

# *A BRDL-based Framework for Motivators and Emotions*

*Antonio Cerone*

antonio.cerone,@nu.edu.kz

Department of Computer Science, Nazarbayev University,  
Astana, Kazakhstan

# *Background and Definitions*

- **Motivation** is an impulse or desire, often determined by a need that cause human being to act.

# *Background and Definitions*

- **Motivation** is an impulse or desire, often determined by a need that cause human being to act.
- **Emotion** is a psychological feeling, usually accompanied by a physiological reaction.

# *Background and Definitions*

- **Motivation** is an impulse or desire, often determined by a need that cause human being to act.
- **Emotion** is a psychological feeling, usually accompanied by a physiological reaction.

Motivations and emotions are

- **related**: both perceived as feelings driving behaviour, originate within us and involve some physical sensations.

# *Background and Definitions*

- **Motivation** is an impulse or desire, often determined by a need that cause human being to act.
- **Emotion** is a psychological feeling, usually accompanied by a physiological reaction.

Motivations and emotions are

- **related**: both perceived as feelings driving behaviour, originate within us and involve some physical sensations.
- **different**: e.g., **motivations** tend to be cyclical and **sustain human activities**, whereas **emotions** tend to **interfere with or change human activities**.

# *Background and Definitions*

- **Motivation** is an impulse or desire, often determined by a need that cause human being to act.
- **Emotion** is a psychological feeling, usually accompanied by a physiological reaction.

Motivations and emotions are

- **related**: both perceived as feelings driving behaviour, originate within us and involve some physical sensations.
- **different**: e.g., **motivations** tend to be cyclical and **sustain human activities**, whereas **emotions** tend to **interfere with or change human activities**.

But **emotions** are not in opposition to reasoning, instead they **motivate human behaviour** and **support the decision making process**

# *Motivation (of the research)*

In our previous work:

- BRDL (Behaviour and Reasoning Description Language) models human memory and memory in order to processes to describe human behaviour and reasoning

# *Motivation (of the research)*

In our previous work:

- BRDL (Behaviour and Reasoning Description Language) models human memory and memory in order to processes to describe human behaviour and reasoning
- human goal are **given initially** or **rationally established as subgoals**



# *Motivation (of the research)*

In our previous work:

- BRDL (Behaviour and Reasoning Description Language) models human memory and memory in order to processes to describe human behaviour and reasoning
- human goal are **given initially** or **rationally established as subgoals**

We want to extend BRDL

- with **motivators** that may **establish goals**
- modelling **physiological effects** of motivators
- modelling **emotions**

# *Contents*

- Background
- Motivation

# Contents

- Background
- Motivation
- Overview of BRDL — Behaviour and Reasoning Description Language and Example
- Motivators and Needs
- Modelling External Environment and Internal Physiology
- Modelling Emotions
- Conclusion and Future Work

# *Modelling Cognition: BRDL*

Behaviour and Reasoning Description Language

External Environment

# *Modelling Cognition: BRDL*

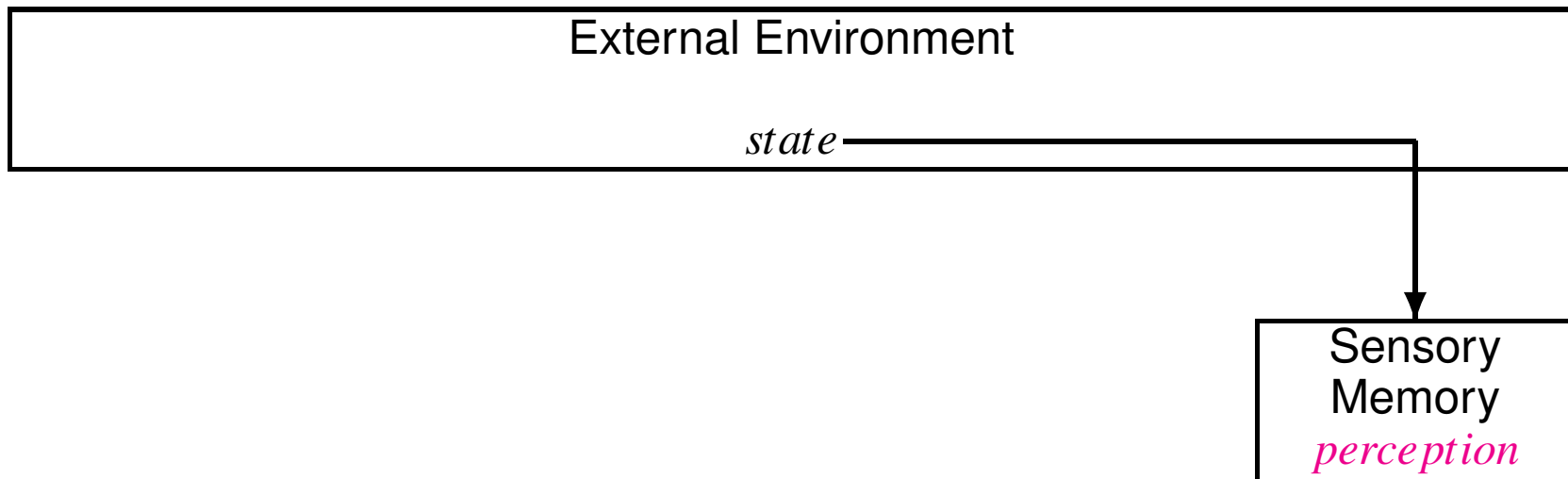
Behaviour and Reasoning Description Language

External Environment

*state*

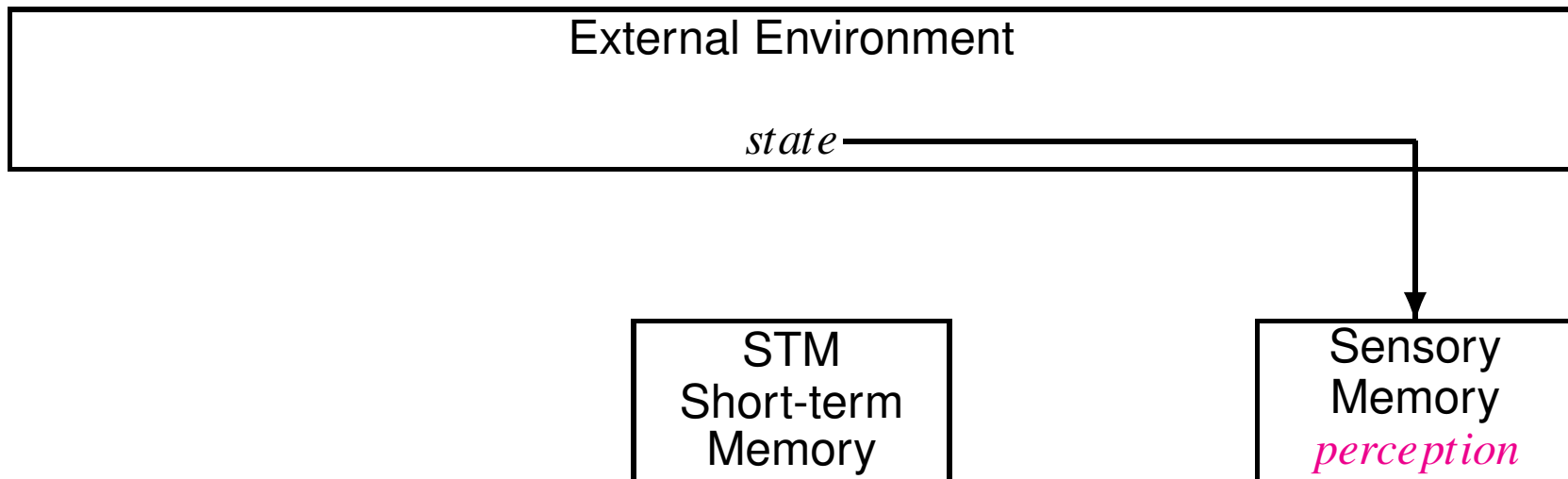
# Modelling Cognition: BRDL

Behaviour and Reasoning Description Language



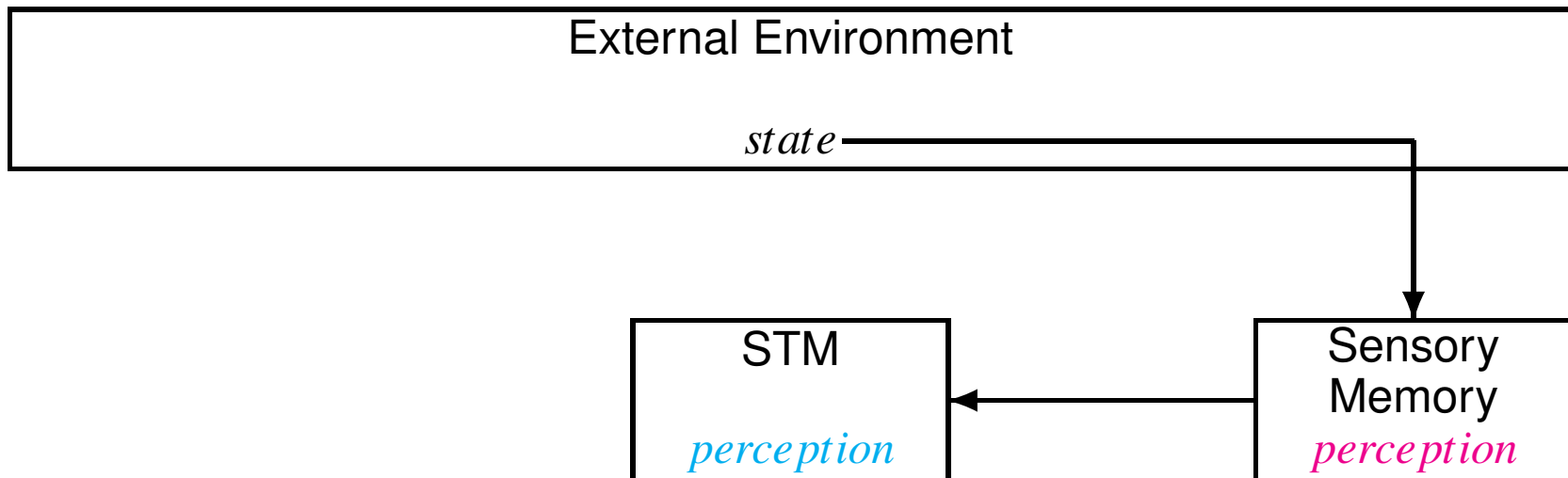
# Modelling Cognition: BRDL

## Behaviour and Reasoning Description Language



# Modelling Cognition: BRDL

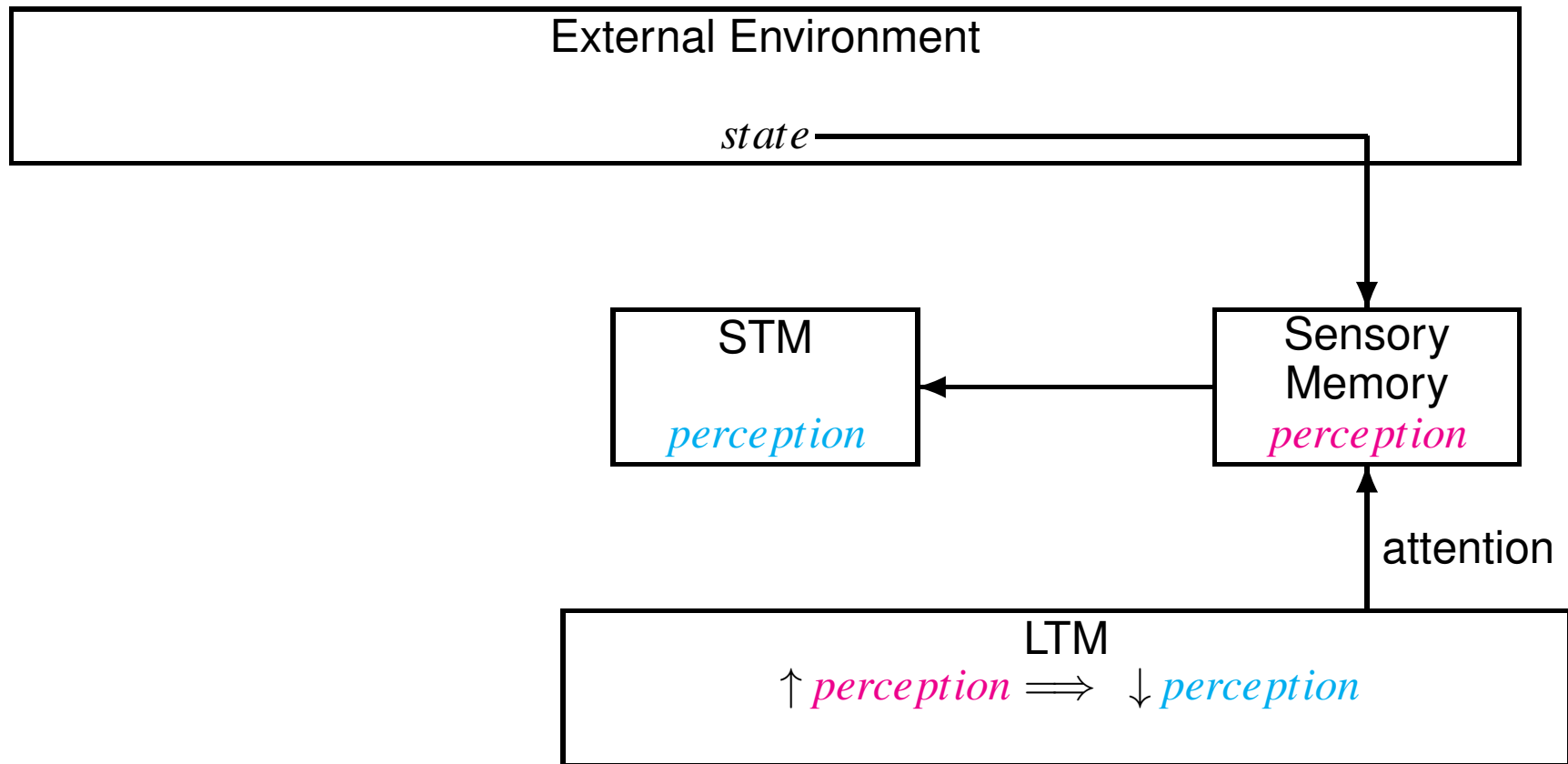
## Behaviour and Reasoning Description Language





