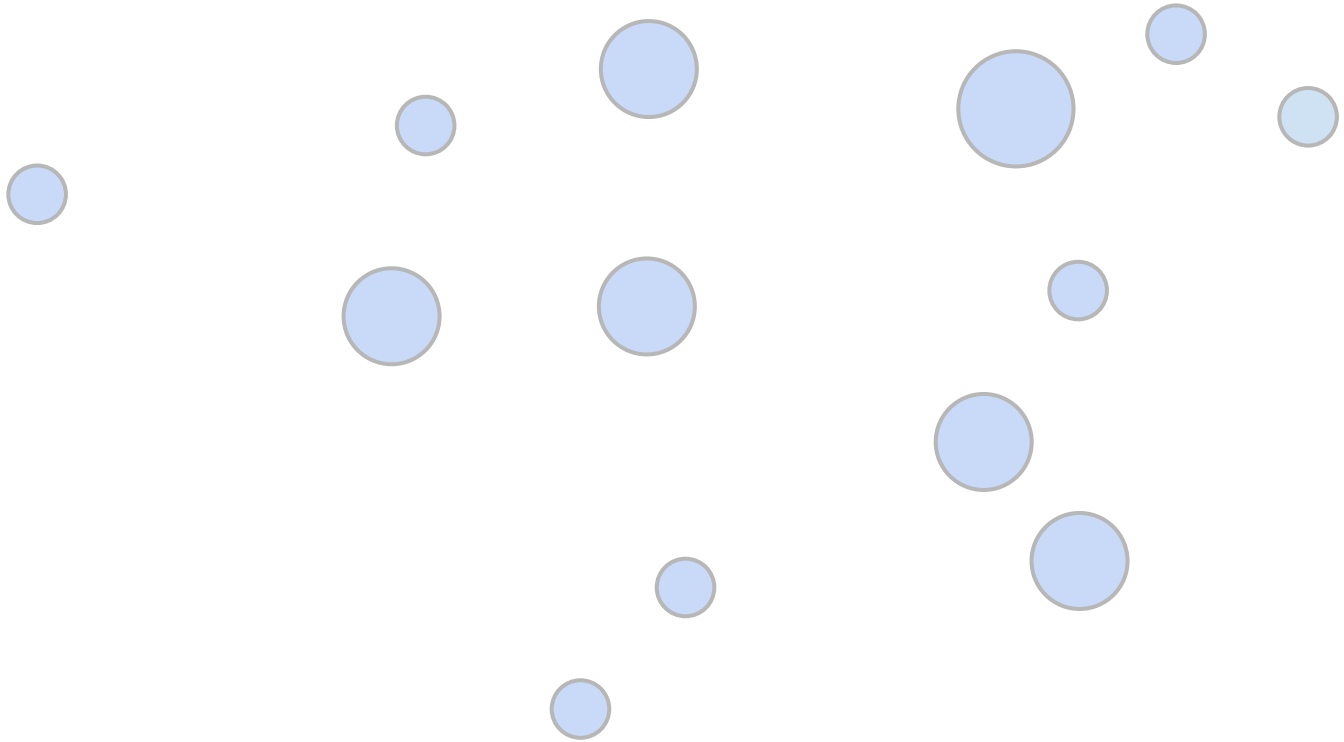
Don't model the answer. Model the dynamics that produce it.

