A hypothetical model of spontaneous creativity in improvisation

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Outline

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- What I mean by "spontaneous creativity"
- A hypothetical model of cognitive selection that accounts for inspiration
  - Statistical models of cognitive process
  - Information theory
- Extending the model to interactive creativity
- Evaluation – a difficult problem
- Motivation
  - (overall) **WHERE DO (MUSICAL) IDEAS COME FROM?**
  - (today) **HOW DOES (MUSICAL) INTERACTION HAPPEN?**

Two kinds of creativity

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- One aspect of creativity is **SPONTANEOUS CREATIVITY**
  - ideas appear, spontaneously, in consciousness
  - cf. Mozart (Holmes, 2009, p. 317)
    - When I am, as it were, completely myself, entirely alone, and of good cheer – say traveling in a carriage, or walking after a good meal, or during the night when I cannot sleep; it is on such occasions that my ideas flow best and most abundantly.
- Compare with the composer working to build (e.g.) a new version of a TV theme, on schedule, and with constraints on "acceptable style"
  - this is a different kind of activity: **CREATIVE REASONING**
- Most creative acts of any size are a **mixture of both**
- Here, I focus on **spontaneous creativity** only

A unifying principle

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EXPECTATION

A unifying principle

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EXPECTATION

- Expectation allows us to deal with the world
  - there is too much data out there to process in real time
  - we need to manage it by predicting what comes next, so we have a chance to get ahead
- Expectation works in lots of domains
  - vision
  - movement understanding
  - speech understanding

Why should it be so?

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- Key evolutionary points
  - organisms survive better if they can learn
  - organisms survive better if they can anticipate
  - organisms survive better if they can anticipate from what they learn
  - organisms cannot be merely reactive
    - anticipation must be proactive
  - organisms must regulate cognitive resource – attention is expensive

A uniform account of cognition

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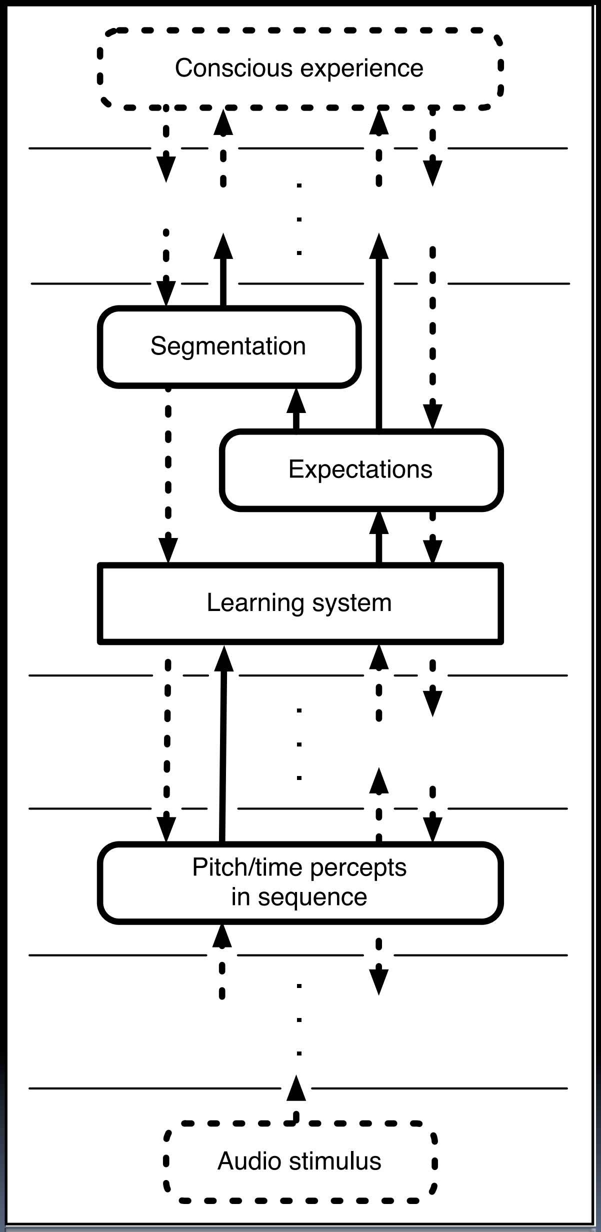
- Cognition as information processing
  - To promote survival
  - To manage the world around an organism
- To promote cognition/information processing
  - need memory
  - need compression/optimisation
    - to represent memories as efficiently as possible (reduce cognitive load)
    - to take advantage of any structure/pattern that may be in the perceptual data and avoid repetition
  - need to compare what is perceived with what is remembered, to **predict**
- A system (biological or computational) that can do these things has a big advantage



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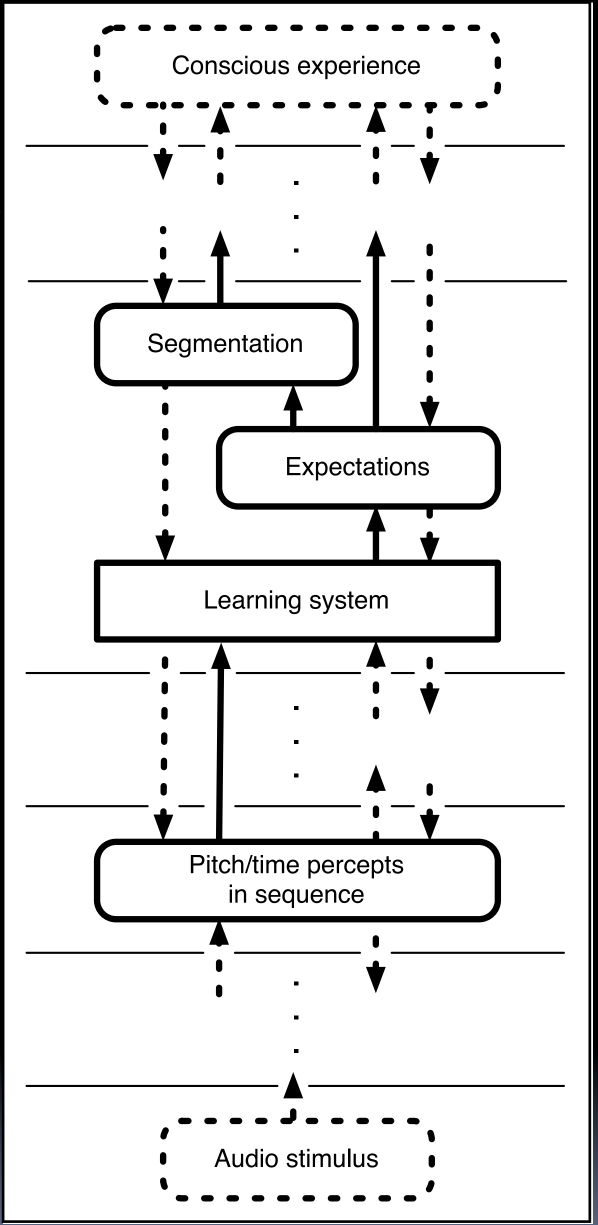