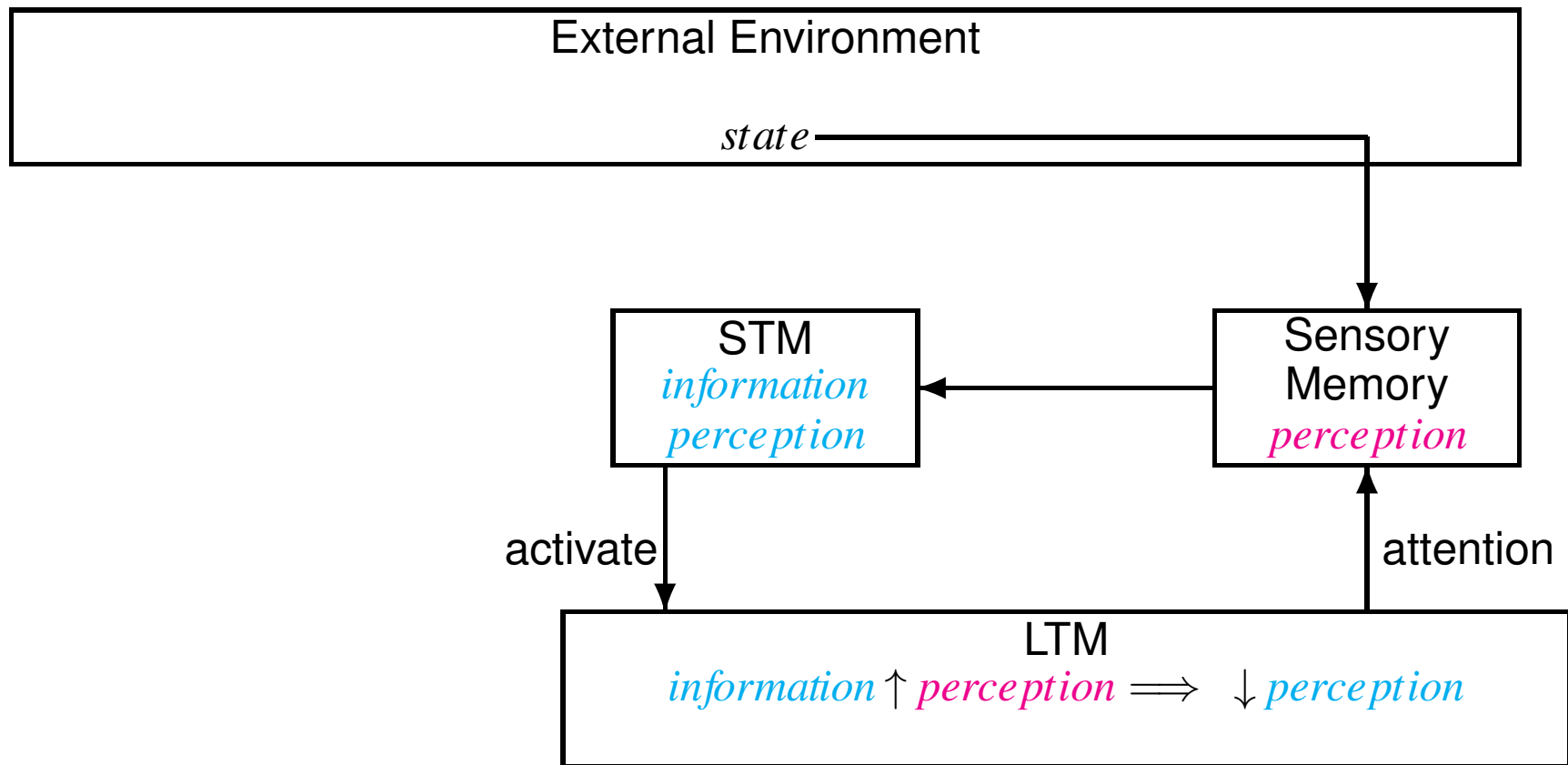
# Modelling Cognition: BRDL

## Behaviour and Reasoning Description Language



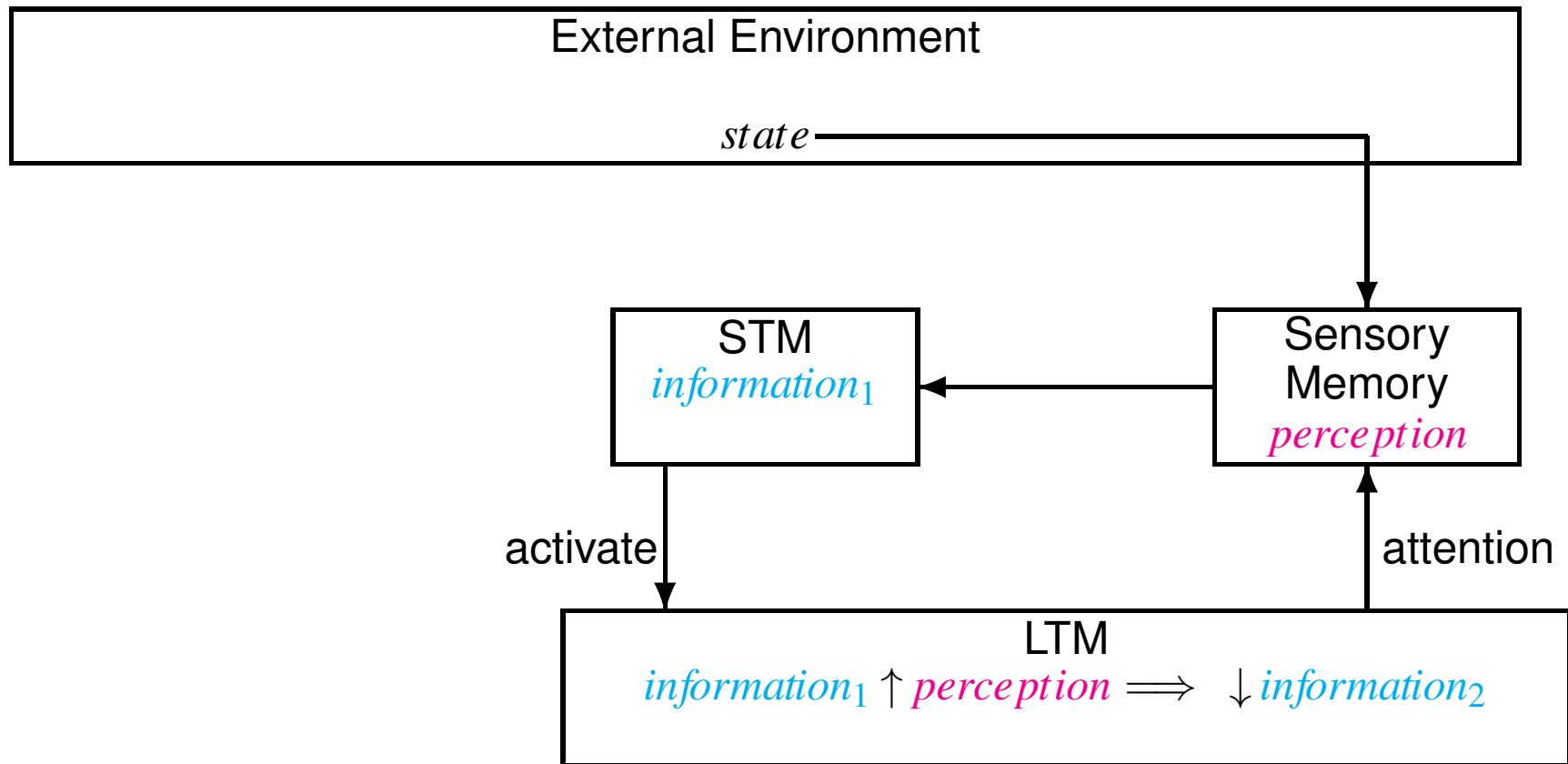
# Modelling Cognition: BRDL

## Behaviour and Reasoning Description Language



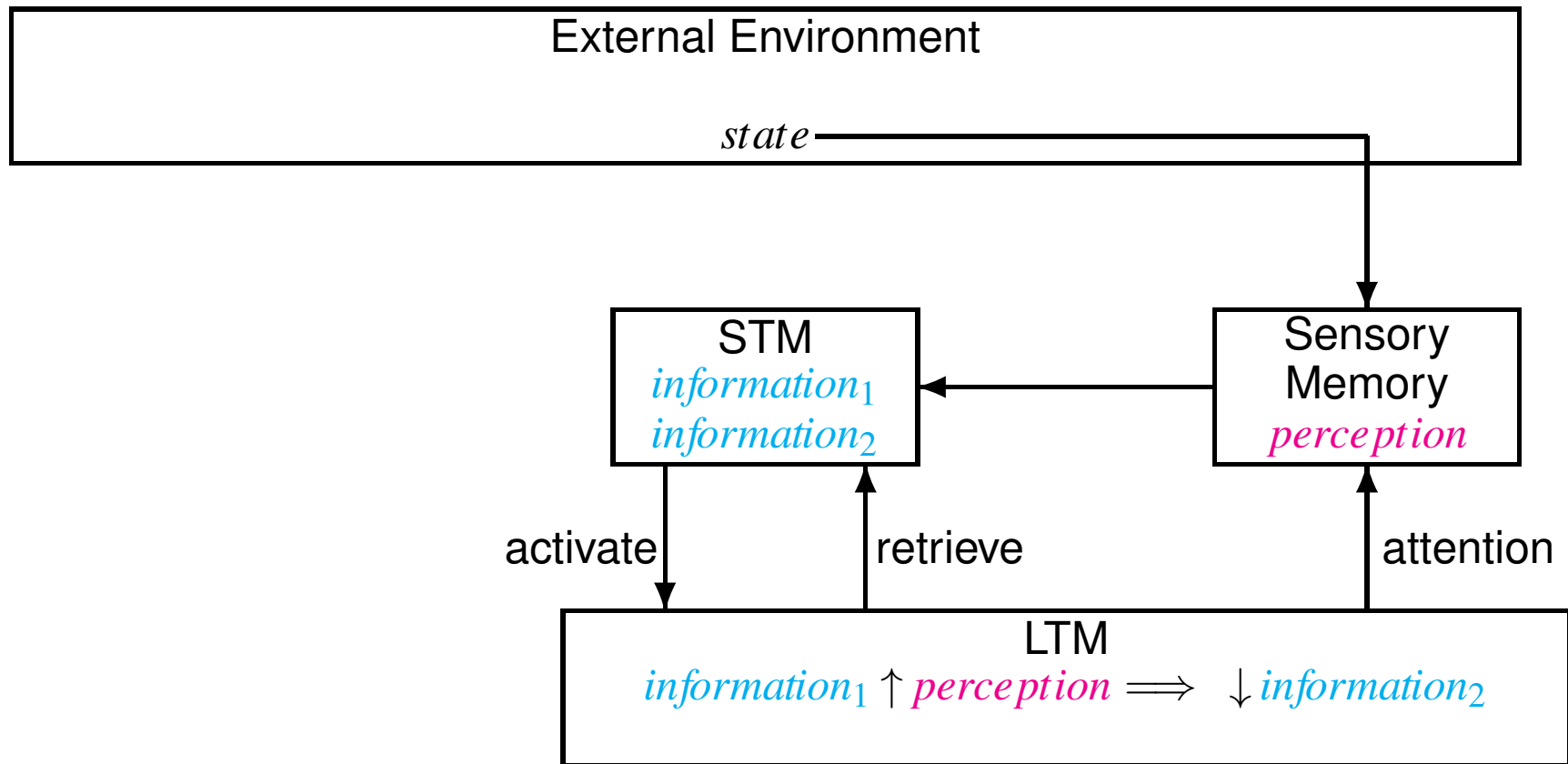
# Modelling Cognition: BRDL

## Behaviour and Reasoning Description Language



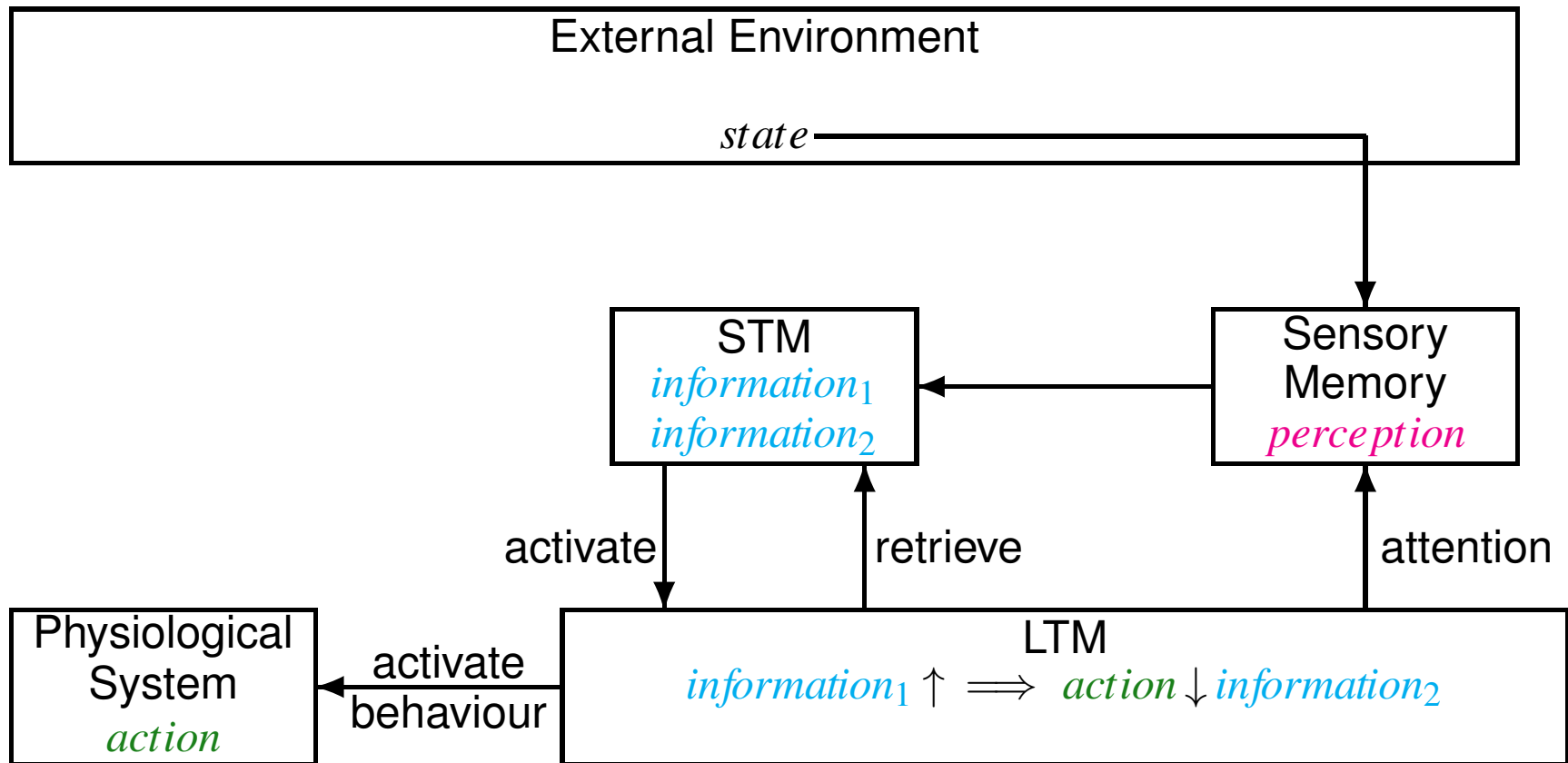