Act IV

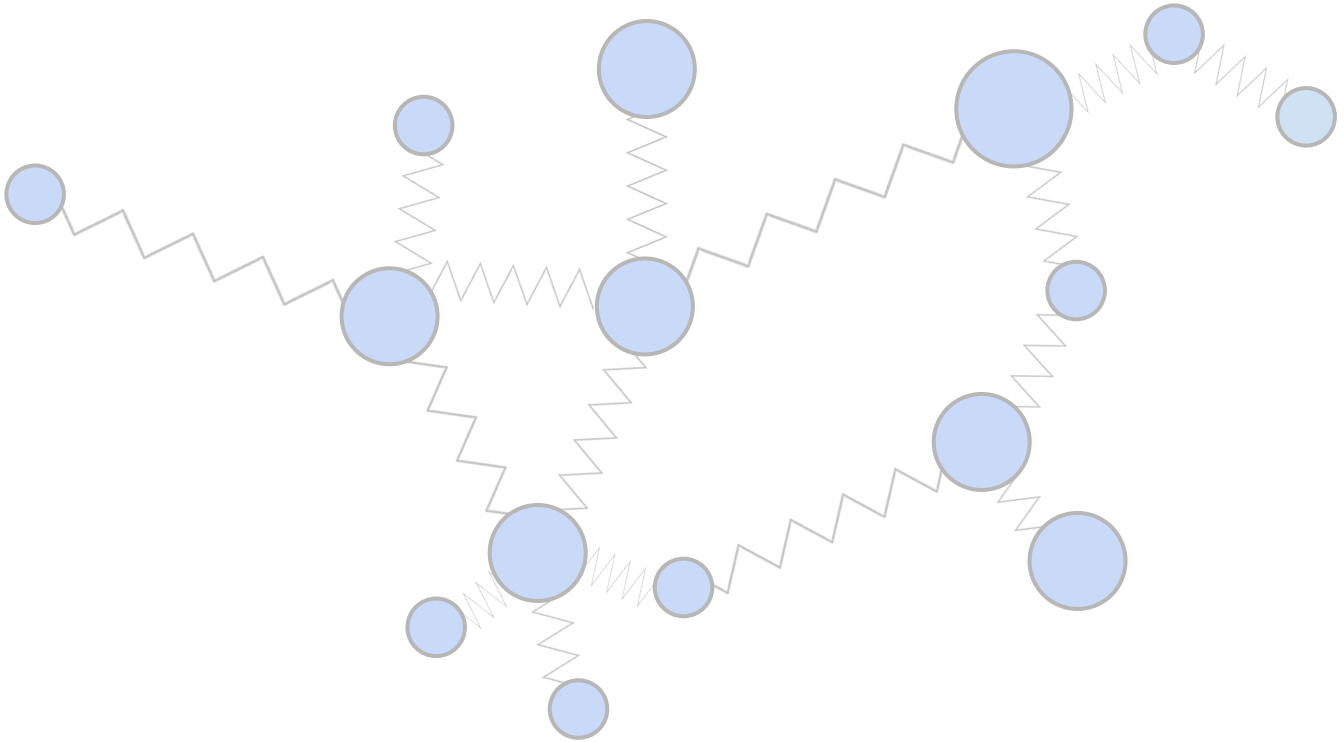
# The Dynamics of Intelligence



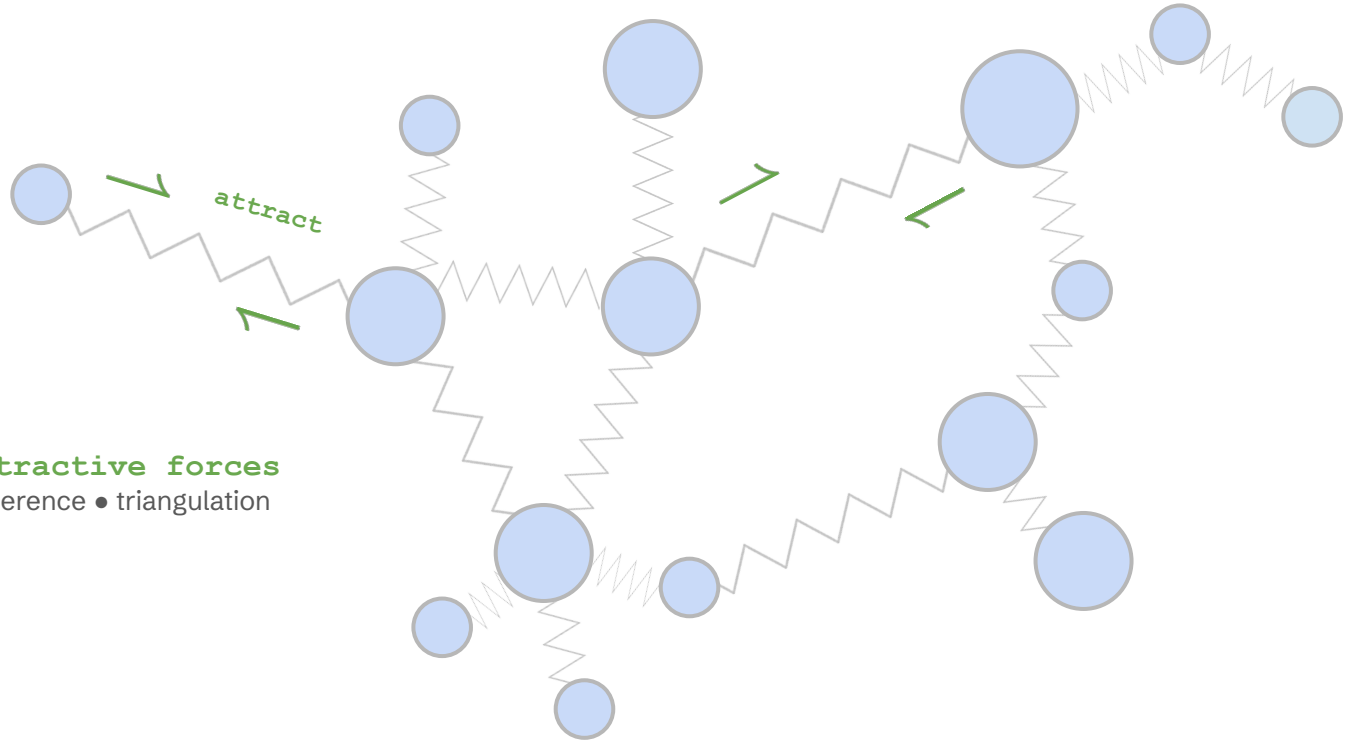
# Competing Forces Shape the Belief State



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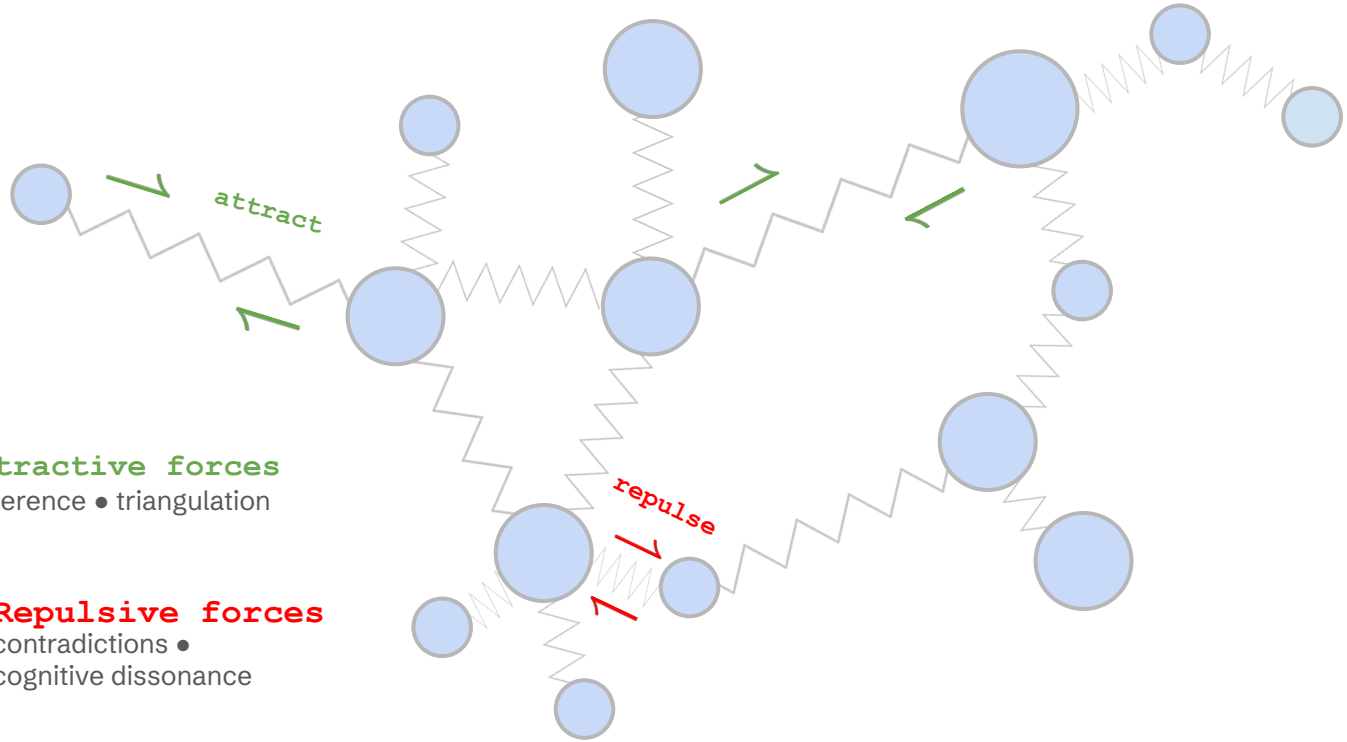