Framework: Global Workspace Theory

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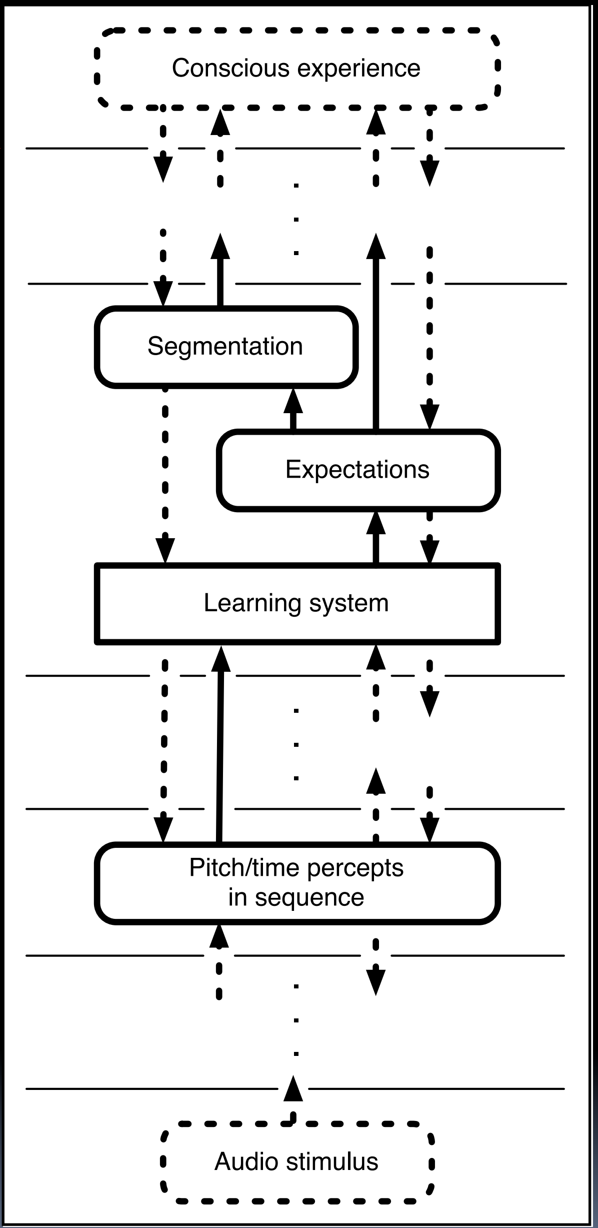
- Bernard Baars (1988) proposed the **Global Workspace Theory**
  - agents, generating cognitive structures, communicating via a shared workspace
  - agnostic as to nature of agent-generators
  - information in workspace is available to all agents and to consciousness
  - agents gain access to blackboard by “recruiting” support from others
  - problem: how to gain access
- Avoid Chalmers’ “hard problem”: what is conscious?
  - ask instead: what is it conscious *of*?



Component: Statistical cognitive models

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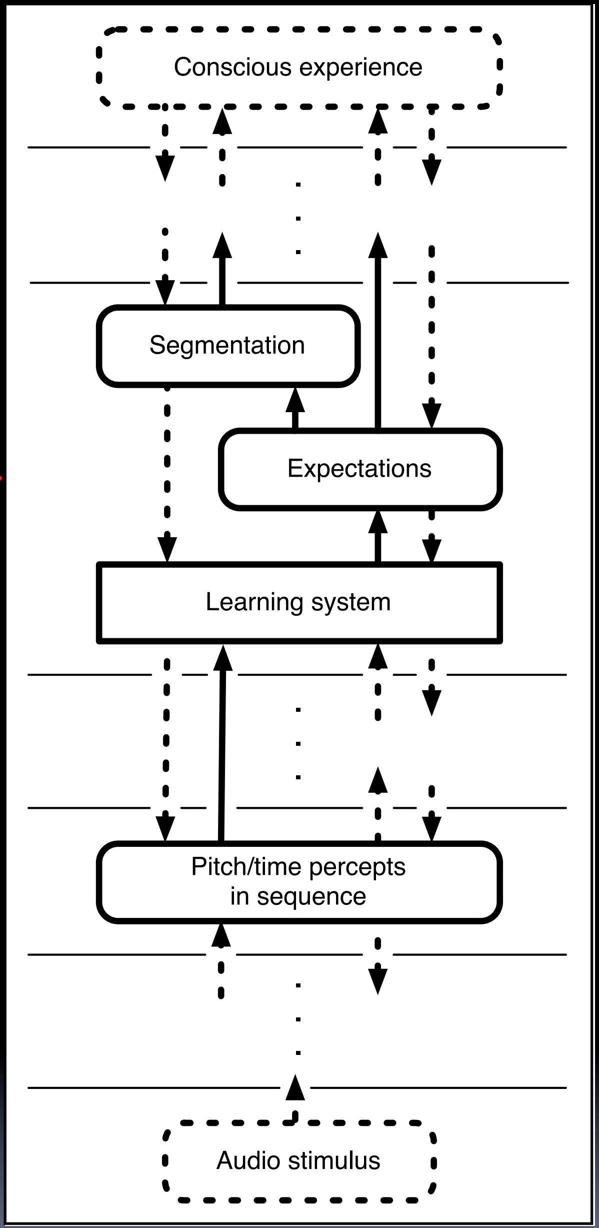
- Model expectation in music and language statistically
  - currently using IDyOM model (Pearce, 2005)
    - predicts human melodic expectation (R^2=.81; Pearce & Wiggins, 2006)
    - predicts human melodic segmentation (F_1=.61; Pearce, Müllensiefen & Wiggins, 2010)
    - predicts language (phoneme) segmentation (F_1=.67; Wiggins, 2011)
- Statistical nature means we can apply information theory (Shannon, 1948)



Unifying concept: Information theory

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- Two versions of Shannon's *entropy* measure (MacKay, 2003)
  - the number of bits required to transmit data between a hearer and a listener given a shared data model
  - *information content*: estimated number of bits required to transmit a given symbol as it is received:

$$h = -\log_2 p_s$$

  - models **unexpectedness**
  - *entropy*: expected value of the number of bits required to transmit a symbol from a given distribution:

$$H = -\sum_i p_i \log_2 p_i$$

  - models **uncertainty**
  - p_s, p_i are probabilities of symbols; i ranges over all symbols in the distribution

Instantiating the Global Workspace

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- Agent generators
  - statistical samplers predicting next in sequence from shared learned models of perceptual and other domains
  - many agents, working in massive parallel
    - at all times, the likelihood of a given prediction is proportional to the number of generators producing it
  - receive perceptual input from sensory systems
    - continually compare previous predictions with current world state
  - continually predict next world state from current matched predictions
    - sensory input does not enter memory directly
    - the expectation that matches best, or a merger of the two, is recorded
  - consider state t (current) and state t+1 (next)
    - at state t, we can calculate h_t, H_t, and H_{t+1} (but not h_{t+1}, because it hasn't happened yet)

