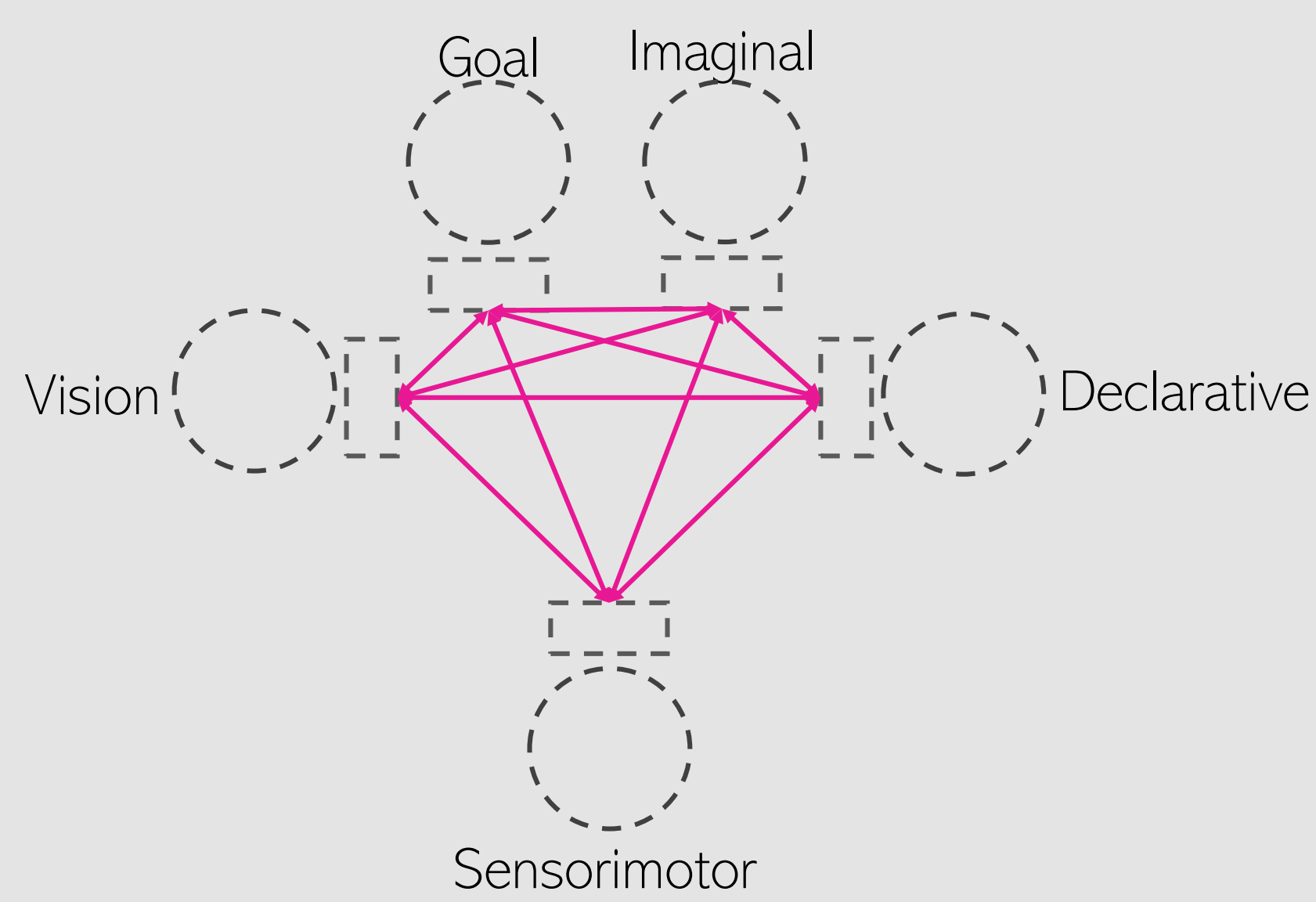
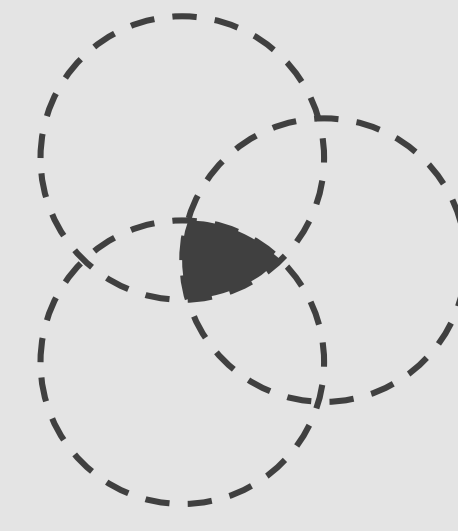