# Modelling Cognition: BRDL

## Behaviour and Reasoning Description Language



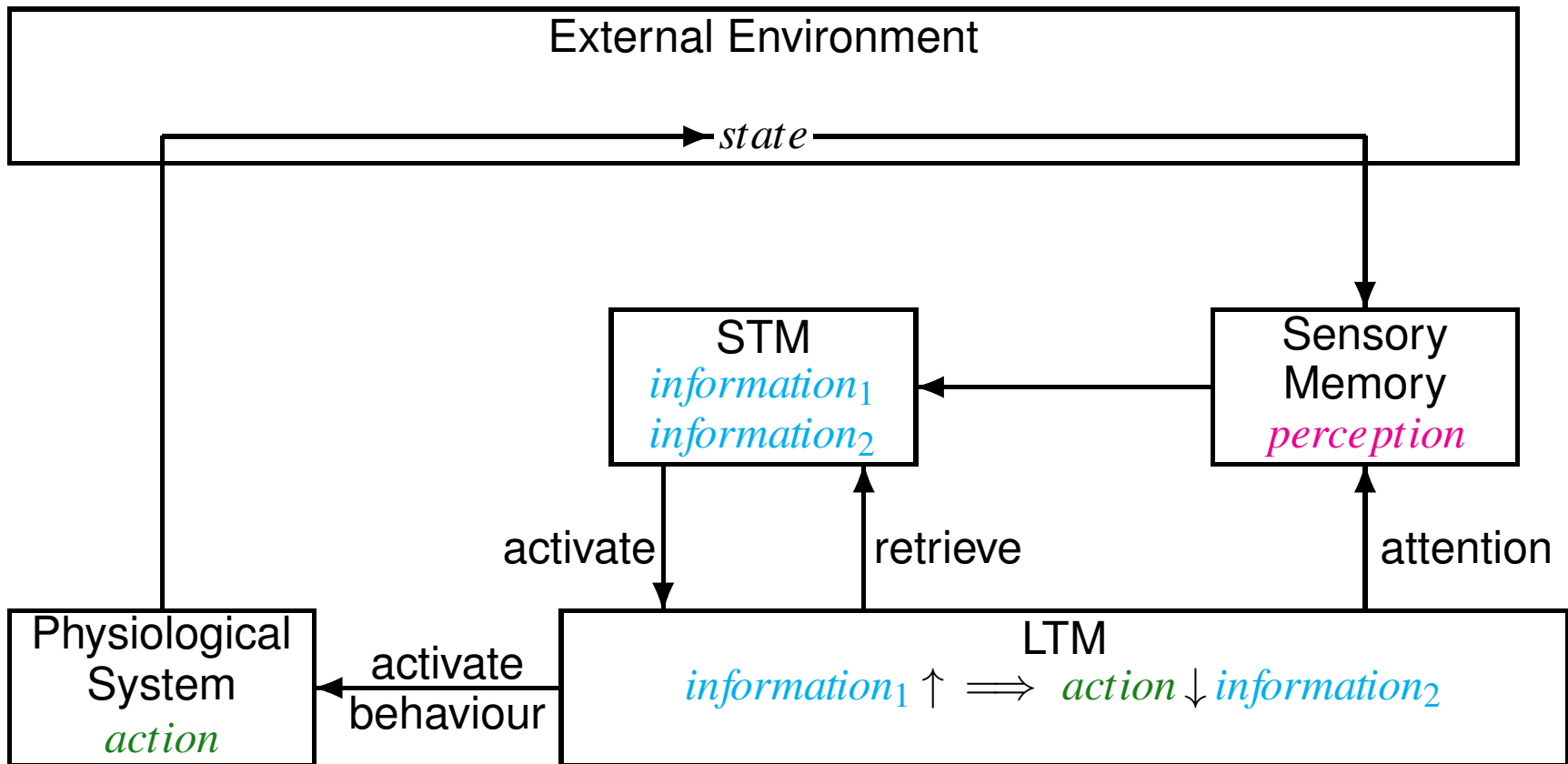
# Modelling Cognition: BRDL

## Behaviour and Reasoning Description Language

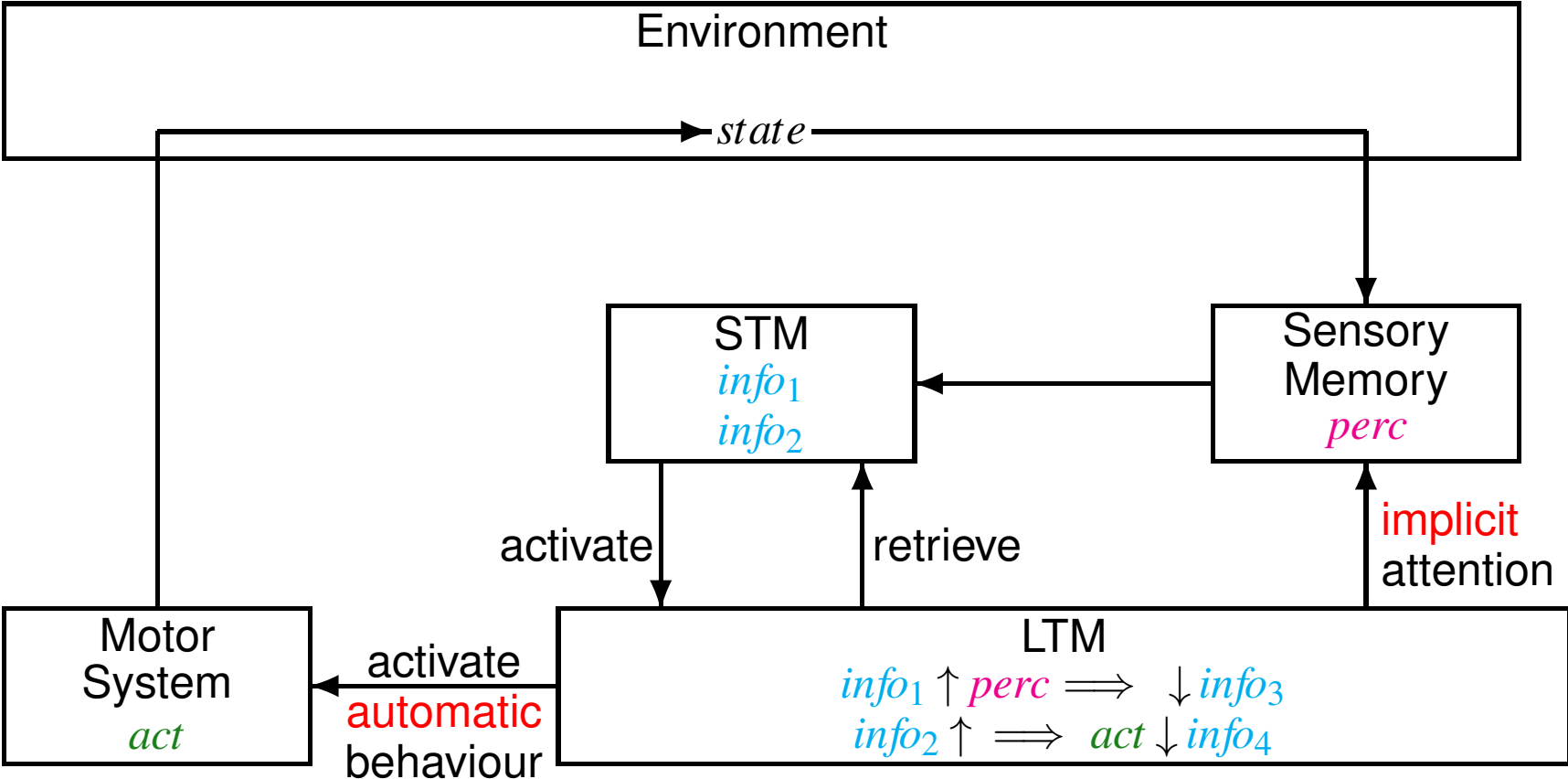


# Modelling Cognition: BRDL

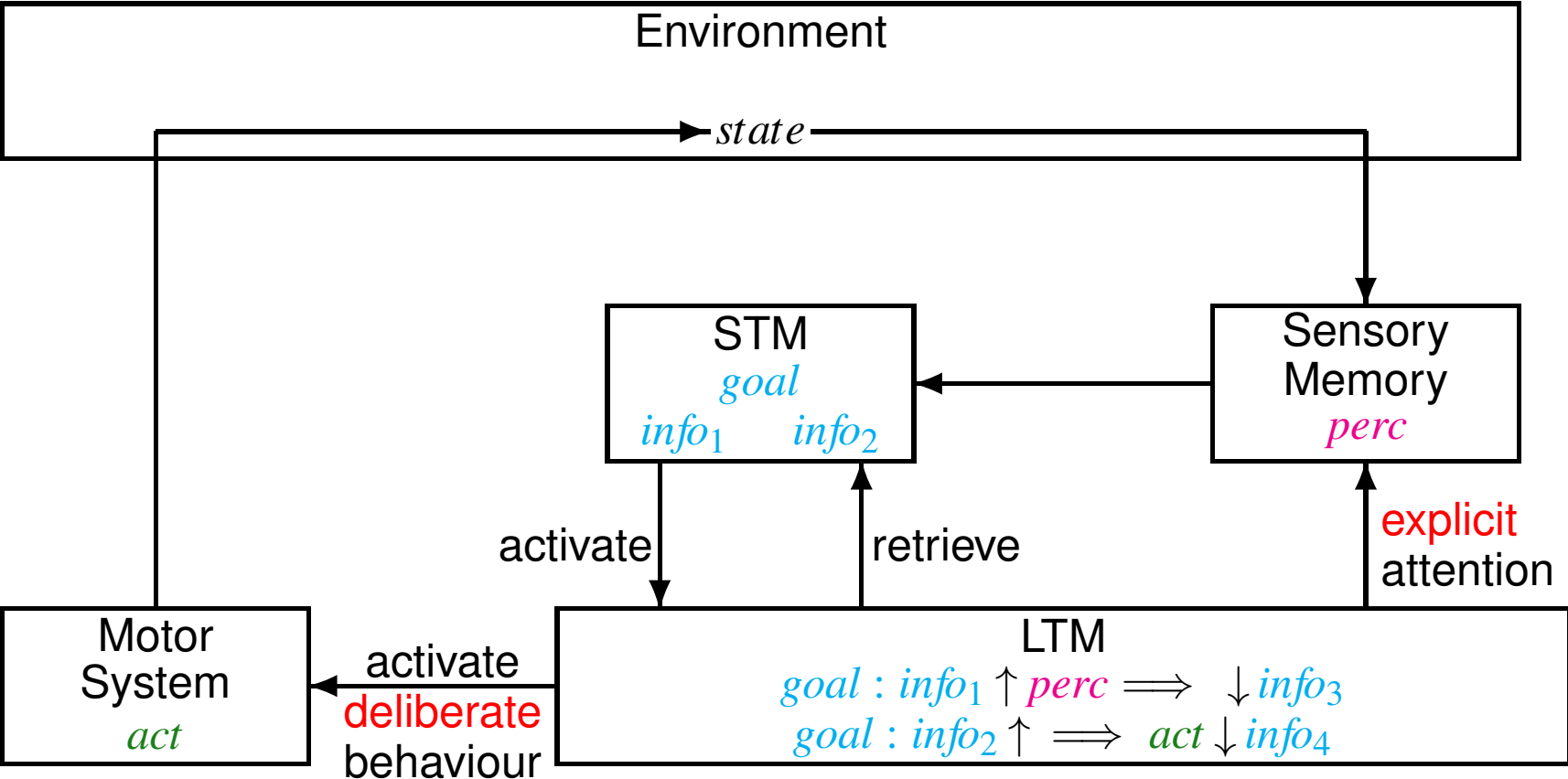
## Behaviour and Reasoning Description Language