# Competing Forces Shape the Belief State




1 **Attractive forces**
coherence • triangulation

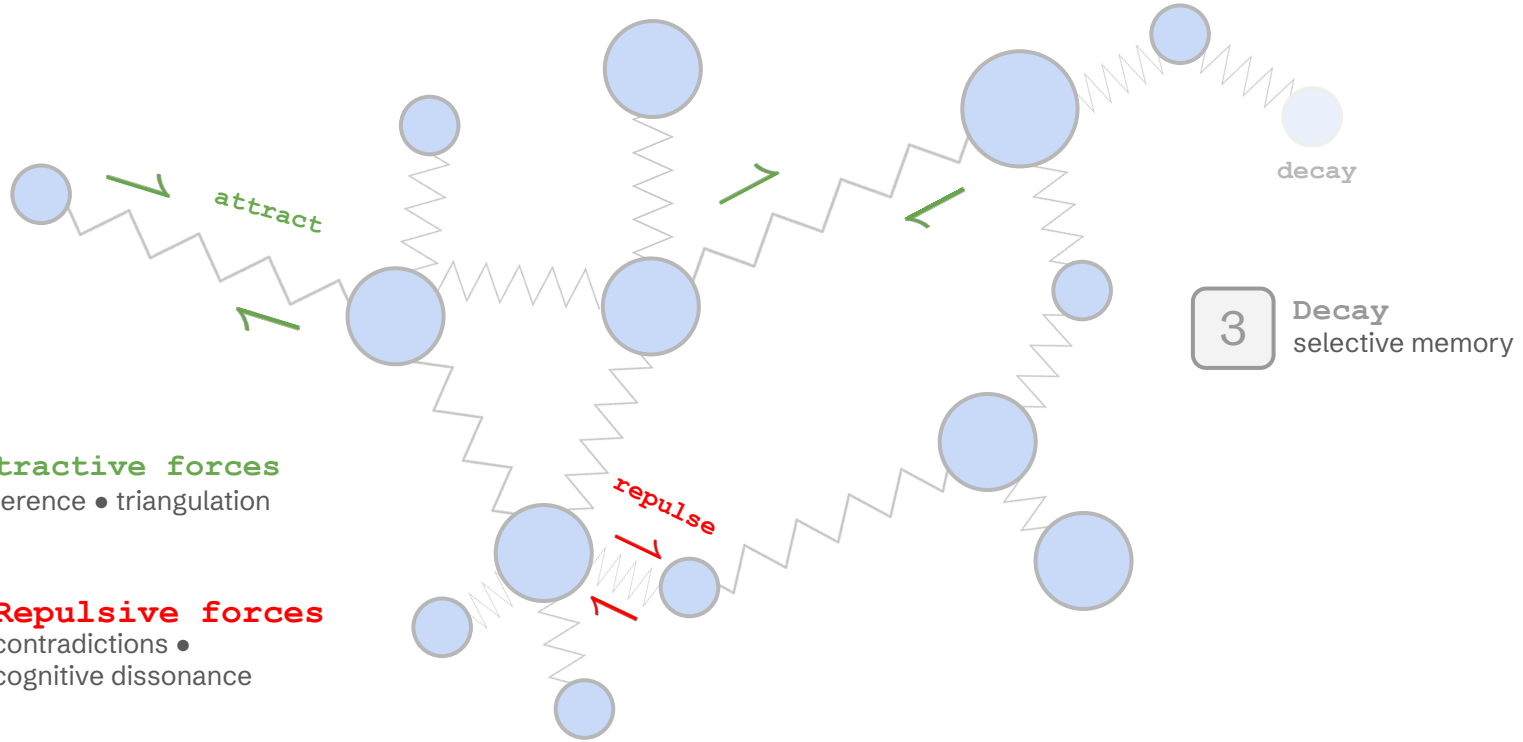
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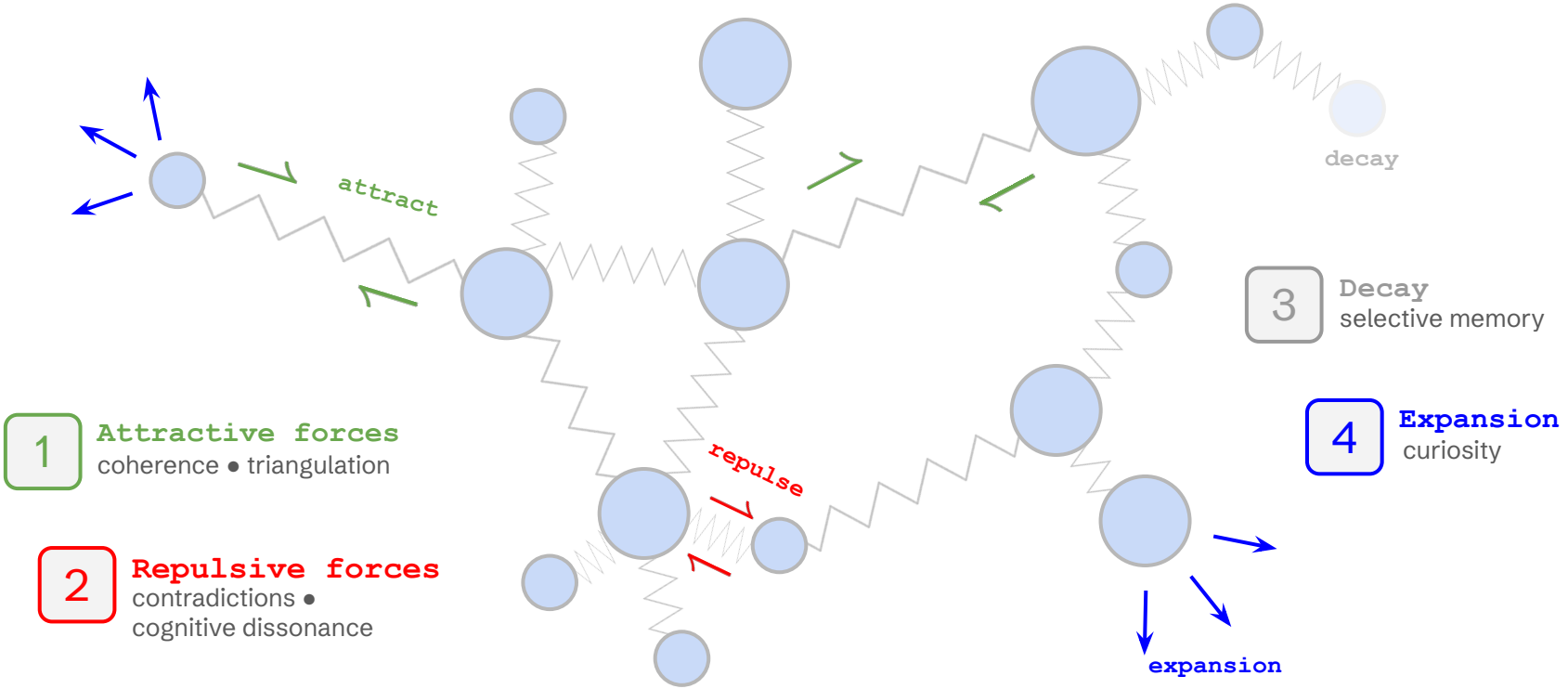