## Framework



ACT-R

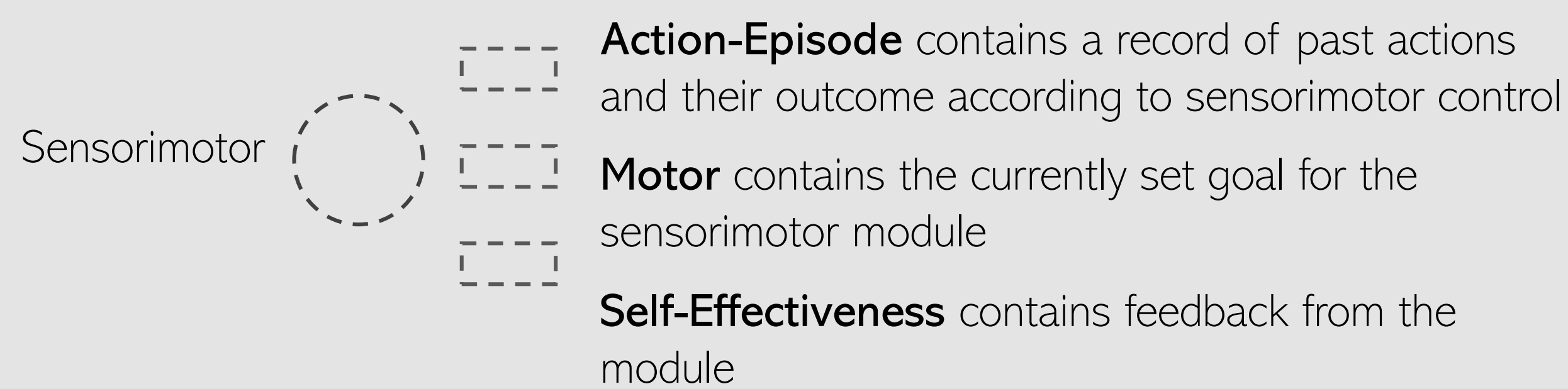


Bayes Modelling

## Communication via buffers

Buffers contain sets of structured symbols, that are processed by the production system.

Three new buffers are added:



## Combines top-down and bottom-up processing.

New sensorimotor module implements bottom-up processing. While the ACT-R production system produces movement goals, sensorimotor system tries to satisfy these location predictions and sends back feedback.

## Extending principle to multiple modules

Only sensorimotor module implements a direct connection between vision and motor systems and provide an abstract way of instructing the system. Allowing the modelling of general agents once this principle is applied to other cognitive processes.

## Self representation (task-specific)

**Currently available actions** are constraint by top down and bottom up factors. In our task, there are only two types of action: activate assistance system and place waypoint in manoeuvrable space.

**Bottom-up constraints** are reports of the effectiveness of the currently conducted action. Effectiveness is measured as the difference between expected goal and achieved position.

**Top-down constraints** are predictable disturbances. Some disturbances are visually perceivable, also the high level cognition part constantly monitors spaceships position and can infer variations on input.

**Current task goal** that can be accomplished in the next few moments. Most of the time, this is a waypoint that marks a future location of the spaceship.

**Uncertainty** affects behaviour. If a situation is not controllable – high prediction errors that cannot be explained away – the agent will act with safety oriented strategies (e.g. keep high distance to obstacles).