Anticipatory agent

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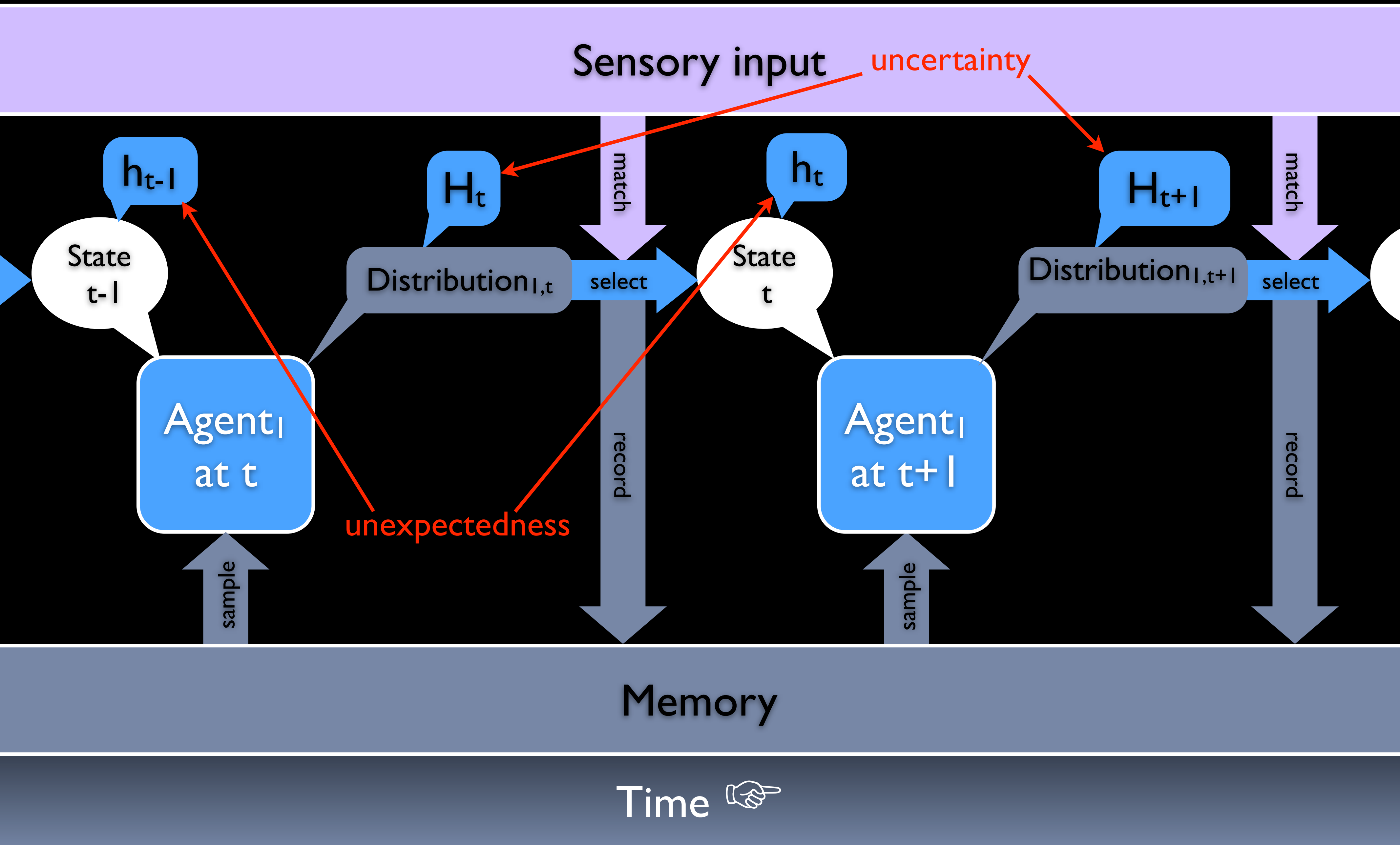

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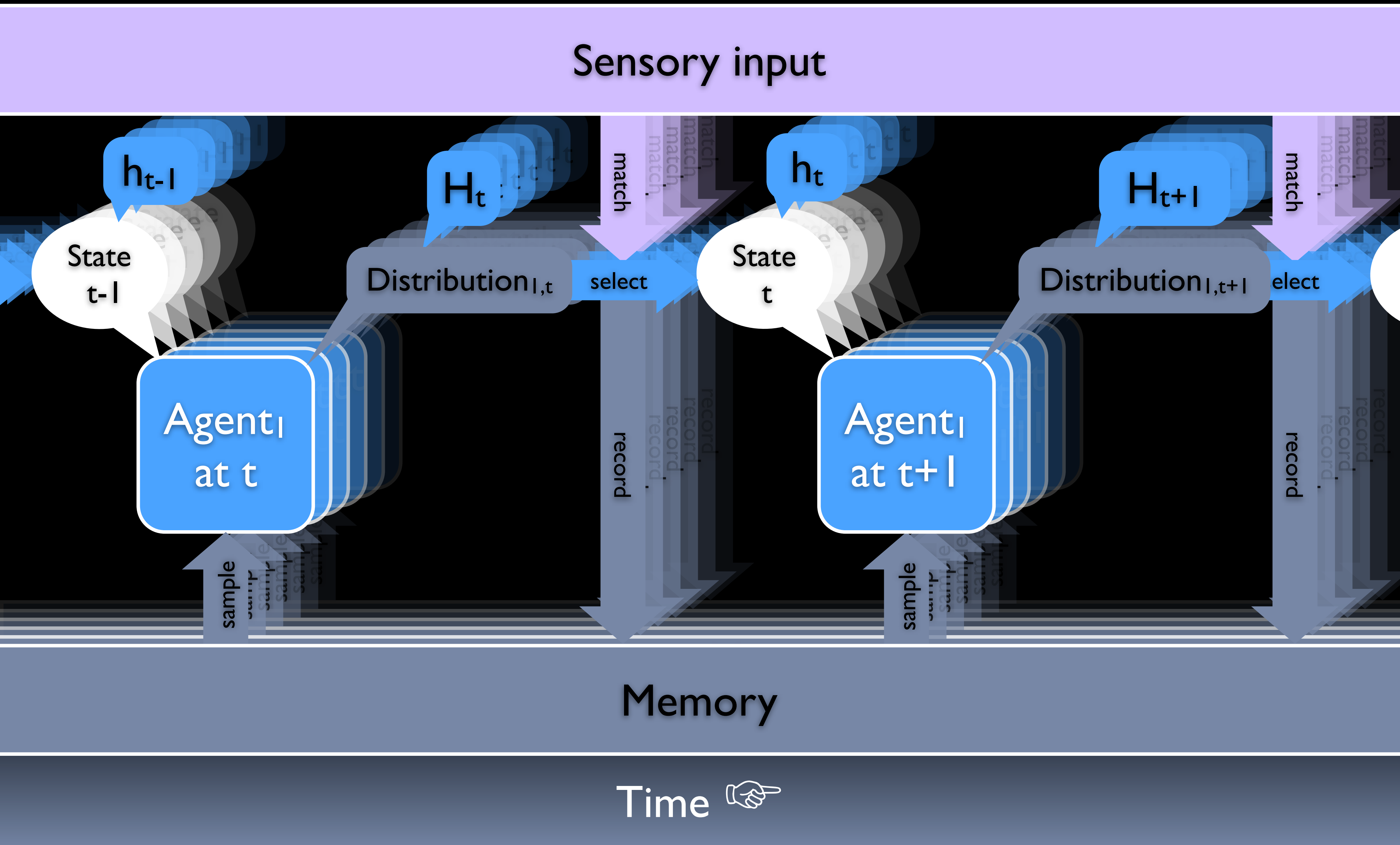
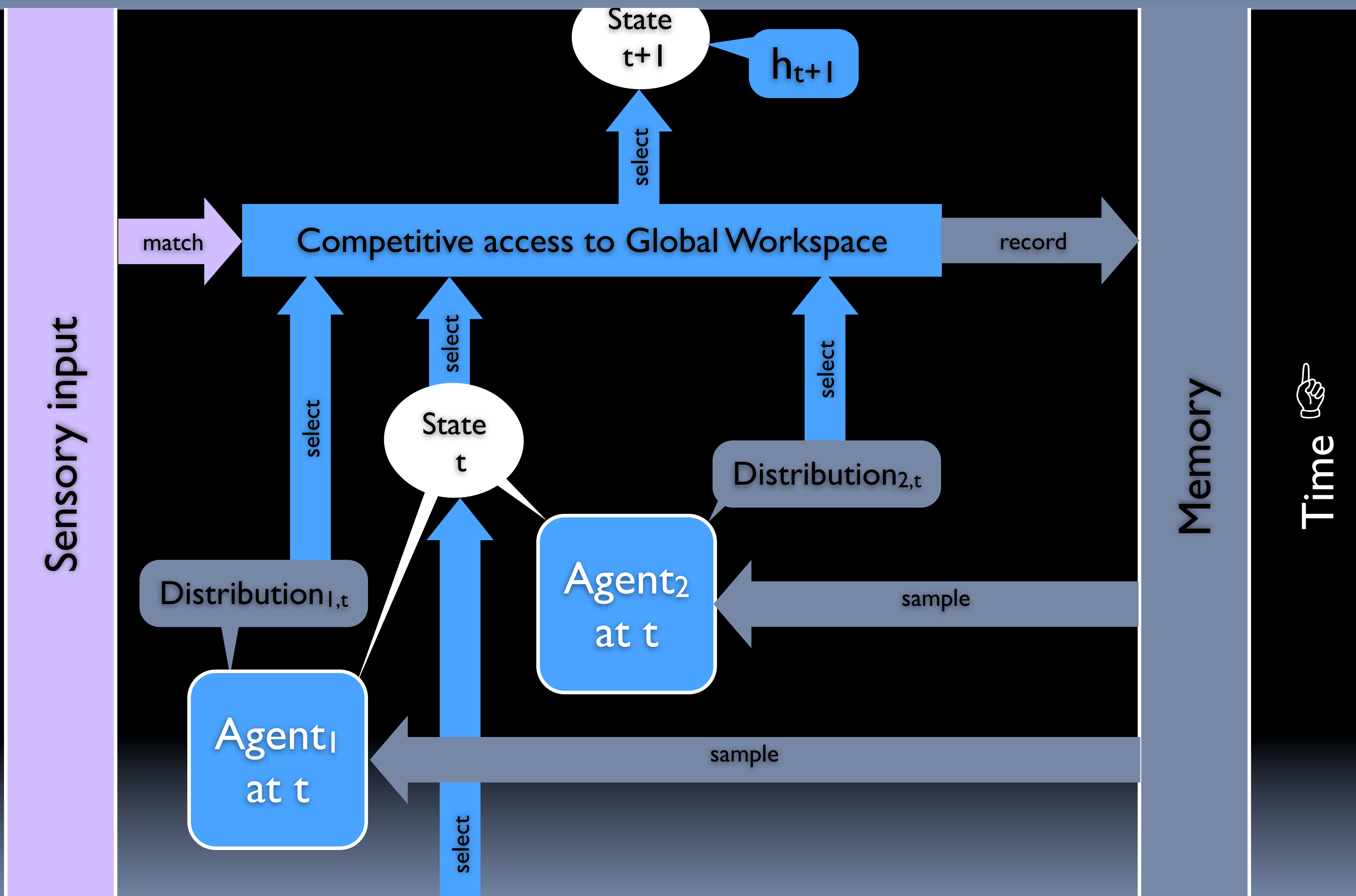