1 **Attractive forces**
coherence • triangulation

2 **Repulsive forces**
contradictions •
cognitive dissonance

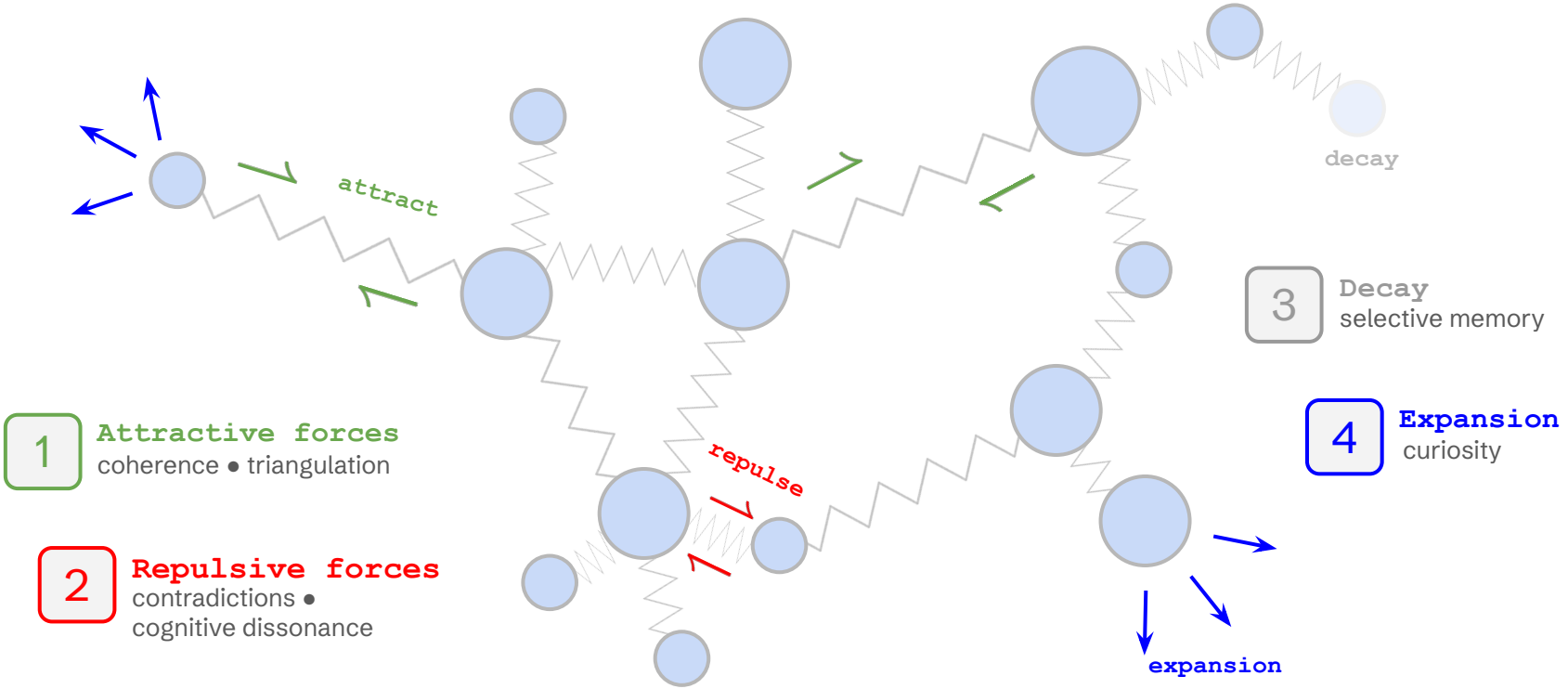
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Belief State Dynamics → n-Body Problem

# Dissonance Is a Force, Not a Bug

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# Dissonance Is a Force, Not a Bug




## What is Cognitive Dissonance?

COMPILATION ERROR
*Two beliefs cannot be reconciled*

↓

DISSONANCE
*Local instability in belief state*

↓

ATTENTION / FOCUS
*Reasoning concentrates around the instability*

↓

PROACTIVITY
*No new input required*

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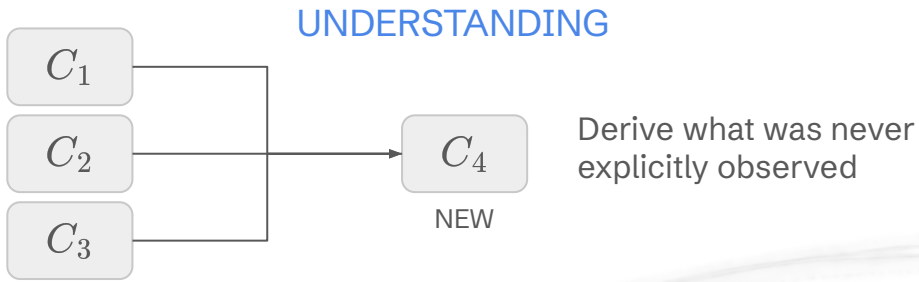
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Not Continual Learning: the system need not keep changing; the Belief State does.

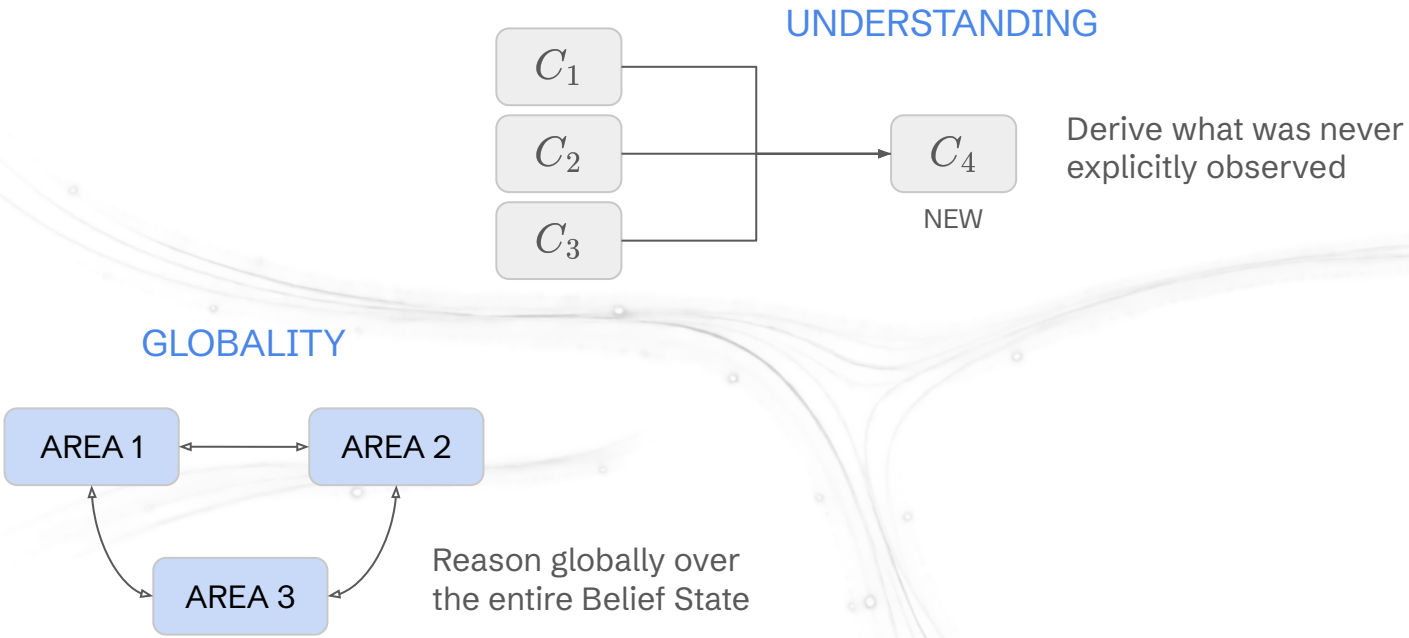
Not Chain-of-Thought: the system "decides" what to reason about, globally.