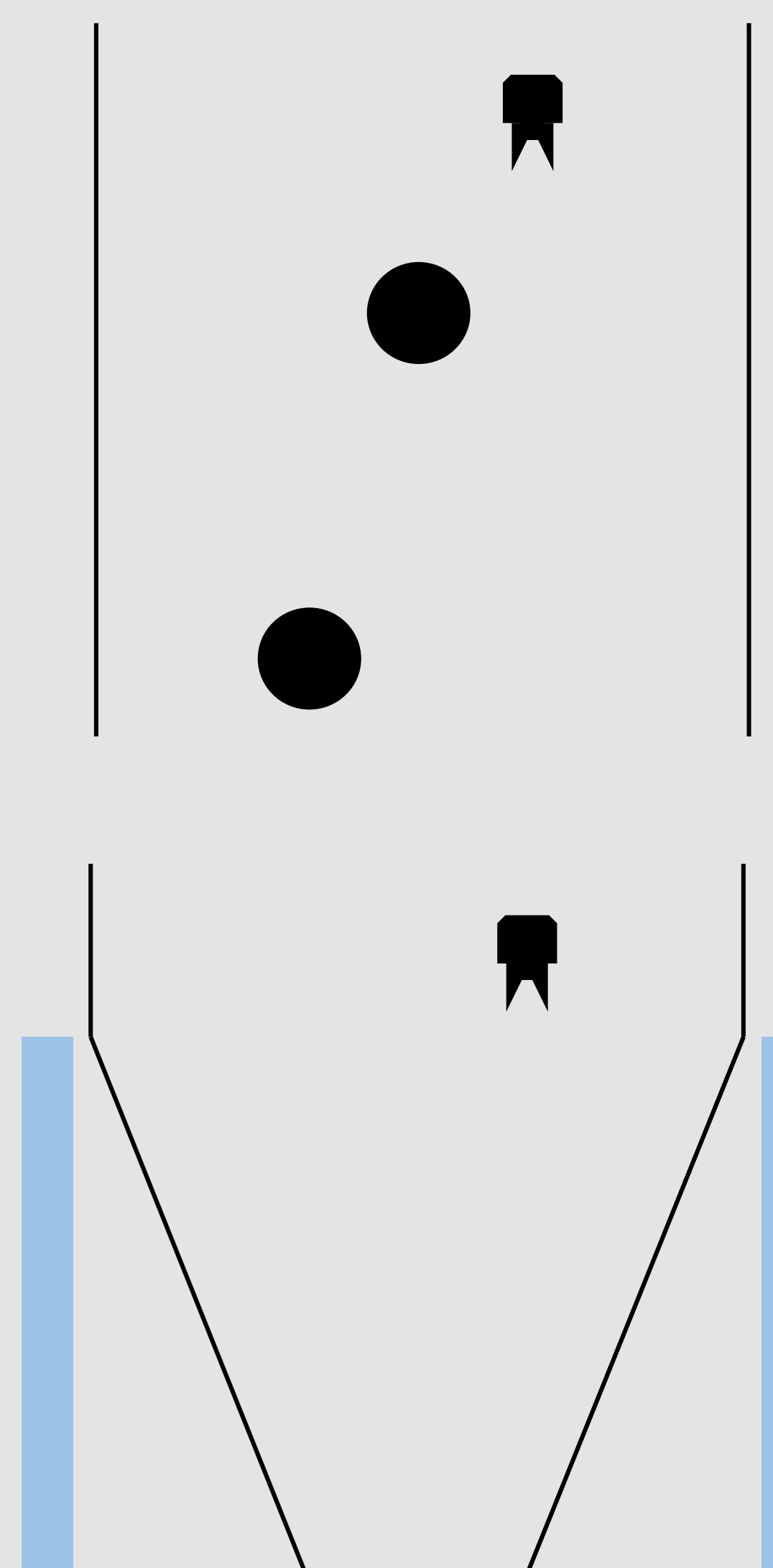
## Example

Agent has no prior knowledge about disturbances or markings.

High level cognition learns strategies to cope with obstacles and disturbances. It therefore sets movement goals.

Sensorimotor module compensates slight variations in input strength and environmental disturbances.

With more time the agent will rely increasingly on sensorimotor compensation and less on top-down strategy corrections.