# Automatic/Implicit Control

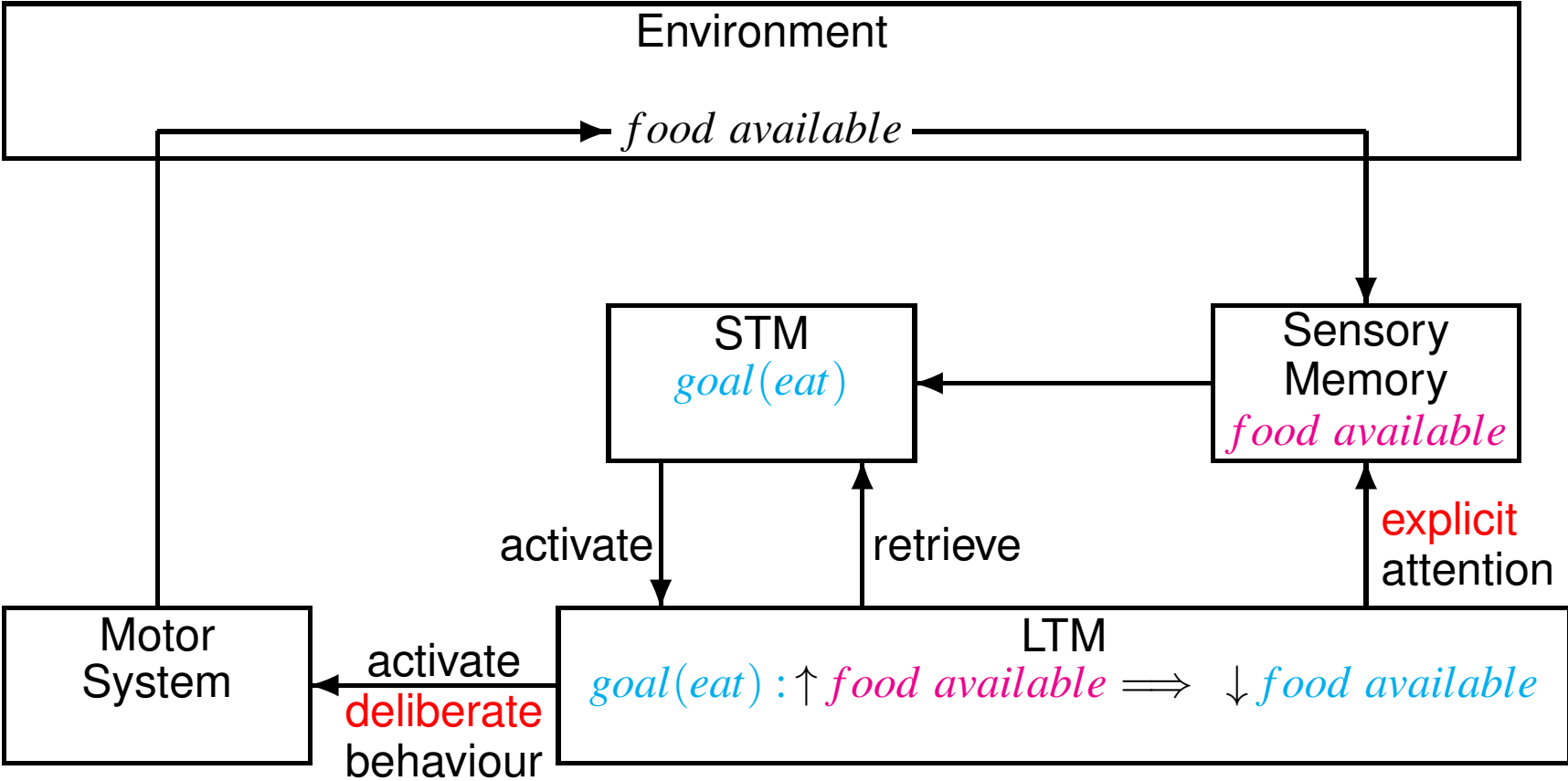


# Deliberate/Explicit Control

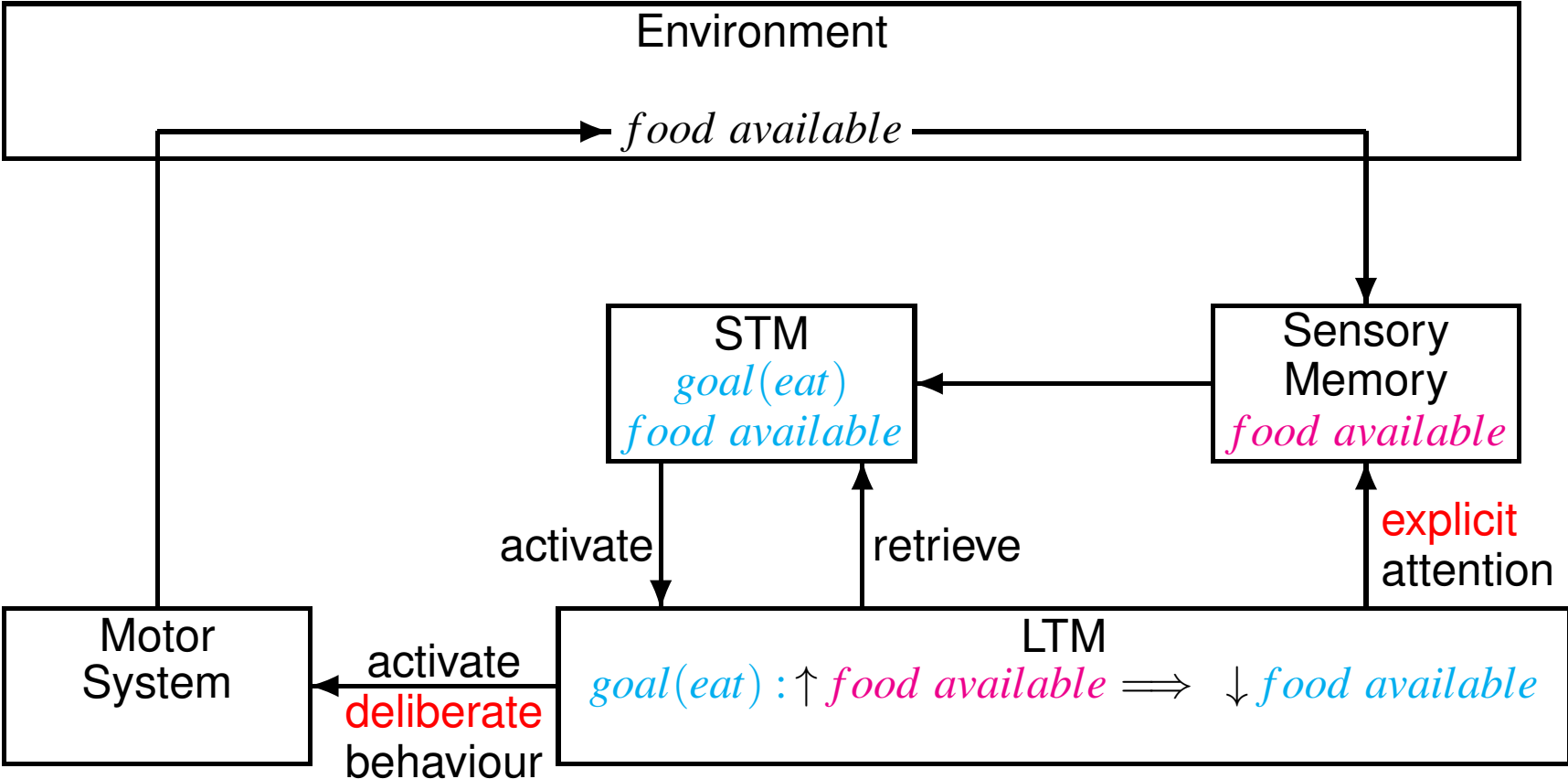




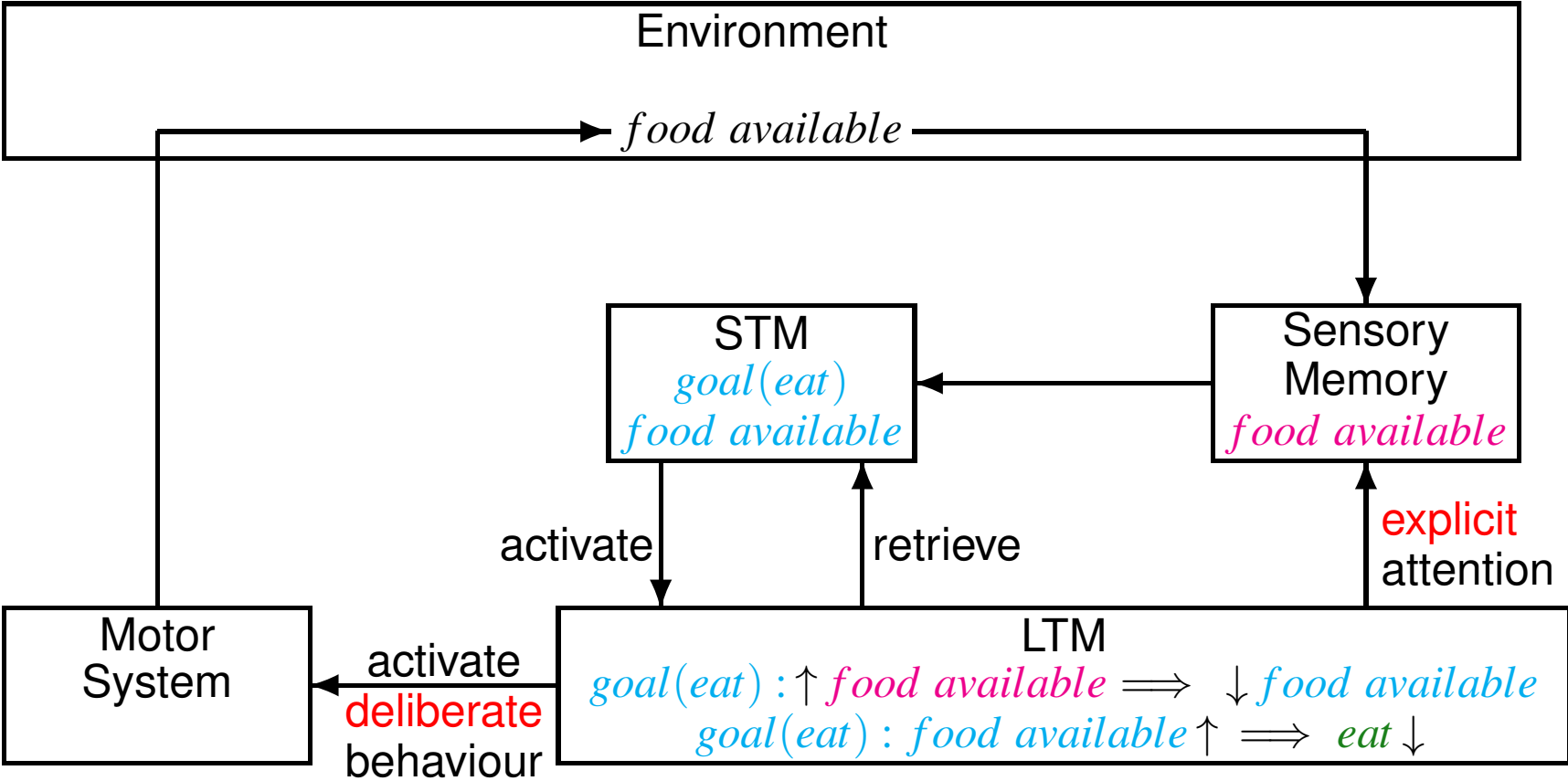
# Example: Eating



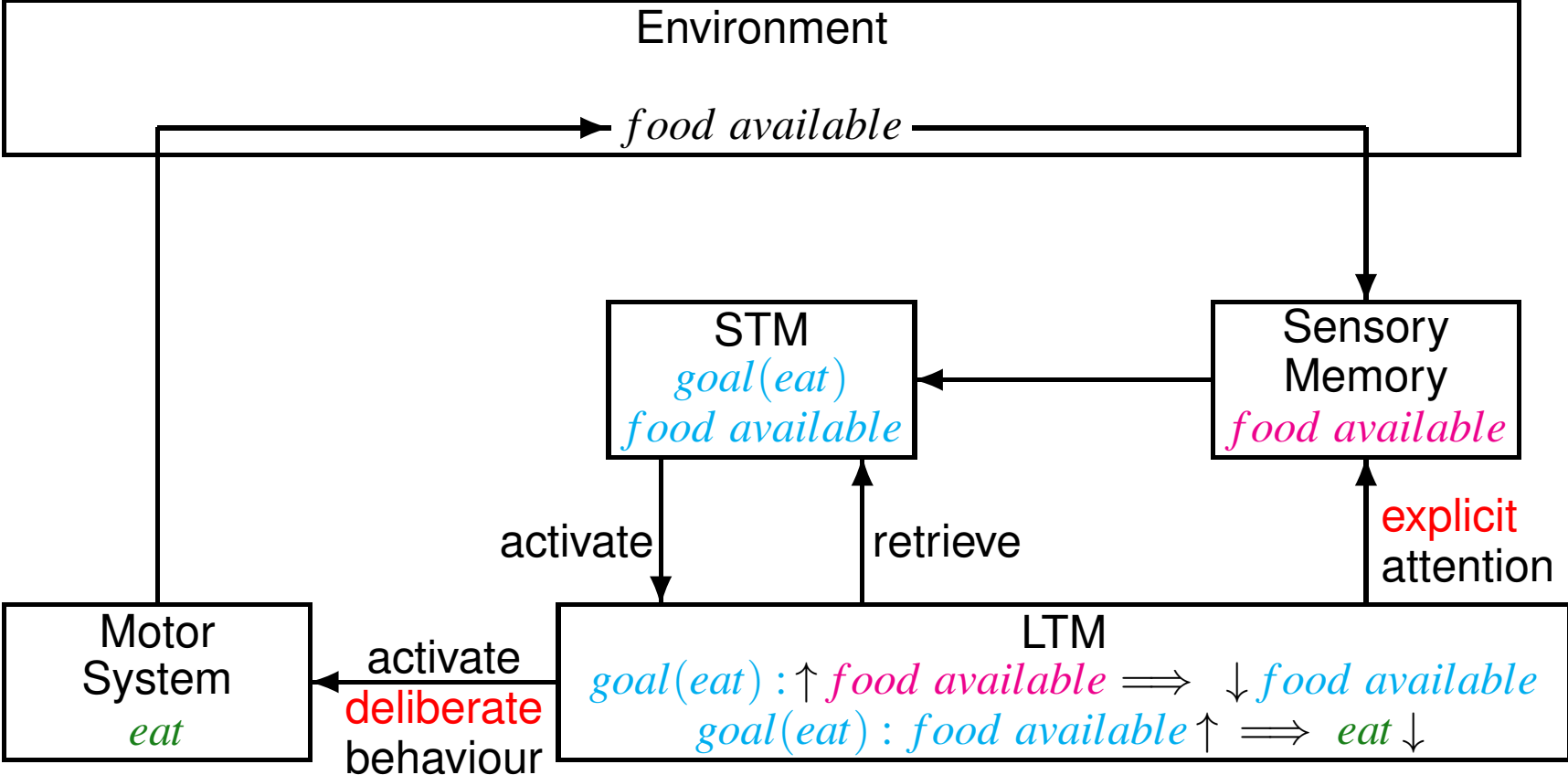
# Example: Eating



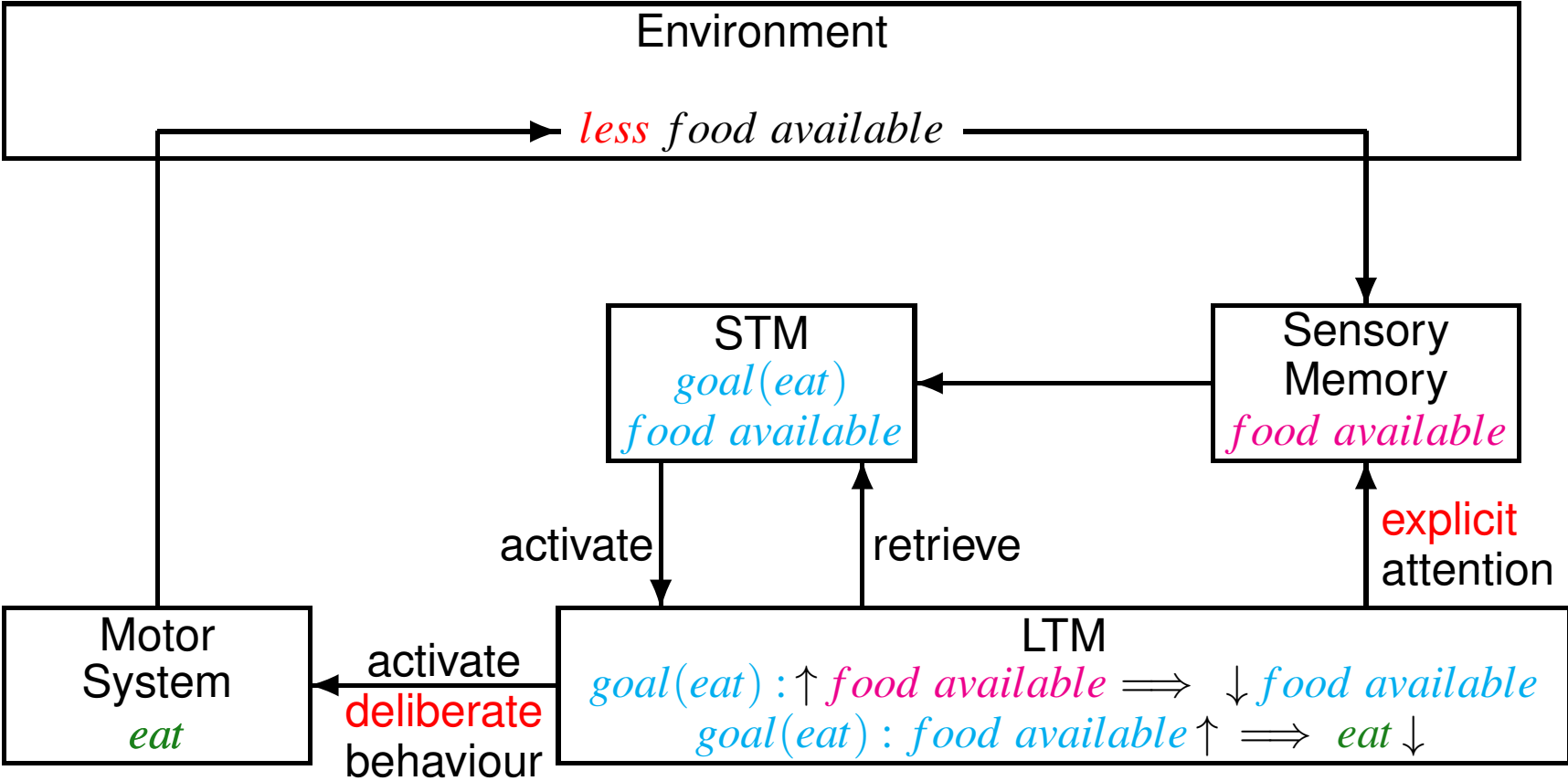