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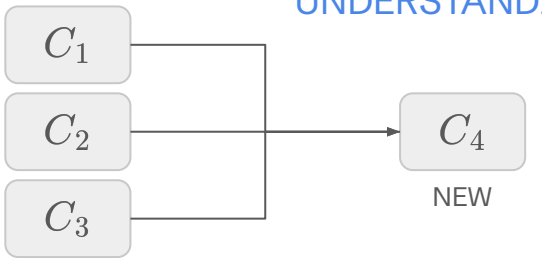


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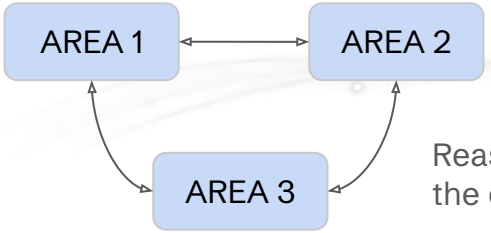
# Continual Reasoning Under Uncertainty (CRUU) (2/2)

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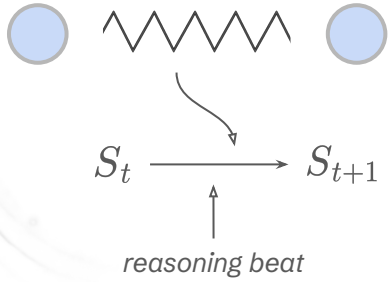

Derive what was never explicitly observed

## GLOBALITY




Reason globally over the entire Belief State

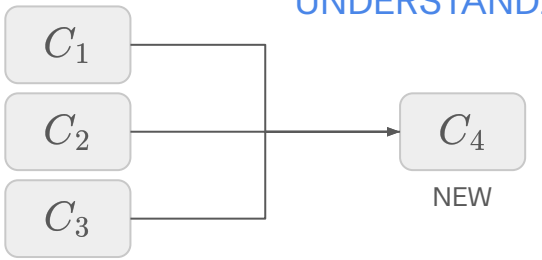
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Internal tension can trigger reasoning

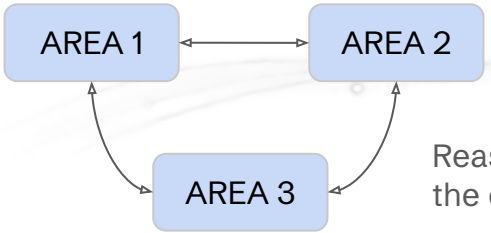
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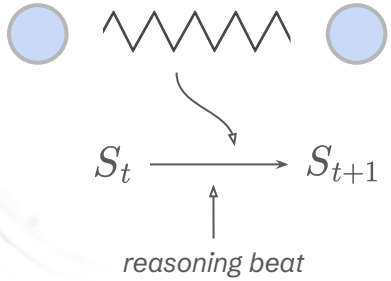

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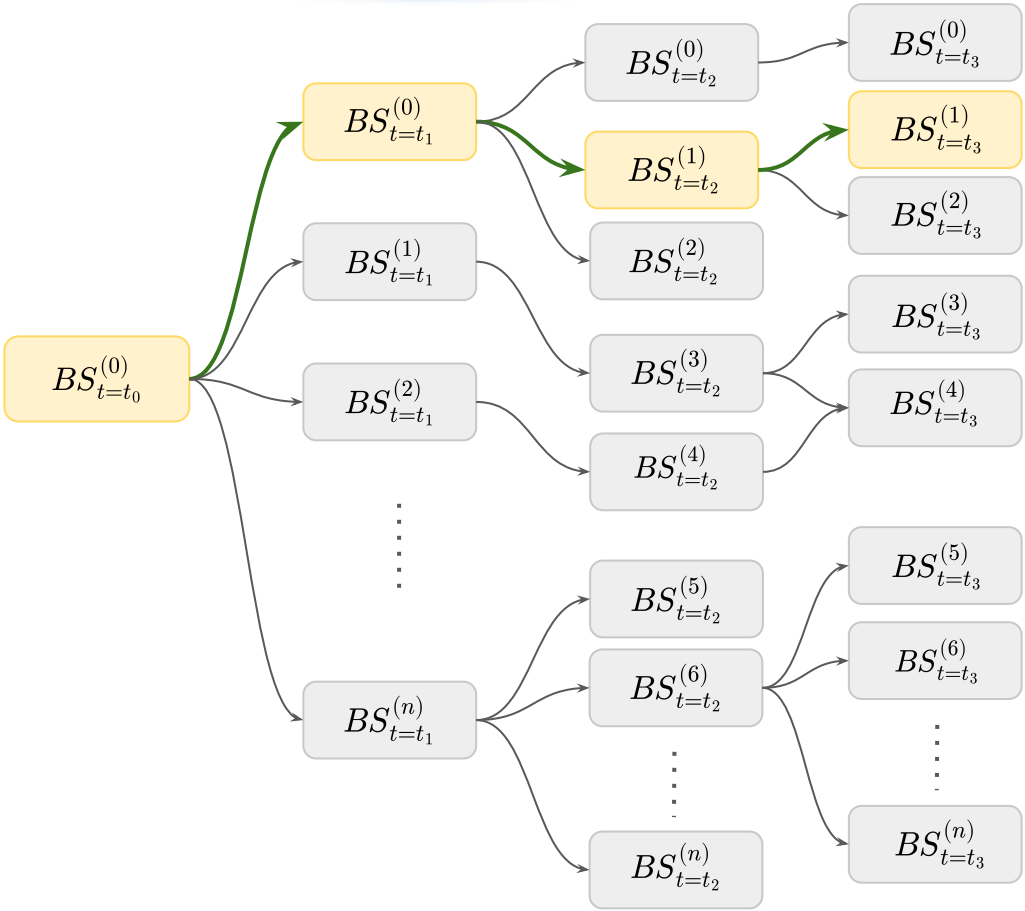
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## NO NEW INPUT REQUIRED

# And Forces Generate Trajectories




## Possibility ≠ Trajectory

Many next states are compatible with the current state.

## Forces Bias Evolution

Competing forces make some transitions more likely than others.

## A Trajectory Is History

Once a transition occurs, the next state inherits the consequences of the path already taken.

# Time Emerges for This Trajectory

$$BS_0$$

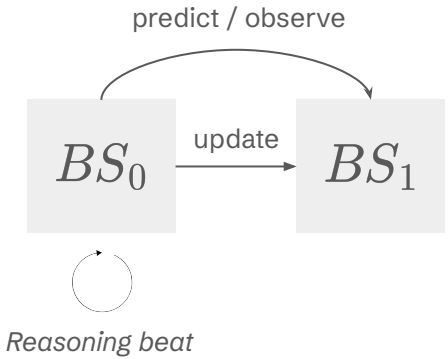
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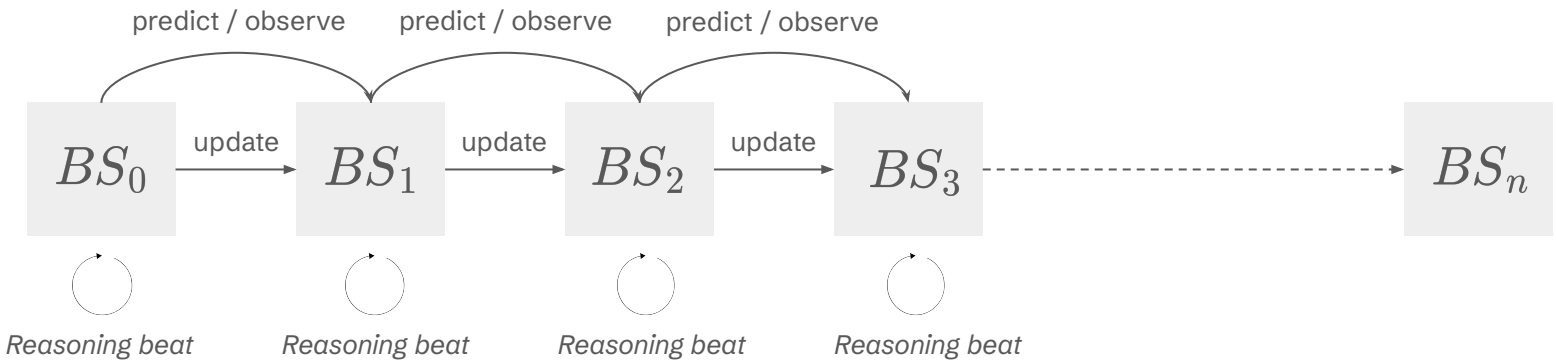