Anticipatory agents in competition



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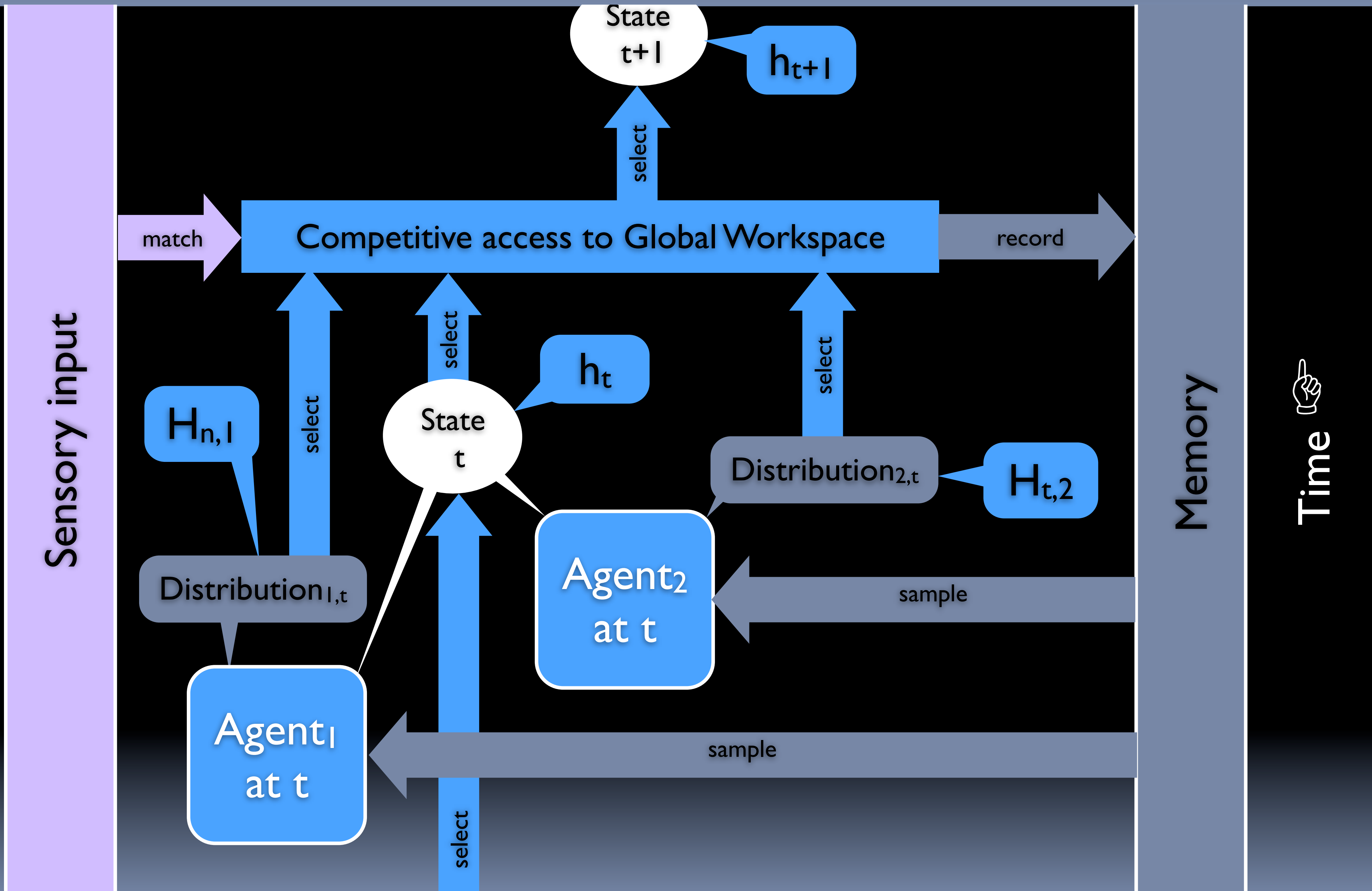

Selecting agent outputs

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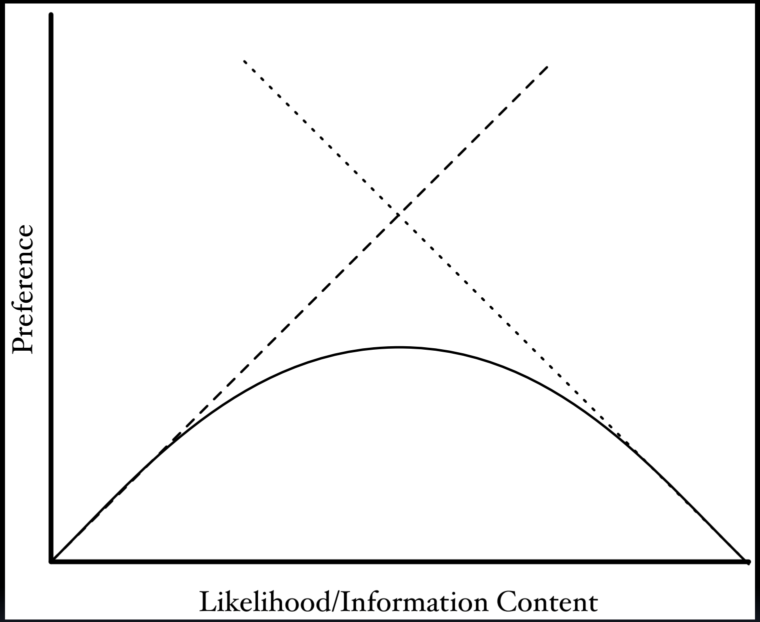
Competitive access to Global Workspace