# Example: Eating



# Example: Eating

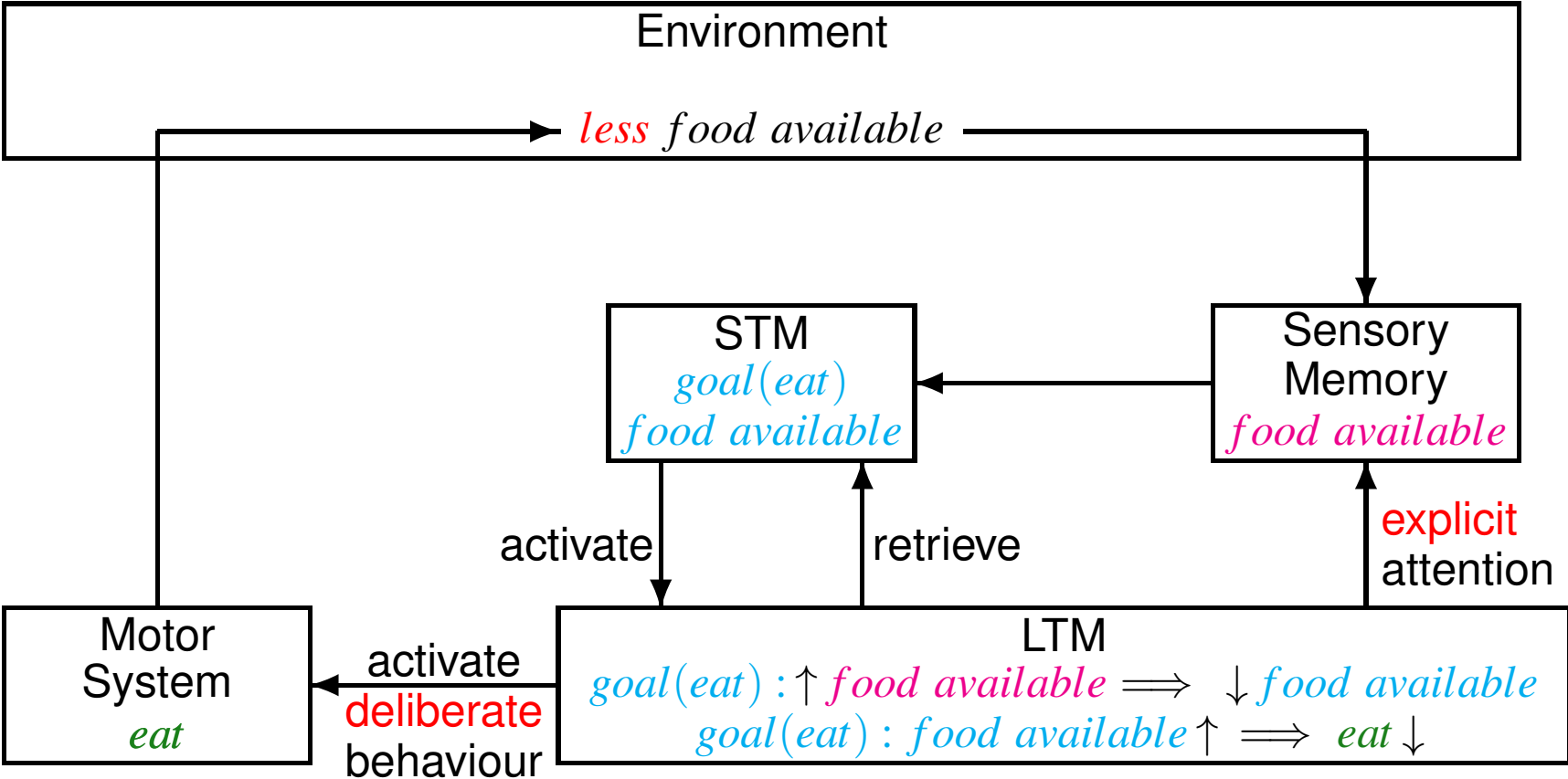


# Example: Eating



# Example: Eating

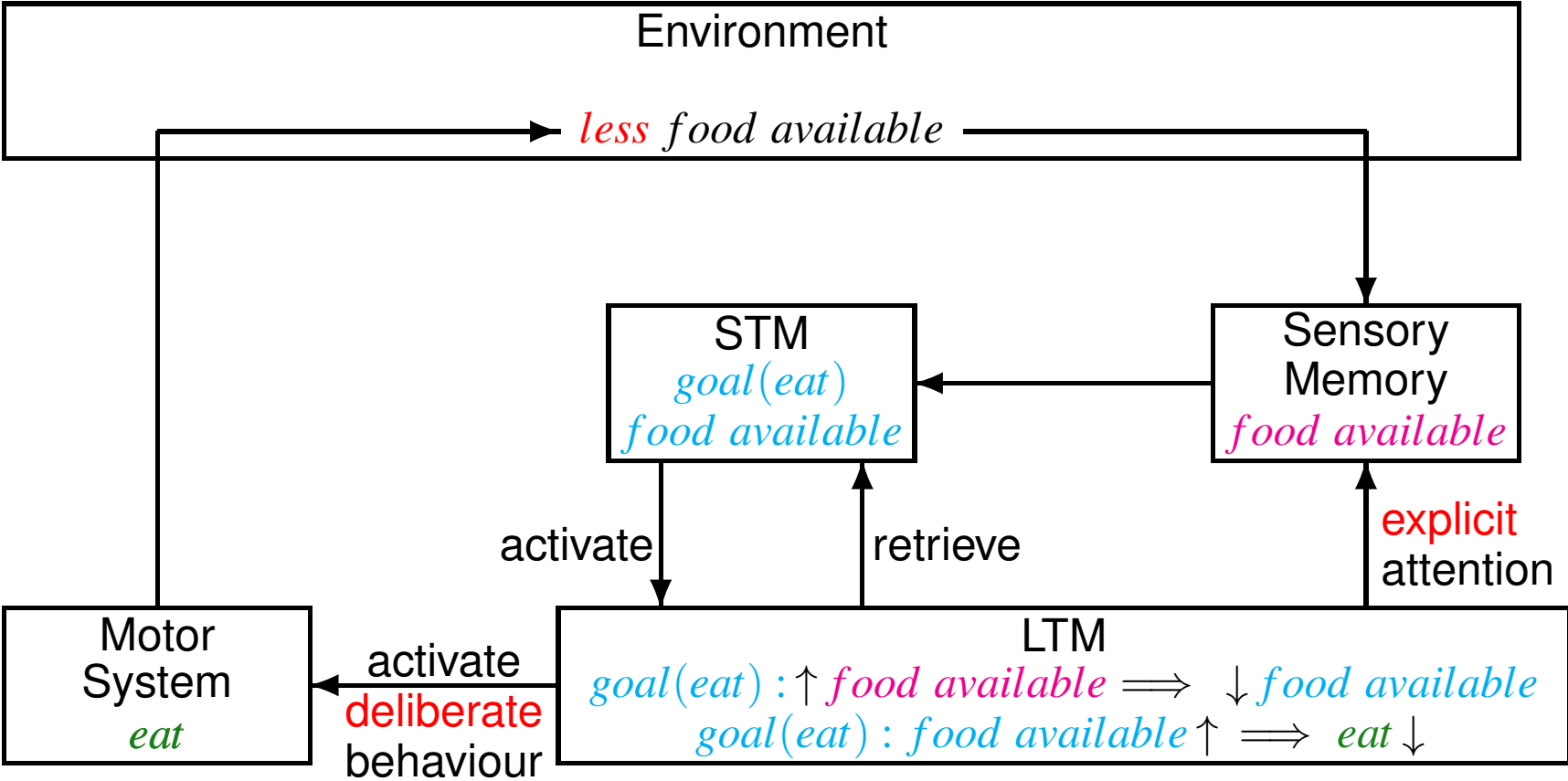
How was *goal(eat)* established in STM?



# Example: Eating

How was *goal(eat)* established in STM?