## ACT-R part

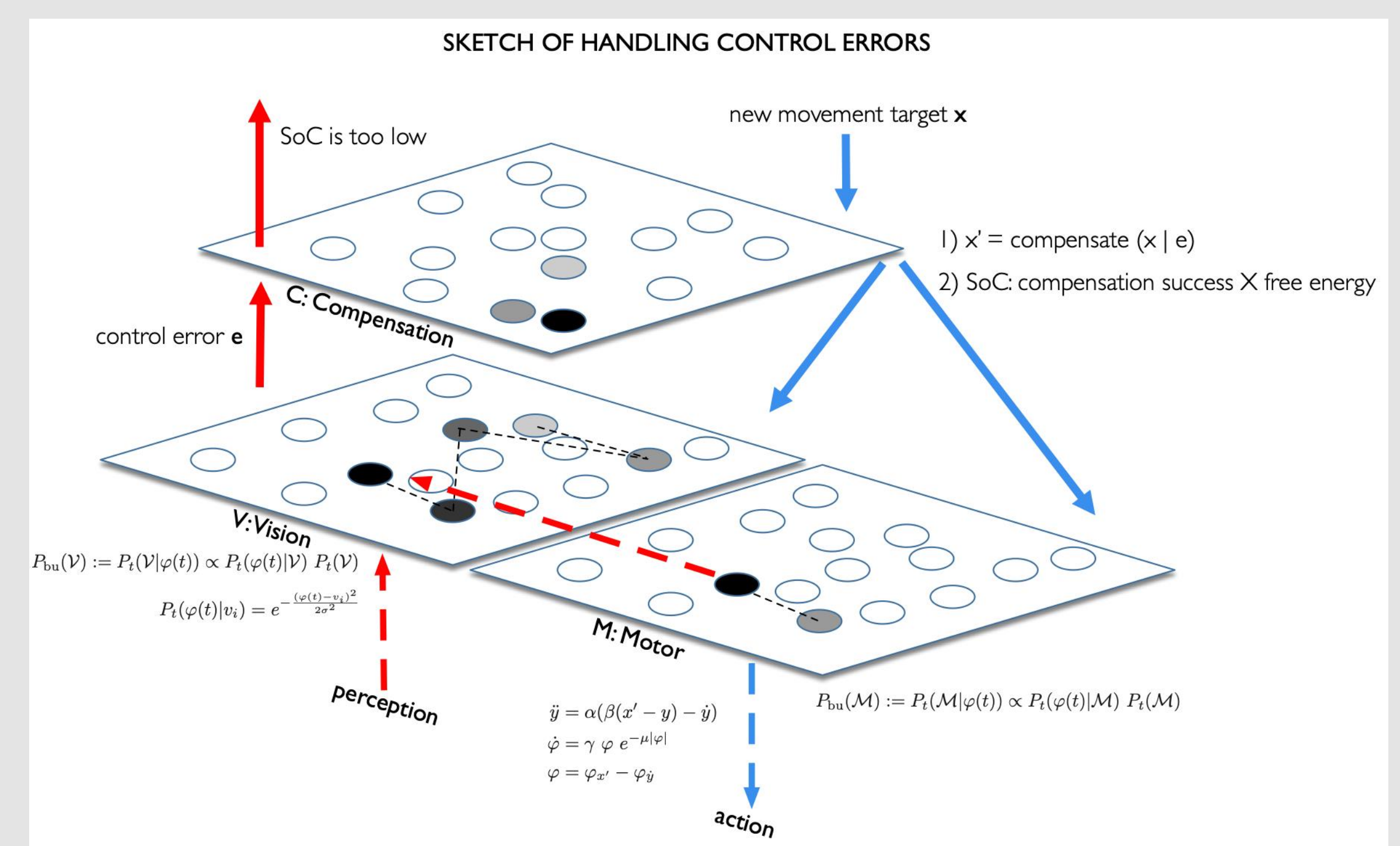
Integrates information from many sources (different modalities, declarative memory) and over long periods of time.

Production system has access to information already processed by modules and delegates tasks back to these modules. In this way, it orchestrates behaviour.

Postdictive and reflective component of the agent that tries to find explanations about unpredicted outcomes and events. ACT-R maintains a history of past events and actions.

Long term decision making and learning.

## Sensorimotor module



Actions have an immediate, directly observable outcome.

Observes primary modality (motor) in full and secondary modality (vision) in parts (only relevant parts)

Short term decision making and learning.

High plasticity allows fast adaption to changes in self representation. Module can compensate some disturbances.

Increasing complexity in hierarchy - from motor actions to sequences and programs - allows for construction of motor programs for different situations

## Task

### Objective

Steer a spaceship through a field of debris. React to fast approaching

### Environment

A small channel that sometimes narrows and widens. Obstacles that damage the spaceship. Environmental disturbances that move the spaceship. Left drift pushes ship to the left in varying strengths and stochastic drift that moves the ship unpredictably. Some disturbances zones are indicated by markings.

### Controls

Spaceship automatically descends.  
Steer right or left  
Activate assistance system that neutralizes effects of disturbance.

### Requirements for agent

React to fast approaching obstacles.  
Motor compensation to adapt to disturbances and systematic input noise  
Strategic planning: where to stay in the channel  
Learn strategies to cope with cones and disturbances

### Empirical study

Human participants play the same game with the same set of rules. Objective is to gather behavioural data to validate cognitive model.

Higher sense of control leads to longer reaction times until strategy of control is changed

Higher sense of control means that the attention for errors of control is increased