- Agents produce (musical) structure representations
- Probability of structure (in learned model) increases "volume"
  - likely structures are generated more often
  - multiple identical predictions are "additive"
- Unexpectedness increases "volume"
  - information content predicts unexpectedness
- Uncertainty decreases "volume"
  - entropy reduces "volume"



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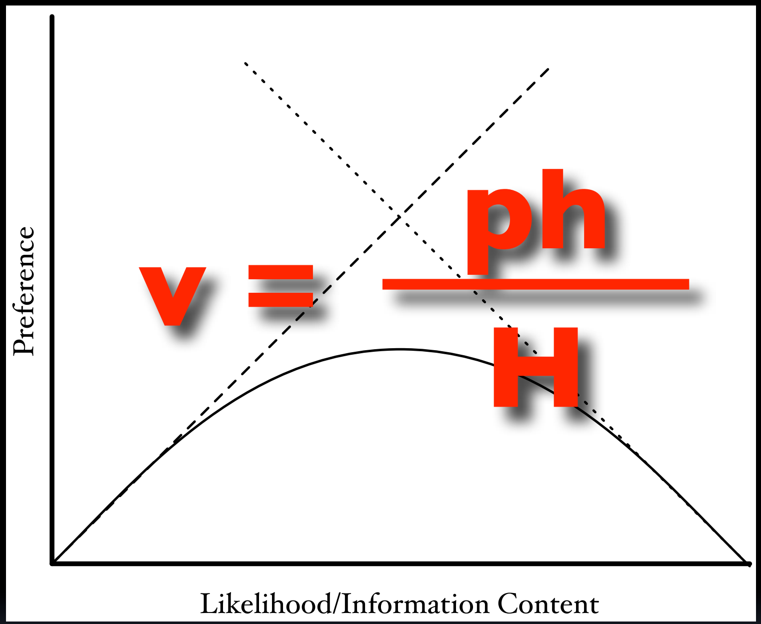

The story so far

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- Mechanism proposed to anticipate and manage events in the world
- Same mechanism can result in creativity in response to sensory input
- Relative lack of sensory input results in “free-wheeling”
    - which in turn allows (apparently) spontaneous creative production
    - cf. Wallas (1926) “aha” moment between incubation and inspiration
        - corresponds with entry of structure into global workspace
- All this is internal to one individual
    - how might cooperative improvisation be included in this framework?

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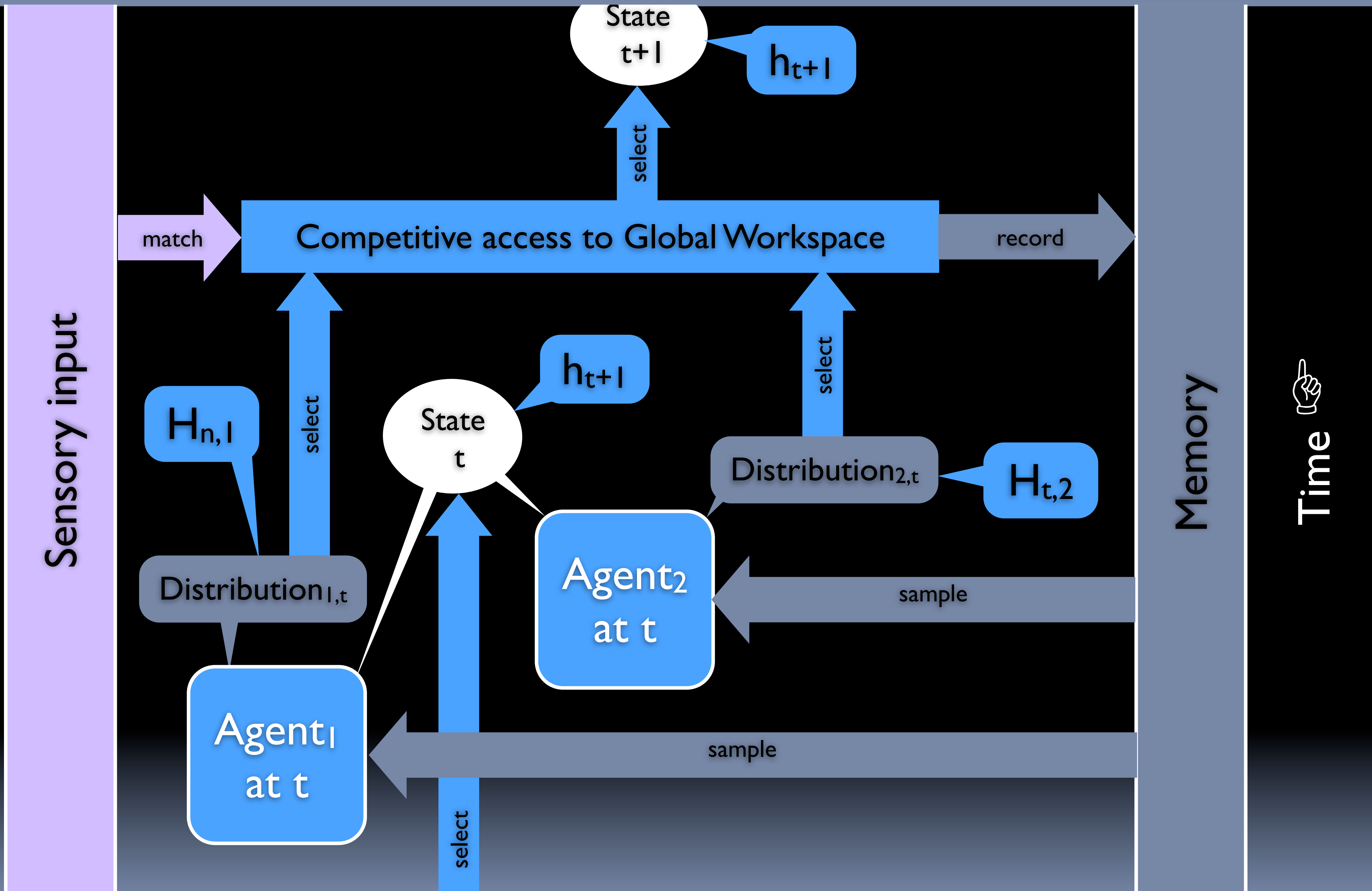
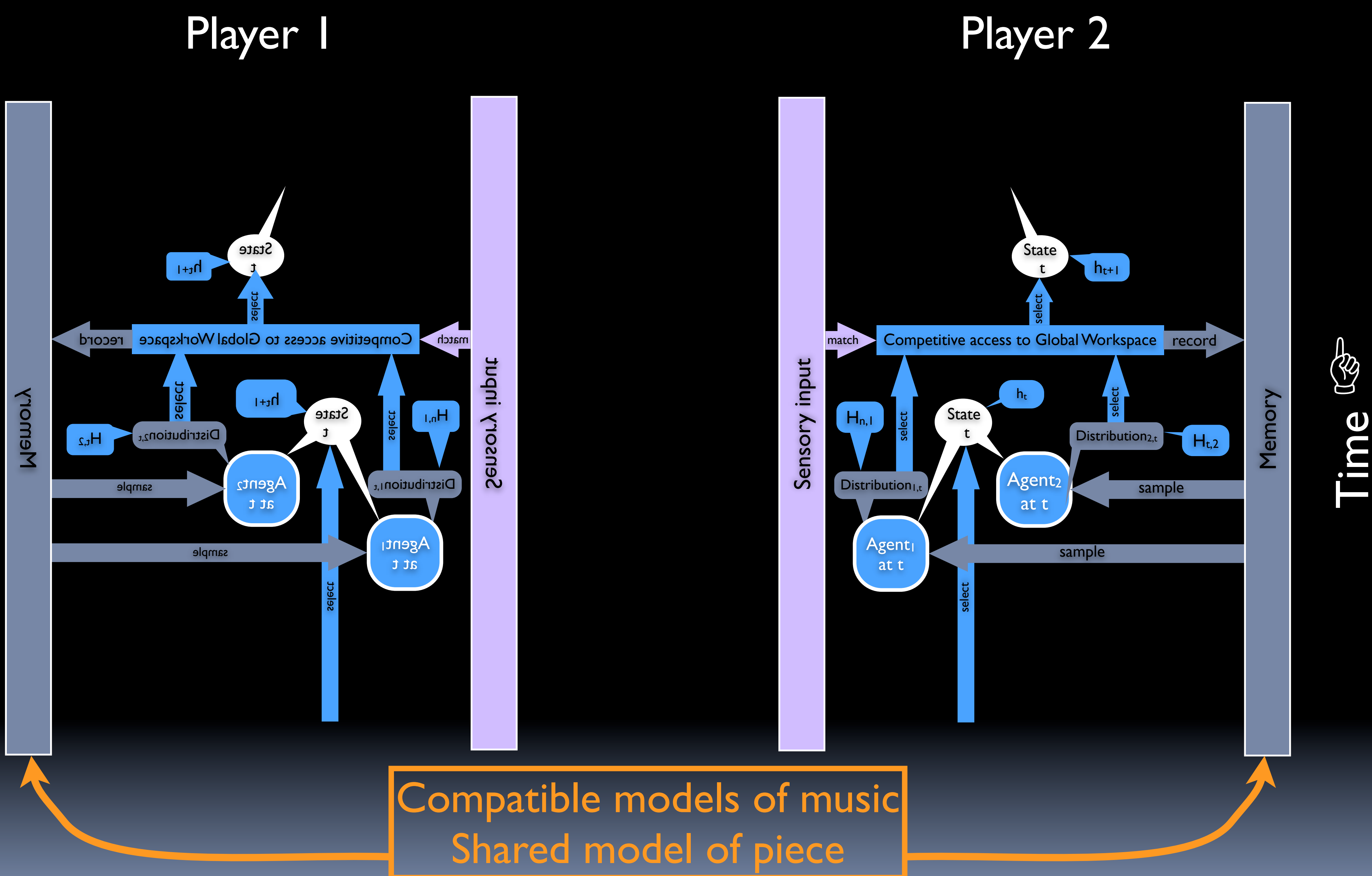