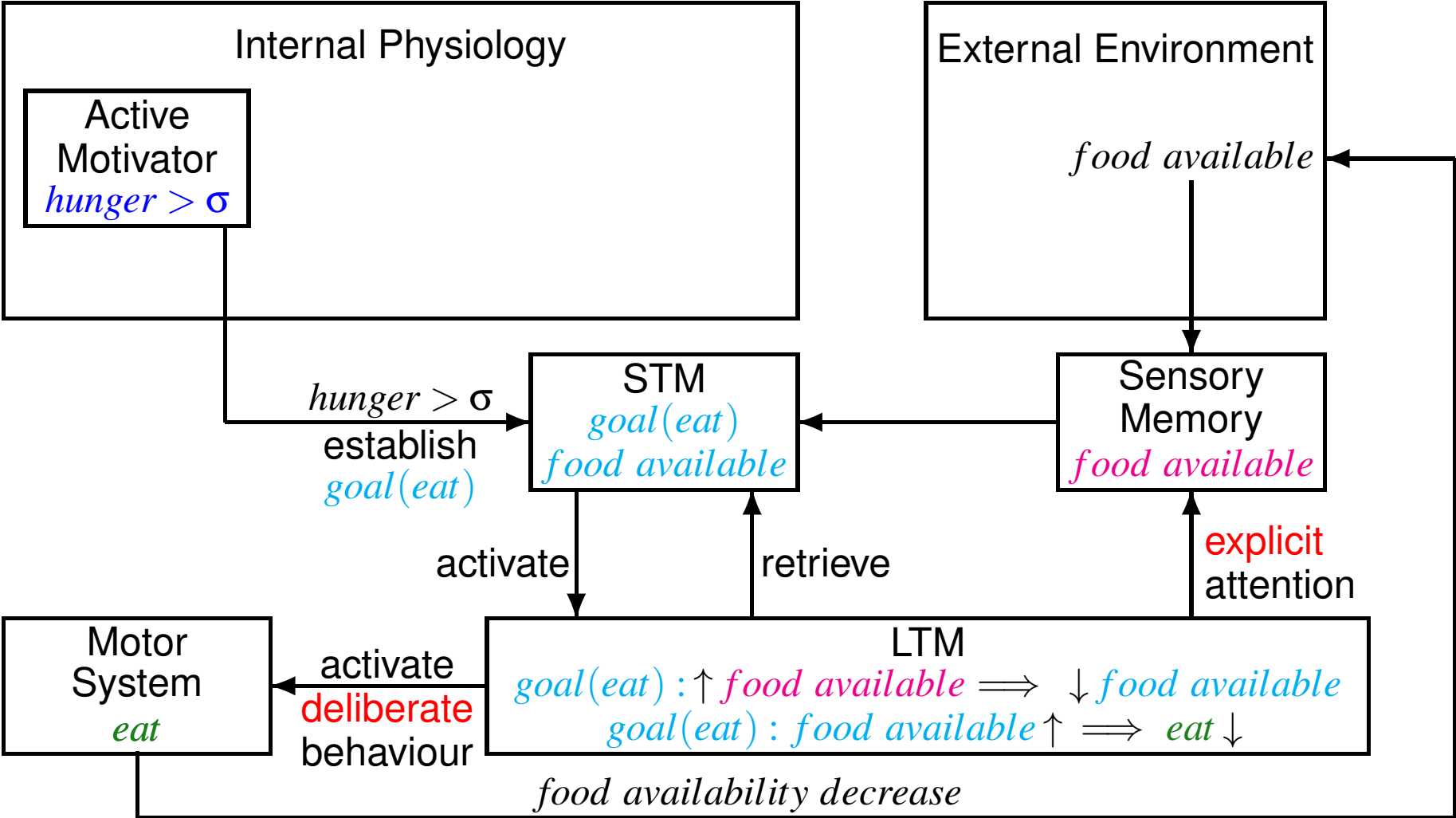
What *motivates* us to eat?



# Motivators

How was *goal(eat)* established in STM?

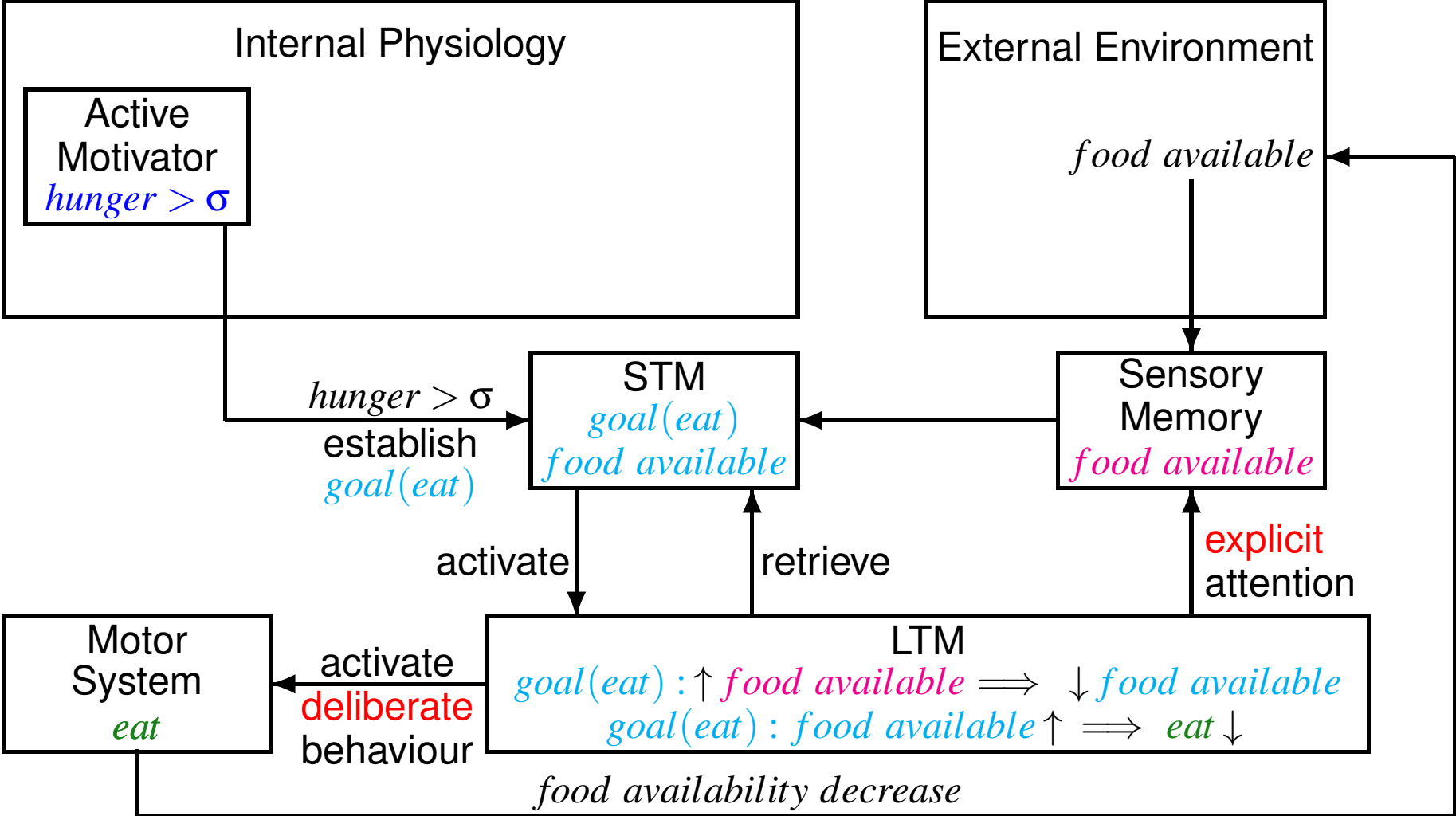
What **motivates** us to eat?





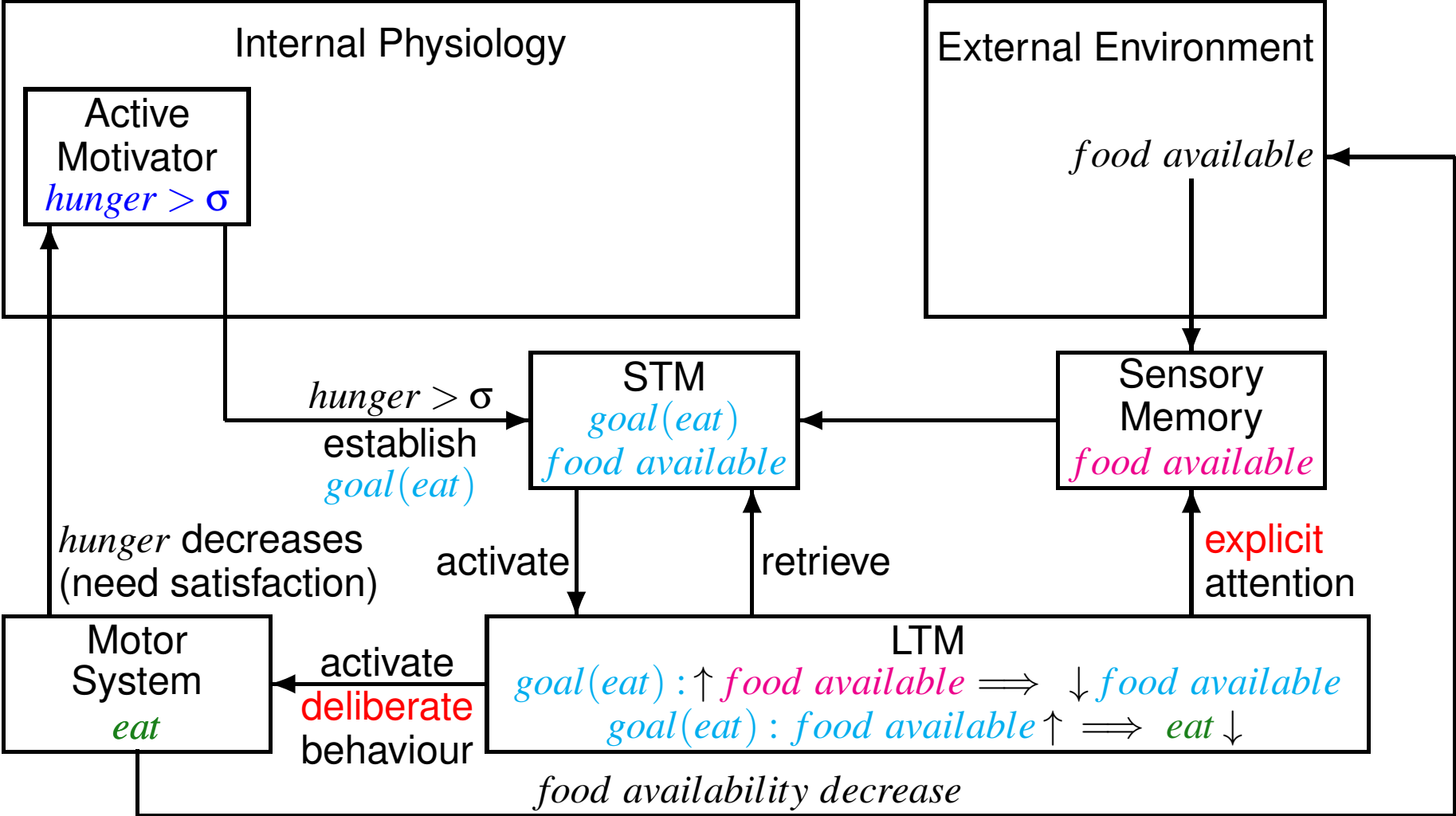
# Motivators

When do we **stop** eating?