*Reasoning beat*

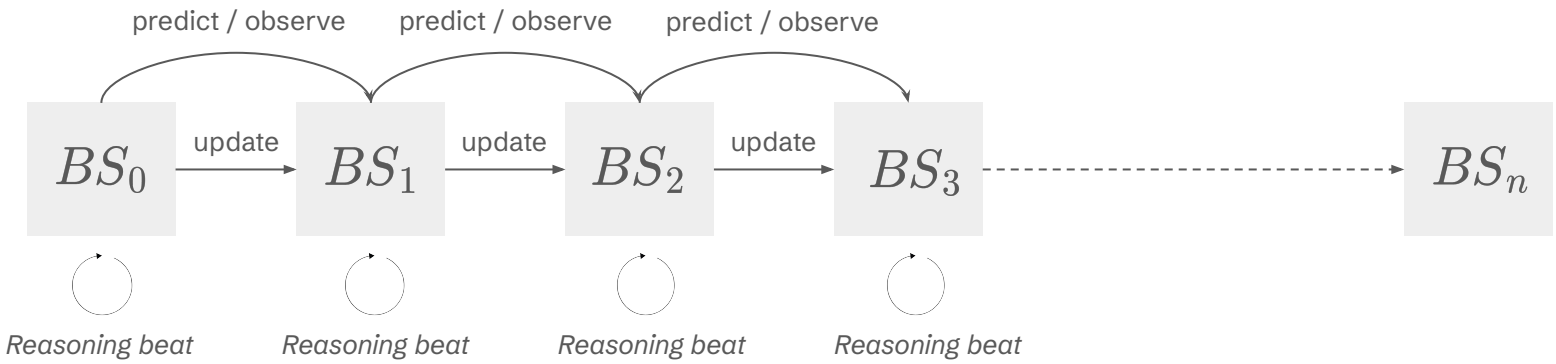
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$$\frac{\partial BS}{\partial t}$$

How does Cognitive State evolve in time?

$$\frac{\partial BS}{\partial t} = \underbrace{\frac{\partial BS}{\partial u}}_{\text{change per update}} \underbrace{\frac{\partial u}{\partial t}}_{\text{update rate}}$$

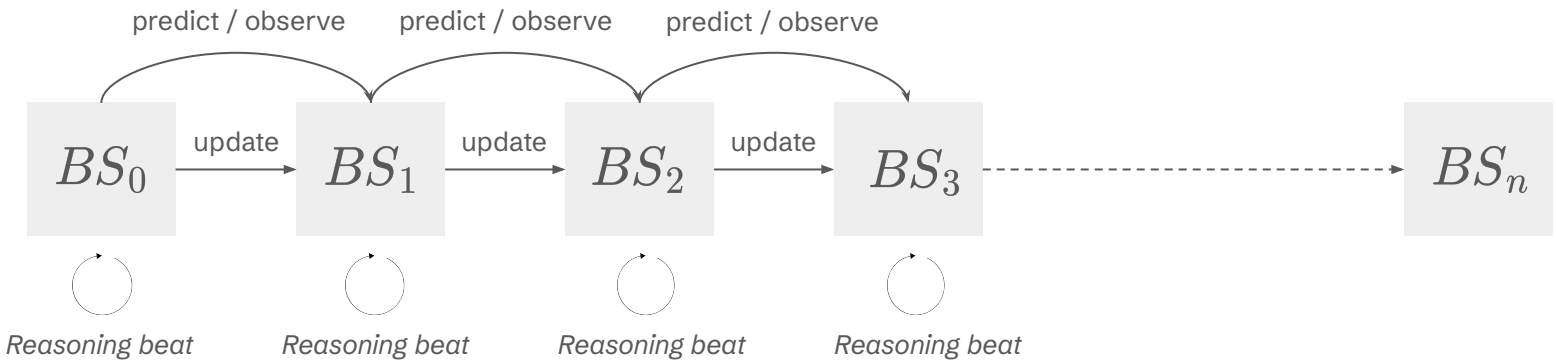
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But what if the update *is* the clock?

$$t_{\text{cog}} \equiv u$$

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$$\text{reasoning beat} \overset{?}{\sim} \text{collapse event}$$

Act V

# The Physics of Consciousness

# None of This Requires Consciousness

## Language Space

- Optimized for communication
- Not the right substrate for reasoning
- Sequential / tokenized
- Lossy projection of cognition

## Cognitive Space

- Representation of beliefs, hypotheses, causal structure
- Persistent internal state
- Reasoning as state evolution
- Sufficient to model intelligence without invoking consciousness

## Consciousness

- Not implied by cognition alone
- Requires additional explanatory structure
- A separate problem from intelligence

A Theory of Intelligence is not yet a Theory of Consciousness.

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- Language exposes one serialized trajectory at a time.

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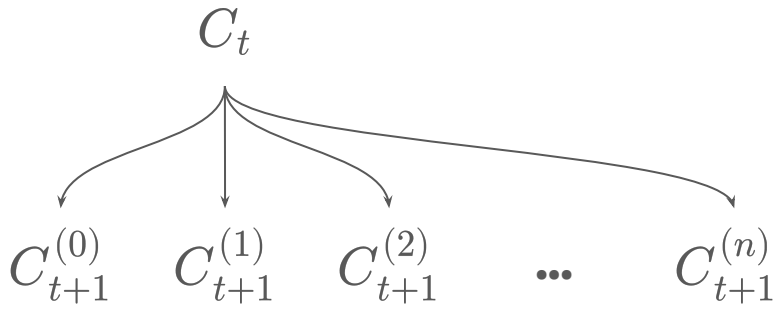
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Belief Space needs to represent possibilities before commitment.

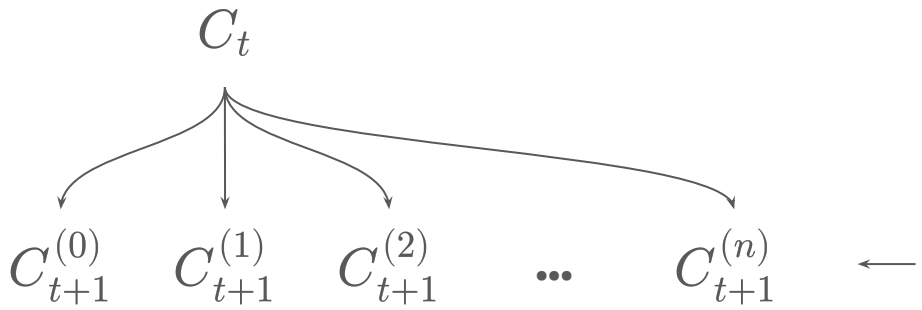
Quantum State representations are a natural fit for this.