Anticipatory agents in cooperation



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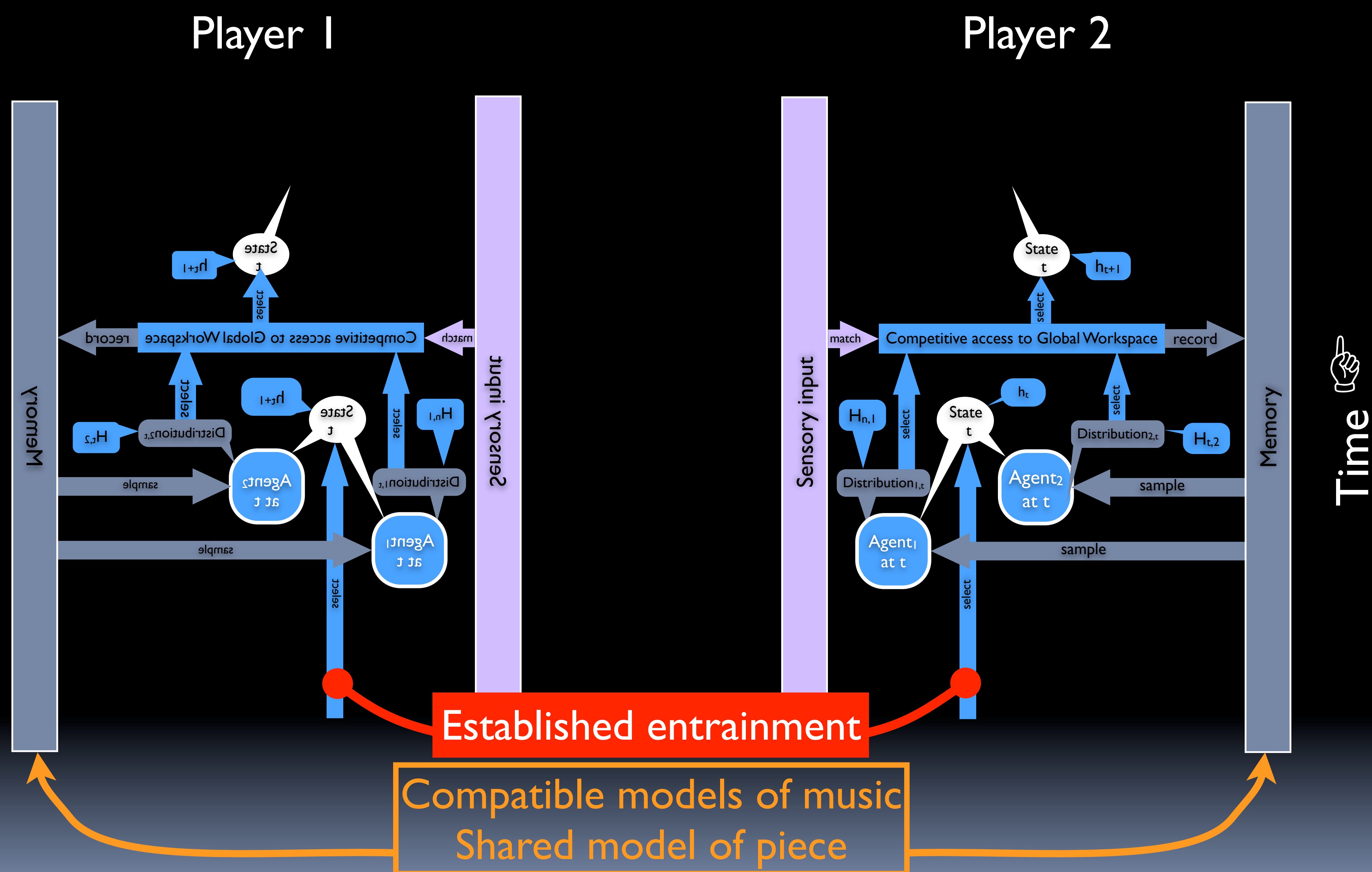