# Need Satisfaction

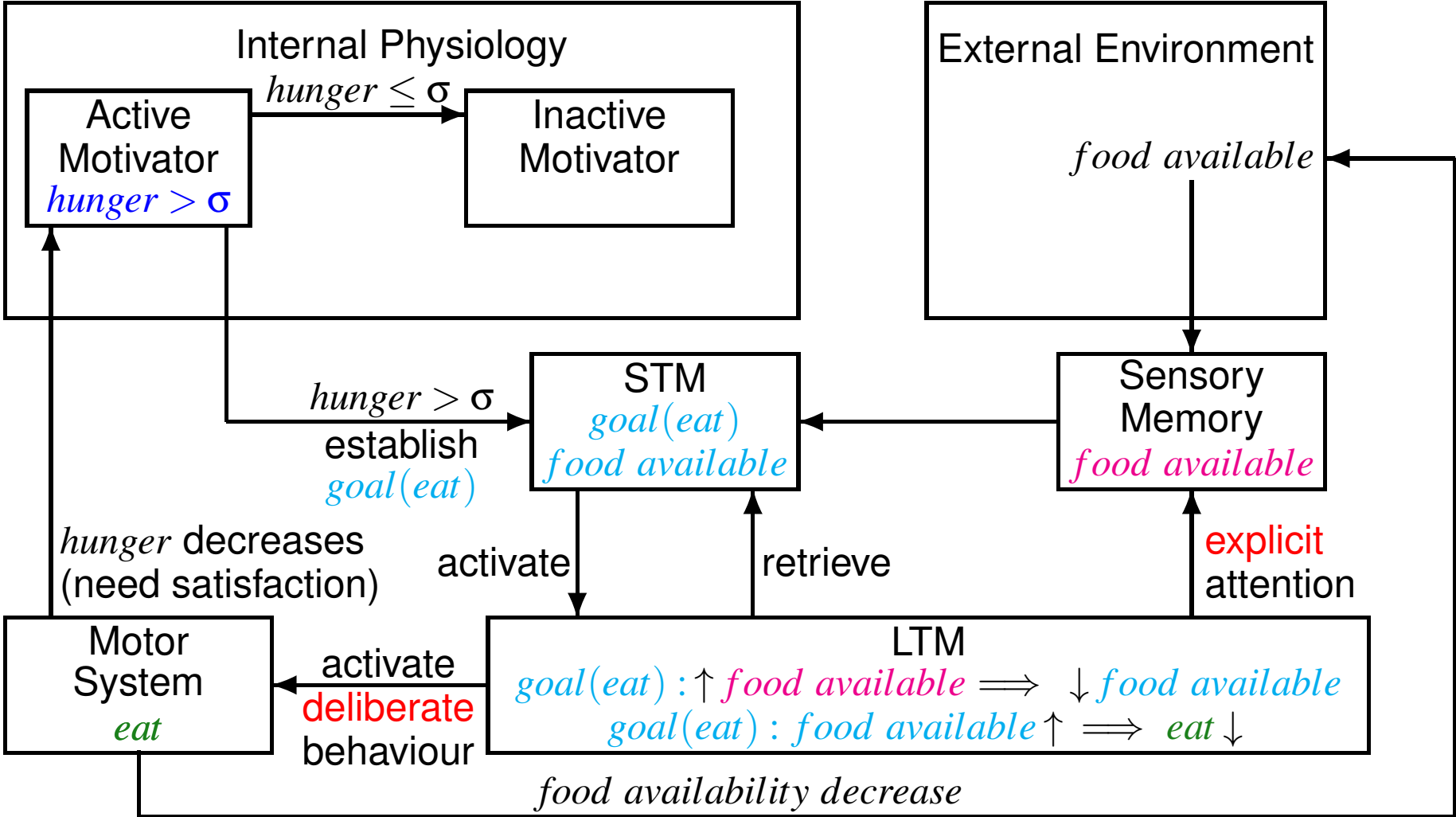
When do we **stop** eating?



# Need Satisfaction

When do we **stop** eating?

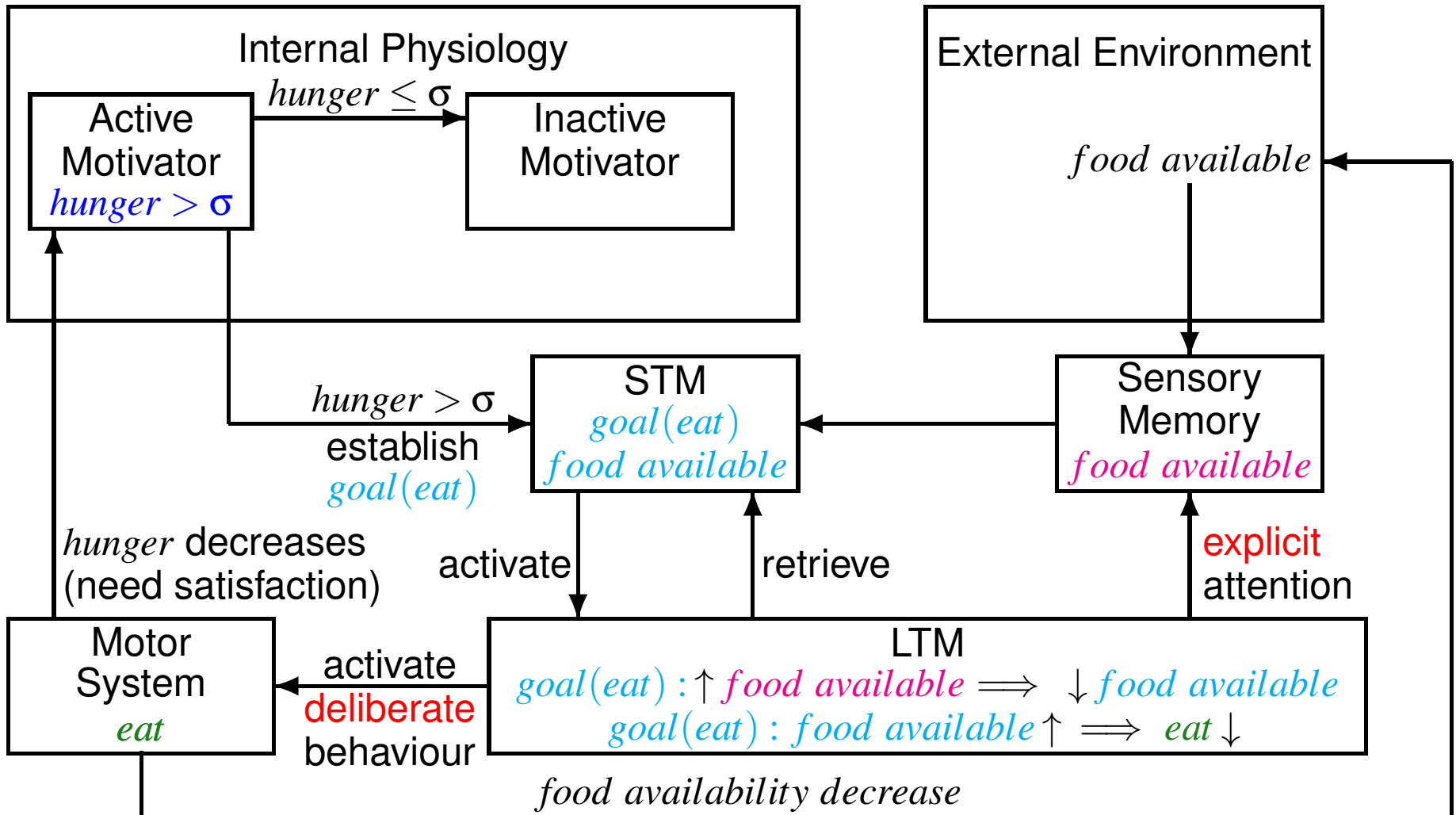
Threshold:  $0 < \sigma$   
saturation



# Need Satisfaction

When do we **start** eating?

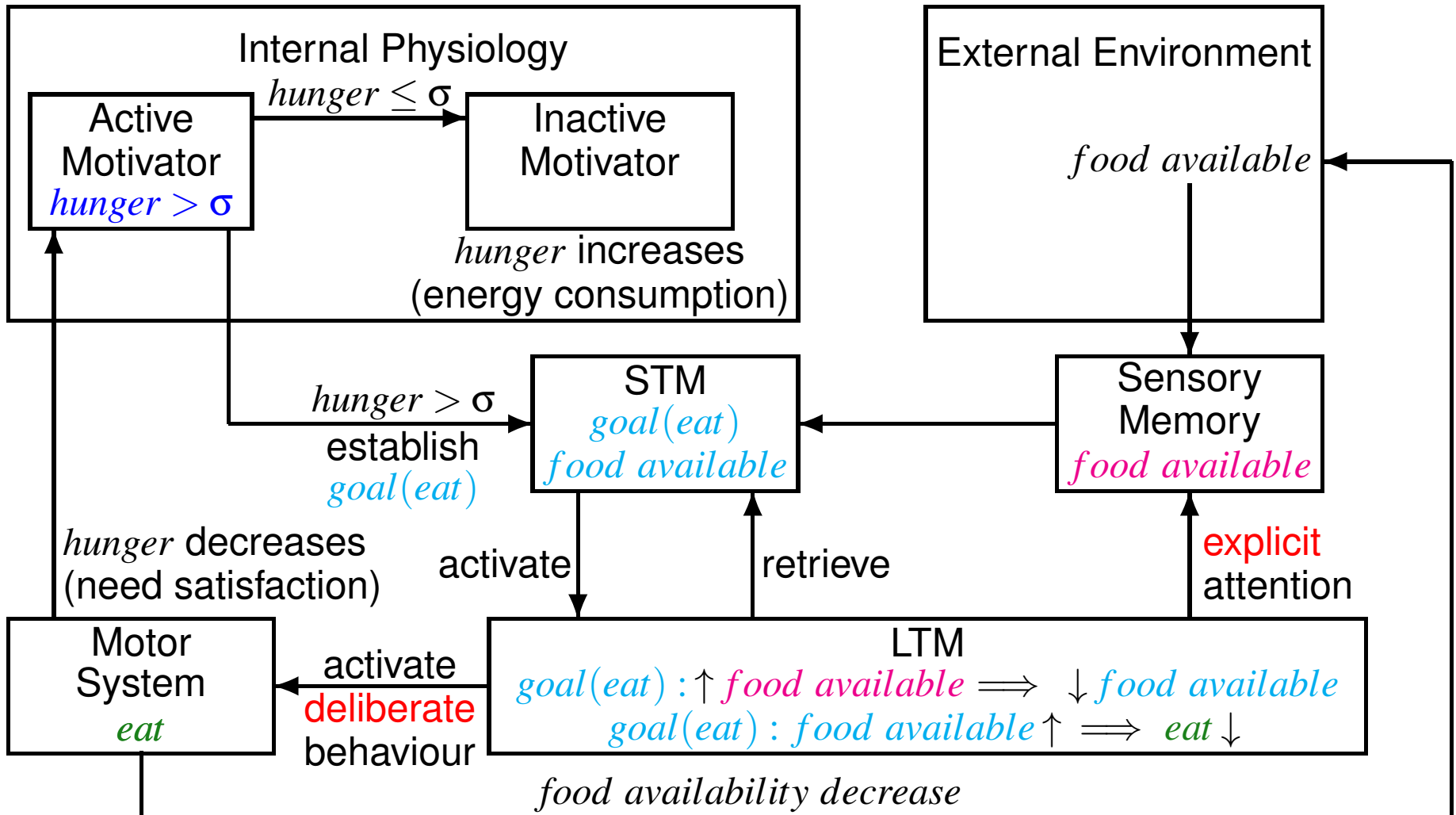
Threshold:  $0 < \sigma$   
saturation



# Need Satisfaction

When do we **start** eating?