# Why Cognition Is Not Enough

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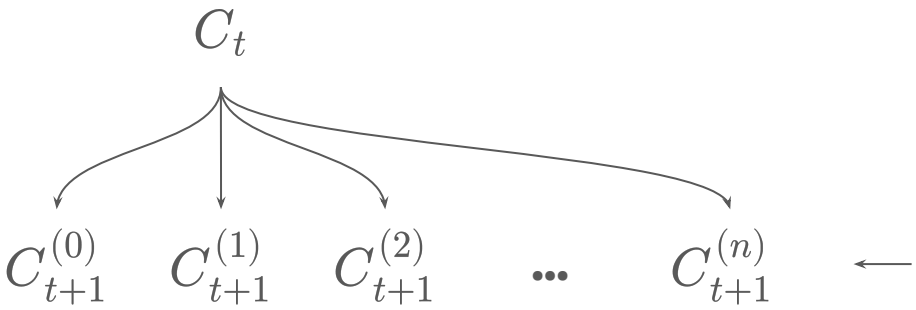
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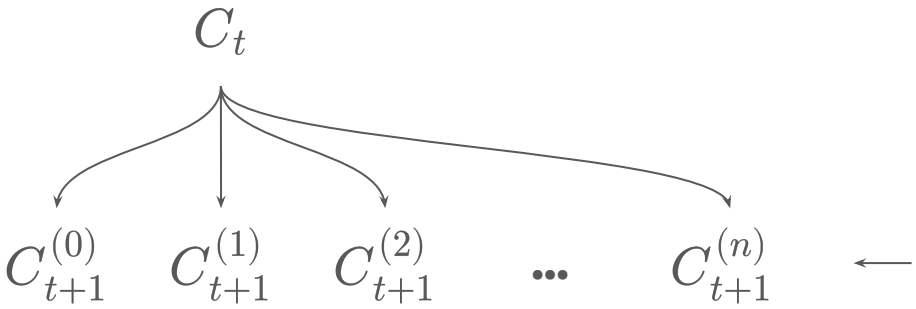

intent • desire • salience • commitment

$C_{t+1}^{(0)}$ $C_{t+1}^{(1)}$ $C_{t+1}^{(2)}$ ••• $C_{t+1}^{(n)}$

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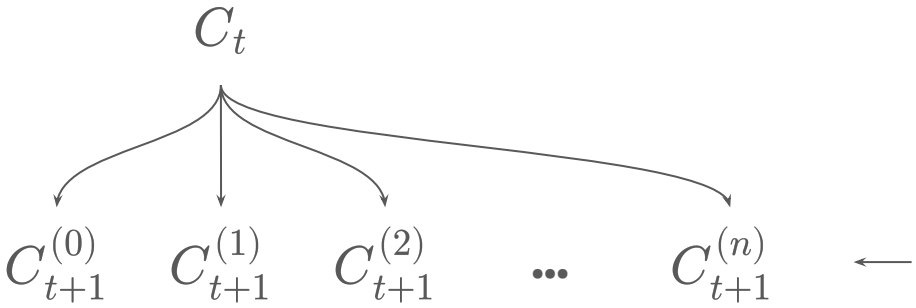

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**Volition** decides the trajectory

*Active Inference intuition:*
*Agents do not just infer the world; they act toward preferred futures.*

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Possible futures are cognitive.

Preferred futures are volitional.

# Conjugate (Complex) Spaces

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Quantum Mechanics requires a observer ***outside*** the represented state

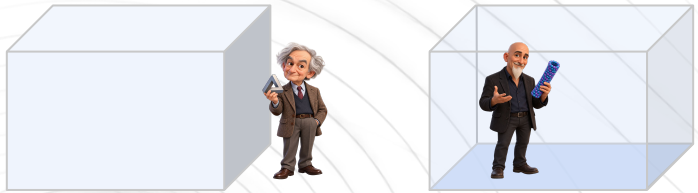


Copenhagen Interpretation

The observer is conceptually distinct from the state being collapsed.

# Conjugate (Complex) Spaces

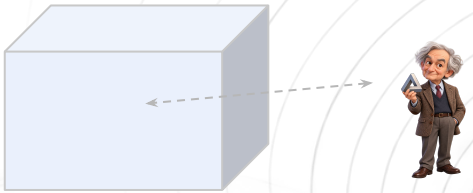
Quantum Mechanics requires a observer ***outside*** the represented state



## Copenhagen Interpretation

The observer is conceptually distinct from the state being collapsed.

But an intelligent agent's selector cannot be disconnected

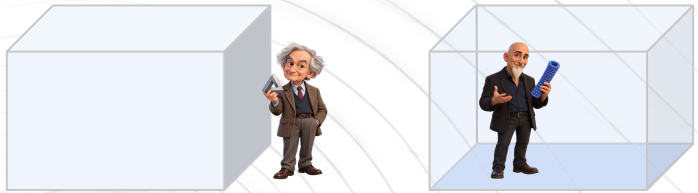


## Active Inference requirement

Goals, preferences and action must continuously affect cognition.

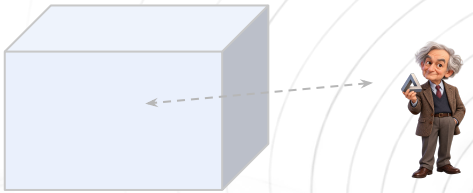
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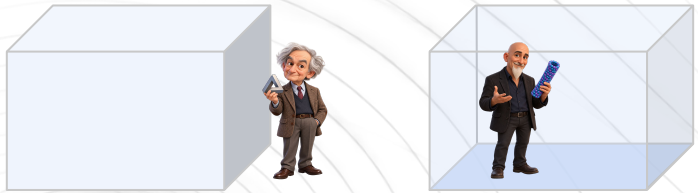
COGNITIVE SPACE
beliefs / hypotheses / world model

$\mathcal{C}$ $\mathcal{V}$

VOLITIONAL SPACE
intent / preference / commitment

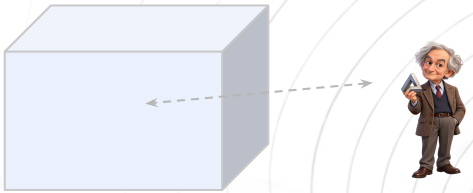
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Conjugate spaces give us separation without independence.
But the observer does not merely observe. The observer *wills*.

# Why Hilbert Spaces?

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## COEXIST

Alternative beliefs remain simultaneously represented $|\psi\rangle = \alpha|B_1\rangle + \beta|B_2\rangle + \cdots$ **without premature commitment**

## PHASE

Complex amplitudes $\alpha, \beta \in \mathbb{C}$ carry **relative phase,** which is what allows constructive / destructive interference.
Probabilities alone throw that information away.

## INTERFERE

Alternatives are not merely a list of probabilities **their relationship changes outcomes**

## EVOLVE

The **persistent cognitive state itself** evolves $|\psi_t\rangle \to |\psi_{t+1}\rangle$ rather than generating a transient sequence and then effectively starting another inference episode.

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## Why not language space?