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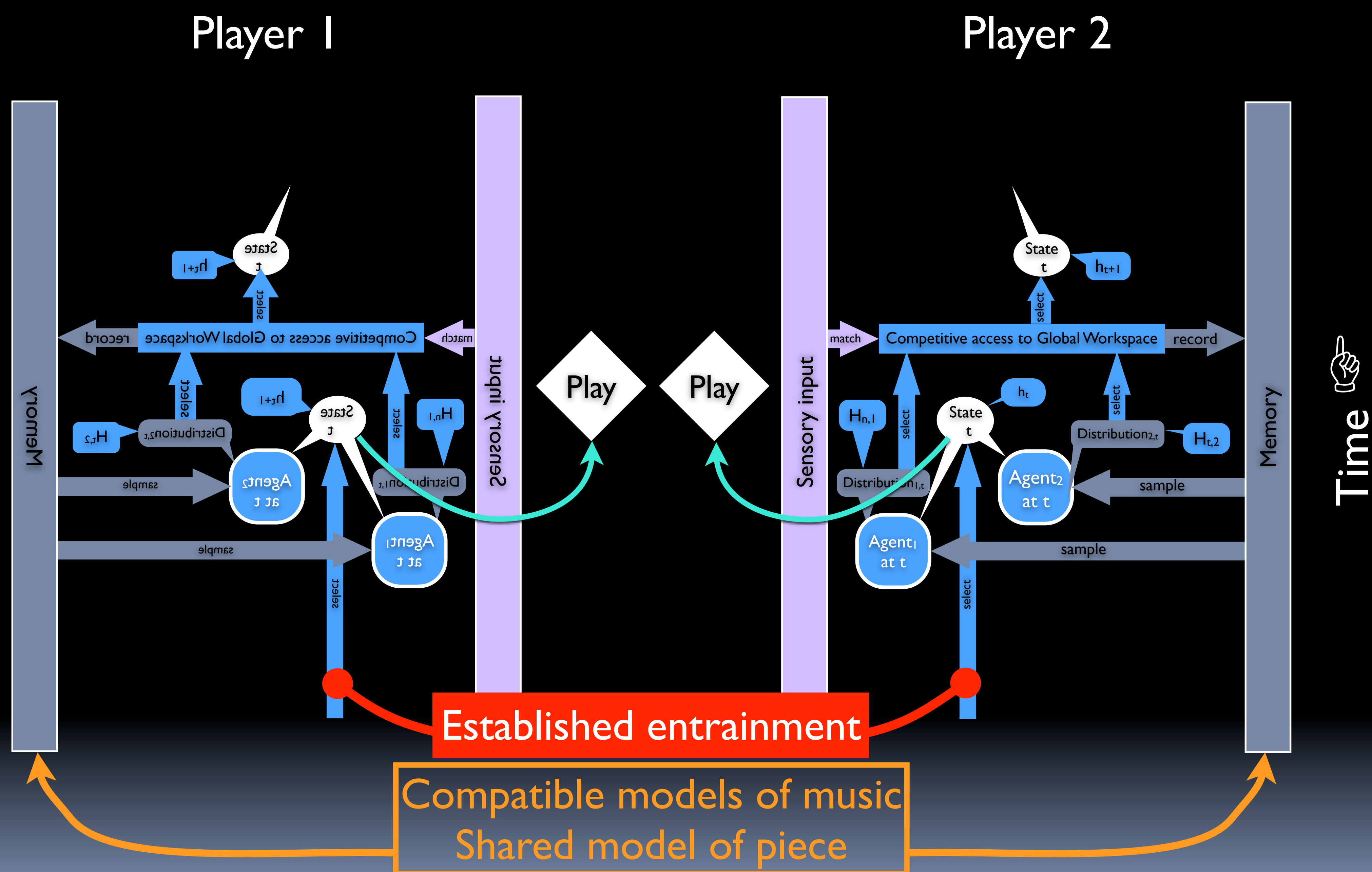

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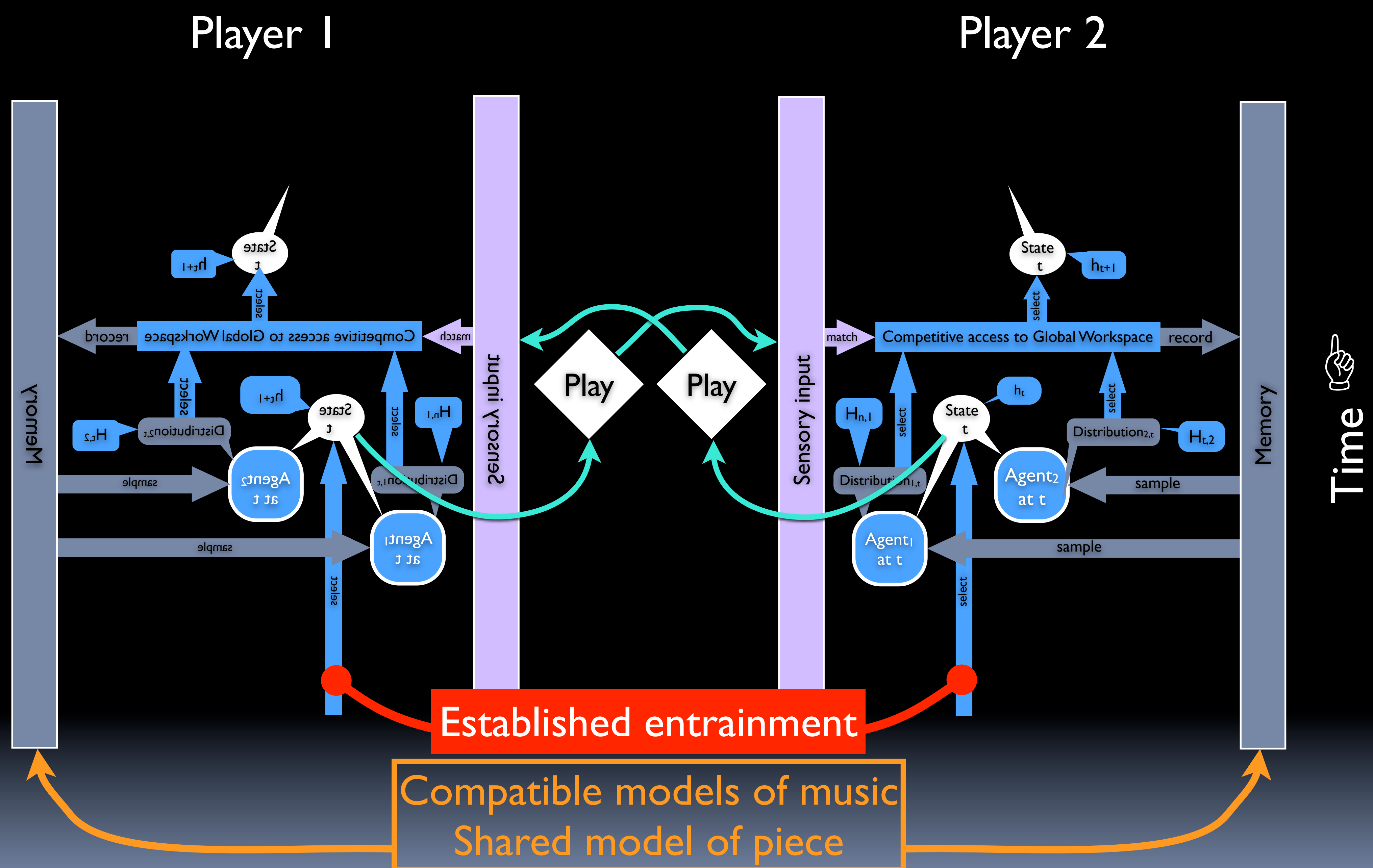