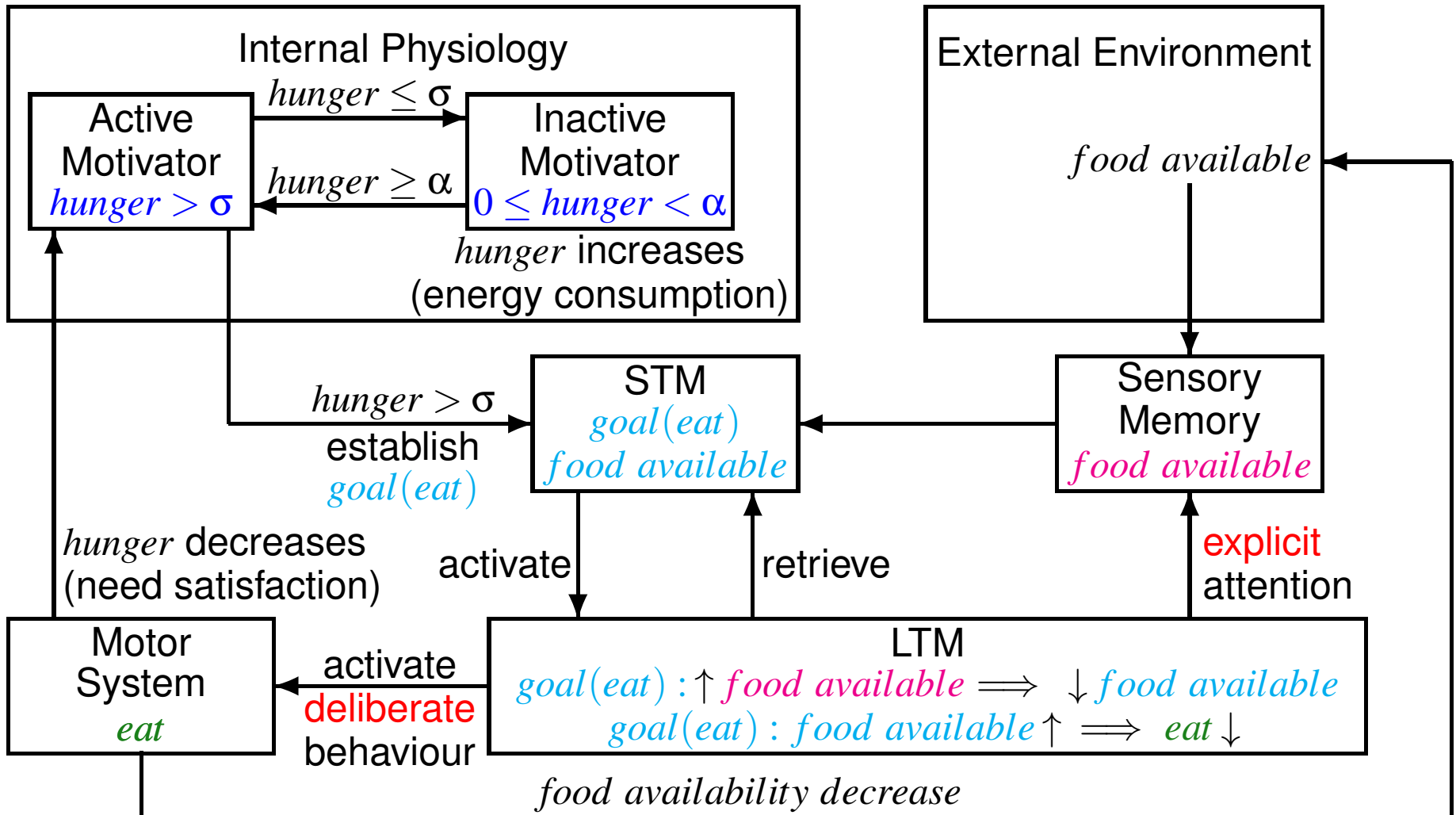
Threshold:  $0 < \sigma$   
saturation



# Need Satisfaction

When do we **start** eating?

Thresholds:  $0 < \sigma < \alpha$   
 saturation      activation





# External Interaction

The external environment is modelled using a Labelled Transition System (LTS)

## Deliberate Behaviour

LTS:  $visible_1 [invisible_1] \xrightarrow{action} visible_2 [invisible_2]$



# External Interaction

The external environment is modelled using a Labelled Transition System (LTS)

## Deliberate Behaviour

LTS:  $visible_1 [invisible_1] \xrightarrow{action} visible_2 [invisible_2]$

LTM:  $g : information_1 \uparrow \Longrightarrow action \downarrow information_2$

STM:  $g, information_1$

# External Interaction

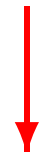
The external environment is modelled using a Labelled Transition System (LTS)

## Deliberate Behaviour

LTS:  $visible_1 [invisible_1] \xrightarrow{action} visible_2 [invisible_2]$

LTM:  $g : information_1 \uparrow \Longrightarrow action \downarrow information_2$

STM:  $g, information_1$



# External Interaction

The external environment is modelled using a Labelled Transition System (LTS)

Explicit Attention ( $perc \in visible_1$ )

LTS: the current state is  $visible_1$

LTM:  $g : information_1 \uparrow perc \implies \downarrow information_2$

STM:  $g, information_1$

# External Interaction

The external environment is modelled using a Labelled Transition System (LTS)

Explicit Attention ( $perc \in visible_1$ )

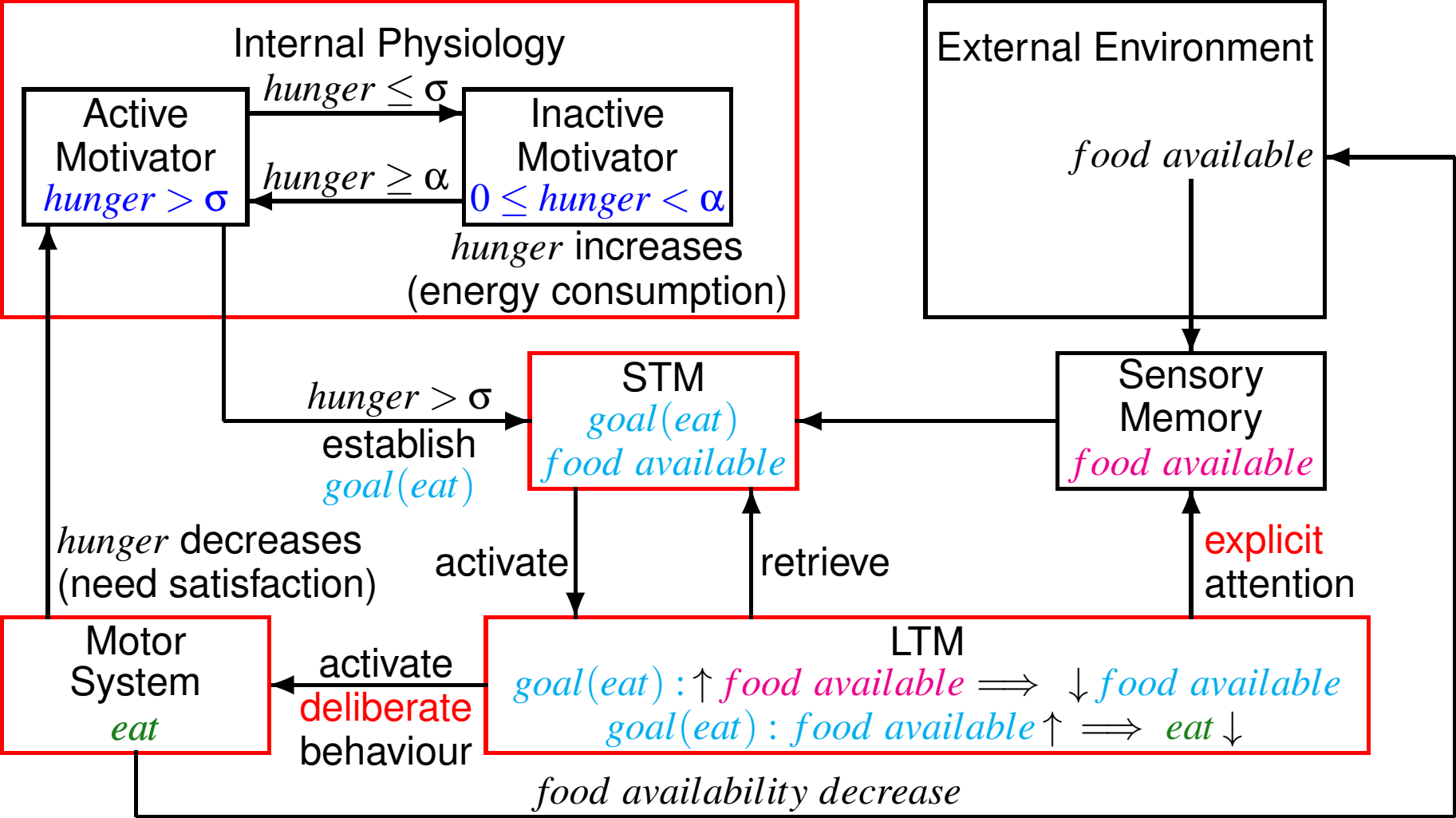
LTS: the current state is  $visible_1$

LTM:  $g : information_1 \uparrow perc \implies \downarrow information_2$

STM:  $g, information_1$

# Internal Physiology Model

Thresholds:  $0 < \sigma < \alpha$   
                  saturation    activation



# *Internal Interaction*

The internal physiology is also modelled using a Labelled Transition System (LTS)

## Activation

LTS: [*hunger* >  $\alpha$ , *inactive*]  $\longrightarrow$  [*active*]

STM:

# Internal Interaction

The internal physiology is also modelled using a Labelled Transition System (LTS)

## Iteration

LTS:  $[hunger > \alpha, active] \xrightarrow{goal(eat)\downarrow} [active]$

STM:



Interaction between Cognition and Physiology

# *Internal Interaction*

The internal physiology is also modelled using a Labelled Transition System (LTS)

## Saturation

LTS:  $[0 \leq \textit{hunger} \leq \sigma, \textit{active}] \longrightarrow [\textit{inactive}]$

STM:



# Cognition $\longleftrightarrow$ Physiology

## Storage

*visible*<sub>1</sub> [*invisible*<sub>1</sub>]  $\xrightarrow{\text{info}\downarrow}$  *visible*<sub>2</sub> [*invisible*<sub>2</sub>]

# Cognition $\longleftrightarrow$ Physiology

## Storage

*visible*<sub>1</sub> [*invisible*<sub>1</sub>]  $\xrightarrow{\text{info}\downarrow}$  *visible*<sub>2</sub> [*invisible*<sub>2</sub>]

## Removal

*visible*<sub>1</sub> [*invisible*<sub>1</sub>]  $\xrightarrow{\text{info}\uparrow}$  *visible*<sub>2</sub> [*invisible*<sub>2</sub>]

# Cognition $\longleftrightarrow$ Physiology

## Storage

*visible*<sub>1</sub> [*invisible*<sub>1</sub>]  $\xrightarrow{\text{info}\downarrow}$  *visible*<sub>2</sub> [*invisible*<sub>2</sub>]

## Removal

*visible*<sub>1</sub> [*invisible*<sub>1</sub>]  $\xrightarrow{\uparrow\text{info}}$  *visible*<sub>2</sub> [*invisible*<sub>2</sub>]

## Reading

*visible*<sub>1</sub> [*invisible*<sub>1</sub>]  $\xrightarrow{\uparrow\text{info}\downarrow}$  *visible*<sub>2</sub> [*invisible*<sub>2</sub>]

# Modelling Emotions

## Physiological Stimulus

$$[hunger > \delta, E] \xrightarrow{eat} [hunger = \delta, E \cup joy]$$

# Modelling Emotions

## Physiological Stimulus

$$[hunger > \delta, E] \xrightarrow{eat} [hunger - = \delta, E \cup joy]$$

## Positive Psychological Stimulus

$$[hunger > \sigma, E] \xrightarrow{\uparrow food\ available \downarrow} [E \cup joy]$$

# Modelling Emotions

## Physiological Stimulus

$$[hunger > \delta, E] \xrightarrow{eat} [hunger - = \delta, E \cup joy]$$

## Positive Psychological Stimulus

$$[hunger > \sigma, E] \xrightarrow{\uparrow food\ available \downarrow} [E \cup joy]$$

## Negative Psychological Stimulus

$$[hunger > \sigma, E] \xrightarrow{\uparrow food\ unavailable \downarrow} [E \cup sadness \setminus joy]$$

# *Conclusion and Future Work*

## Conclusion

We extended BRDL by including motivator and emotion to model the interaction between cognition and physiology, in order to support

- formalisation and comparison of theories of motivation and emotion (for psychologists)
- exploration and analysis of motivational and emotional aspects in HCI (for computer scientists and usability analysts)

# Conclusion and Future Work

## Conclusion

We extended BRDL by including motivator and emotion to model the interaction between cognition and physiology, in order to support

- formalisation and comparison of theories of motivation and emotion (for psychologists)
- exploration and analysis of motivational and emotional aspects in HCI (for computer scientists and usability analysts)

## Future Work

- Implement the BRDL extension into Maude
- Incorporate the BRDL extension in the ColIMASC (Collaborative Modelling and Analysis of Systems and Cognition) tool, available at <http://colmasc.herokuapp.com>.



# Conclusion and Future Work

## Conclusion

We extended BRDL by including motivator and emotion to model the interaction between cognition and physiology, in order to support

- formalisation and comparison of theories of motivation and emotion (for psychologists)
- exploration and analysis of motivational and emotional aspects in HCI (for computer scientists and usability analysts)

## Future Work

- Implement the BRDL extension into Maude
- Incorporate the BRDL extension in the ColIMASC (Collaborative Modelling and Analysis of Systems and Cognition) tool, available at <http://colmasc.herokuapp.com>.