SERIALIZATION · PROBABILITIES ·
TRANSIENT INFERENCE · NO EXPLICIT PHASE

| Need | Hilbert representation | LLM / language representation |
|---|---|---|
| **COEXIST** | superposed alternatives | serialized expression |
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## Complex Hilbert Spaces

*A geometry for quantum state evolution*

# What the Formalism Buys Us

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COGNITION

$\mathcal{H}_C$

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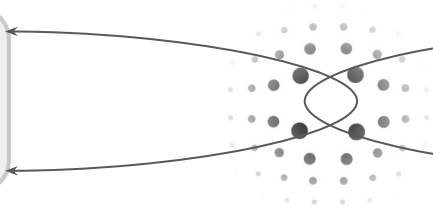
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$\mathcal{H}_V$

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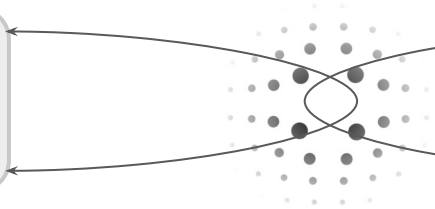
GAUGE FIELD

$$\hat{G}_{CV} = \hat{G}^{\dagger}_{CV}$$

*In physics, interactions can themselves be represented as fields.*

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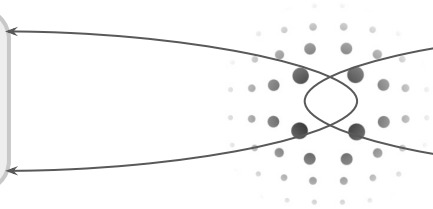
HERMITIAN COUPLING

$$g_i \in \mathbb{R}$$

*Hermitian coupling leads to real eigenvalues...*

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OBSERVABLE COUPLING?
$$\Psi \equiv \langle\psi|\hat{G}_{CV}|\psi\rangle \in \mathbb{R}$$

*Could the coupling leave an observable signature?*

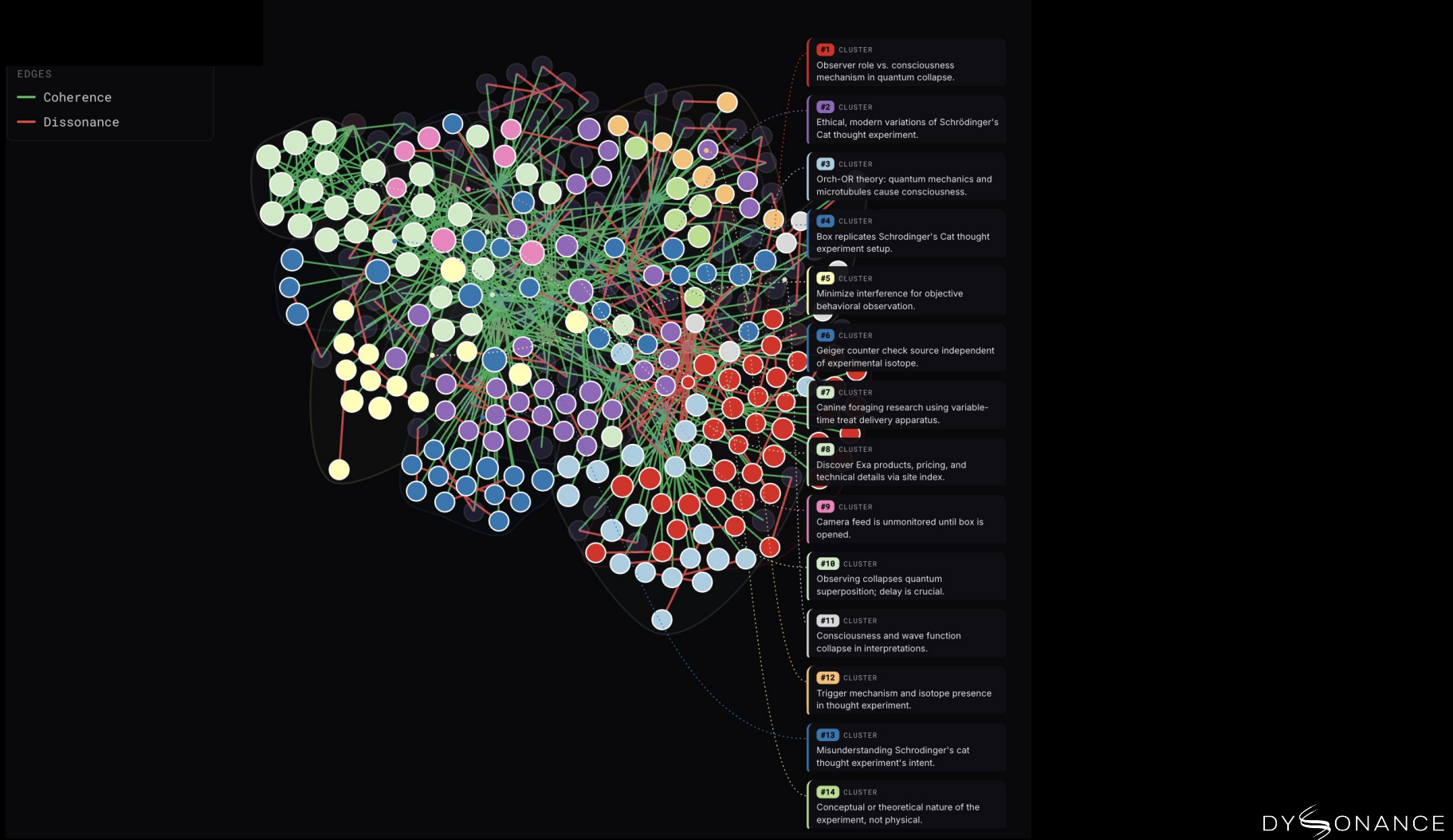
# From Information to Consciousness

Information
→ Interpretation
→ State
→ Interaction
→ Dynamics
→ Consciousness?

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- Data is observed
- Memory is interpreted persistence
- Reasoning is state evolution
- Causality emerges from interaction
- Temporality emerges from evolution
- Consciousness may require an additional coupled space


EDGES
Coherence
Dissonance
#1 CLUSTER
Observer role vs. consciousness mechanism in quantum collapse.
#2 CLUSTER
Ethical, modern variations of Schrödinger's Cat thought experiment.
#3 CLUSTER
Orch-OR theory: quantum mechanics and microtubules cause consciousness.
#4 CLUSTER
Box replicates Schrodinger's Cat thought experiment setup.
#5 CLUSTER
Minimize interference for objective behavioral observation.
#6 CLUSTER
Geiger counter check source independent of experimental isotope.
#7 CLUSTER
Canine foraging research using variable-time treat delivery apparatus.
#8 CLUSTER
Discover Exa products, pricing, and technical details via site index.
#9 CLUSTER
Camera feed is unmonitored until box is opened.
#10 CLUSTER
Observing collapses quantum superposition; delay is crucial.
#11 CLUSTER
Consciousness and wave function collapse in interpretations.
#12 CLUSTER
Trigger mechanism and isotope presence in thought experiment.
#13 CLUSTER
Misunderstanding Schrodinger's cat thought experiment's intent.
#14 CLUSTER
Conceptual or theoretical nature of the experiment, not physical.

DYSONANCE