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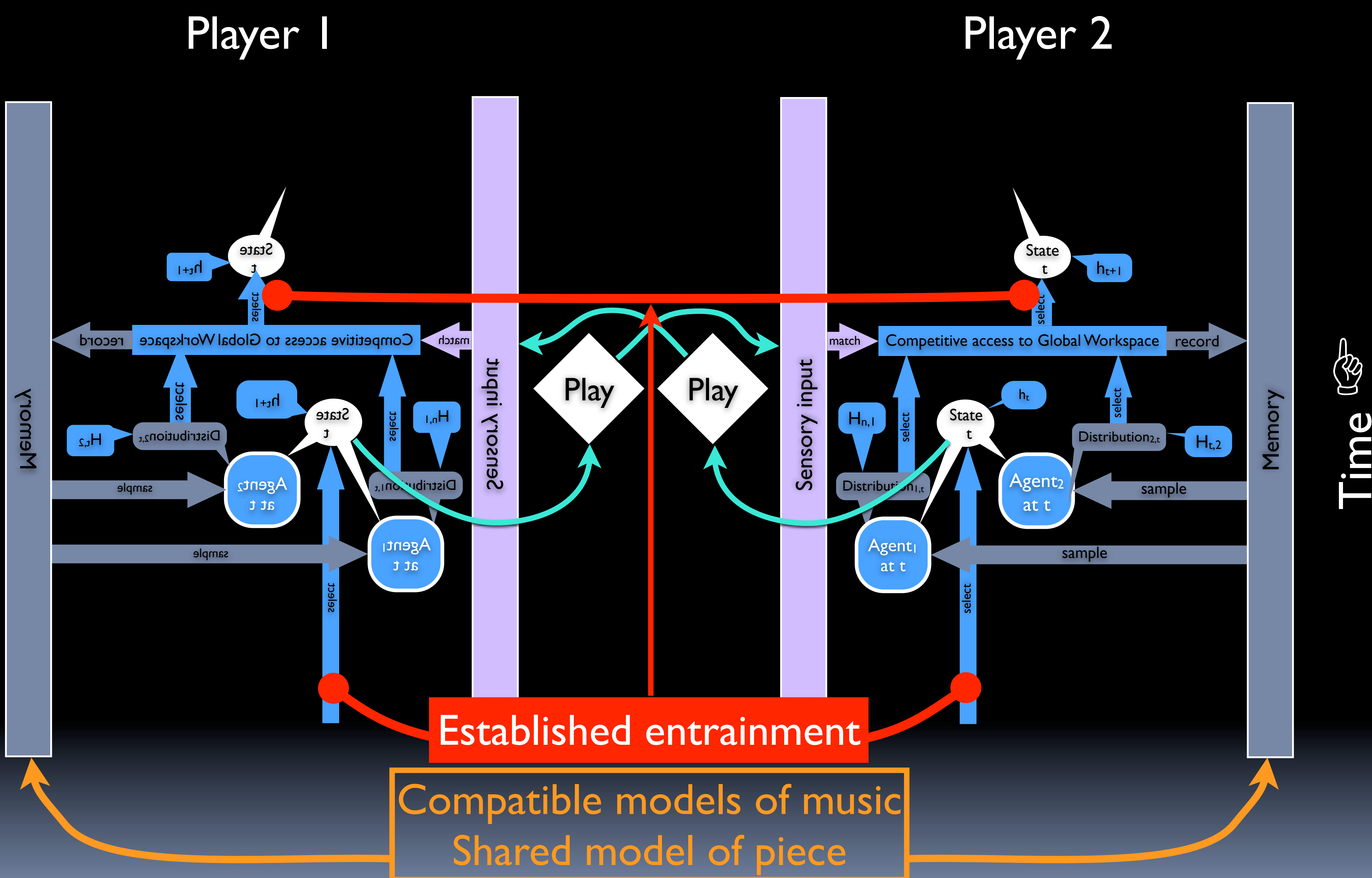

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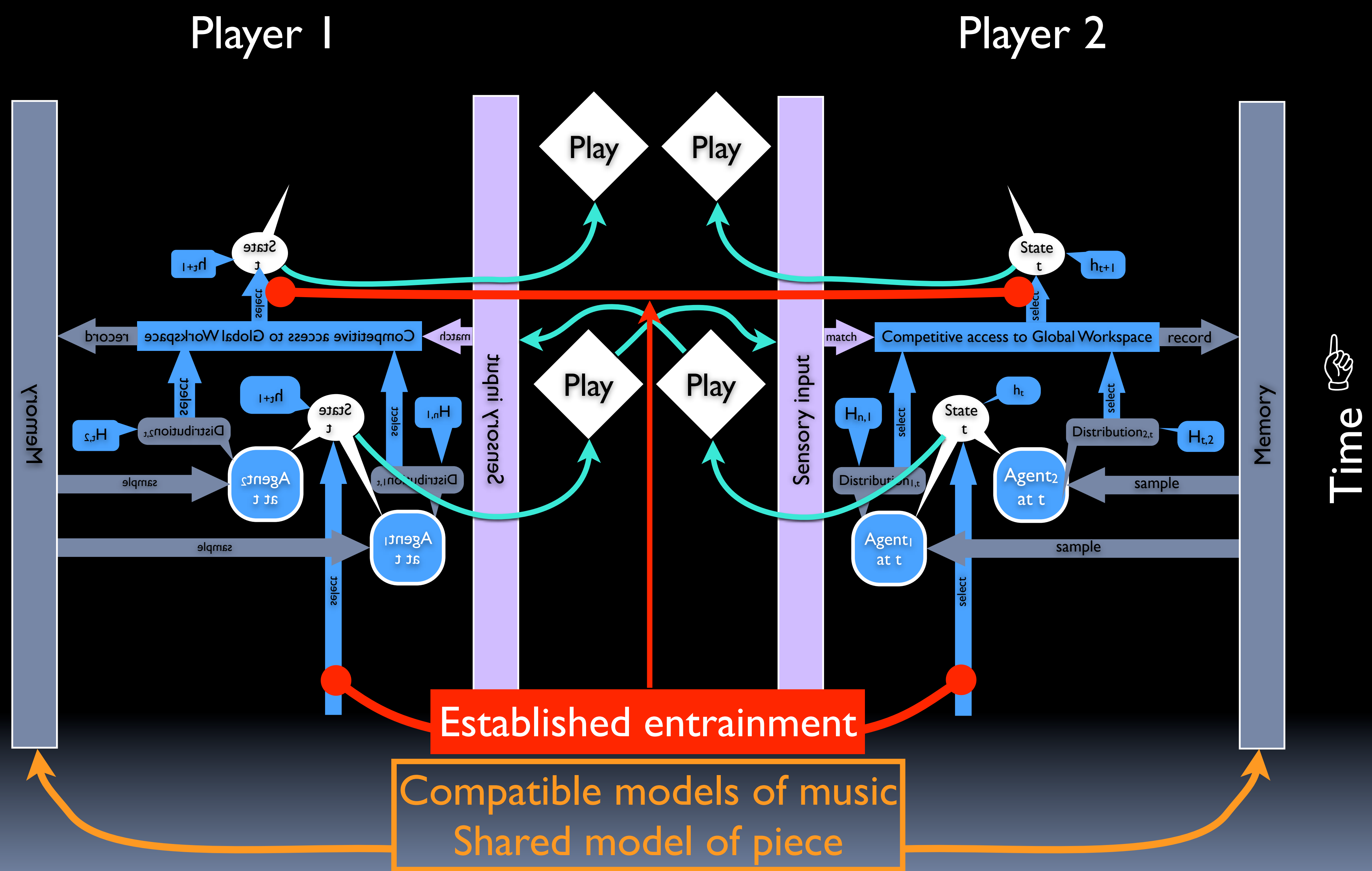

Consequences

- Given
  - perceptual mechanisms – given as discrete representations – ongoing research
  - learned enculturation – statistical mechanisms
    - musical technique (e.g. ability to hear musically, ability to play)
    - musical knowledge (e.g. chord sequences of particular songs, music "theory")
  - mechanism for entrainment – open question (Large et al., oscillatory model?)
  - reward mechanism (why is it fun?)
    - maybe somatic responses to memory activity (Biederman & Vessel, 1996)
    - maybe emotional responses to interaction itself (cf. intuitive parentese)
    - these are mechanisms that promote societal bonding = good for survival
- ... improvisatory behaviour naturally arises from a cognitive mechanism for survival in the world

Evaluation

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- Creativity is a slippery concept in humans
  - how can we evaluate the model?
- Doing this with music is in a sense easier than with language or other kinds of knowledge
  - no real-world inference necessary
  - but that doesn't make it easier to evaluate
- **Build the beast and see what it does!**
  - does it produce novel and interesting (musical) ideas?
  - does its behaviour match human behaviours?
  - Use evaluation methods from CC
    - Ritchie's artefact analysis
    - Colton's FACE & IDEA formalisms, etc.

Where to find more

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- Full (long) paper on model due on line in next 3 weeks:
  - Wiggins, G. (2012) The Mind's Chorus: Creativity before Consciousness. *Cognitive Computation*. Special issue on Computational Creativity, Intelligence and Autonomy, June.