# Computational Modelling of Emotion

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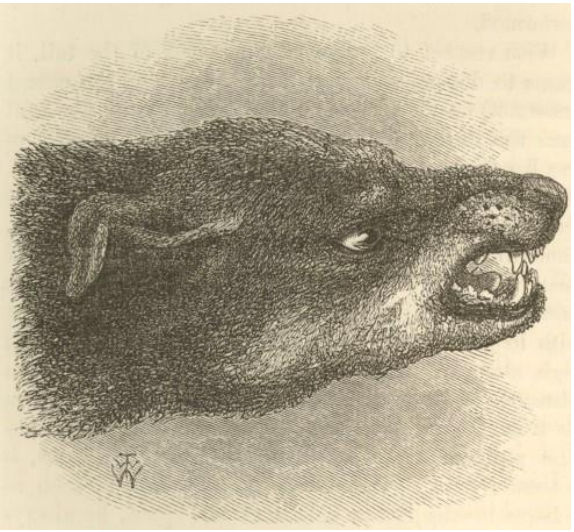
# What is an emotion?

- Darwin (1872) – relatively shallow behavioural criteria for emotion
- Blushing, frowning, scowling, gaping etc
- Emotions are vestigial – no deep functional theory that relates observable phenomena to global system of underlying control mechanisms!



# Functions of Emotions – not so cognitive

## 1. Mobilization of physiological resources

Running from a predator

But also, the *Yerkes–Dodson Law* links the level of arousal with the complexity of the task. For a harder task higher levels of arousal are needed to attain optimal performance.

## 2. A means of communication

emotional expressions serve to communicate the emotional status of an animal to others of their species (e.g. fear at sight of a lion)

# Functions of Emotions – more cognitive

## 3. Alteration of goals

- different emotions have associated goals
- cognitively readjust to emotional events.

e.g. anxiety – stop, attend to the environment, escape

## 4. A form of internal information

After extended experience, these somatic markers act to guide decision making resulting in a 'gut feeling' for certain choices.

Emotions can provide information to help with decision making.

# Other criteria – Organised into 4 categories

- Activity of specific regions of the brain
- Introspectable and reportable experience of bodily changes or desires
- Experience of interpreting and labelling situations
- Typical responses such as fighting or running away and increases in heart rate, skin conductance

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- Activity of specific regions of the brain

**Biological implementation**

- Introspectable and reportable experience of bodily changes or desires

**Conscious feeling**

- Experience of interpreting and labelling situations

**Cognitive process of Interpretation**

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**Behavioural response**

# Other criteria – Organised into 4 categories

- Activity of specific regions of the brain

**Biological implementation**

Machine learning (cognitive neuroscience)
- ANN simulations
- Brain activity – PET and MRI Scans
- Physiological measures – GSR, EMG

- Introspectable and reportable experience of bodily changes or desires

**Conscious feeling**

Cognitive modelling
- access consciousness
- global availability
- self-monitoring

- Experience of interpreting and labelling situations

**Cognitive process of Interpretation**

Cognitive modelling
- models of appraisal
- models of deliberation

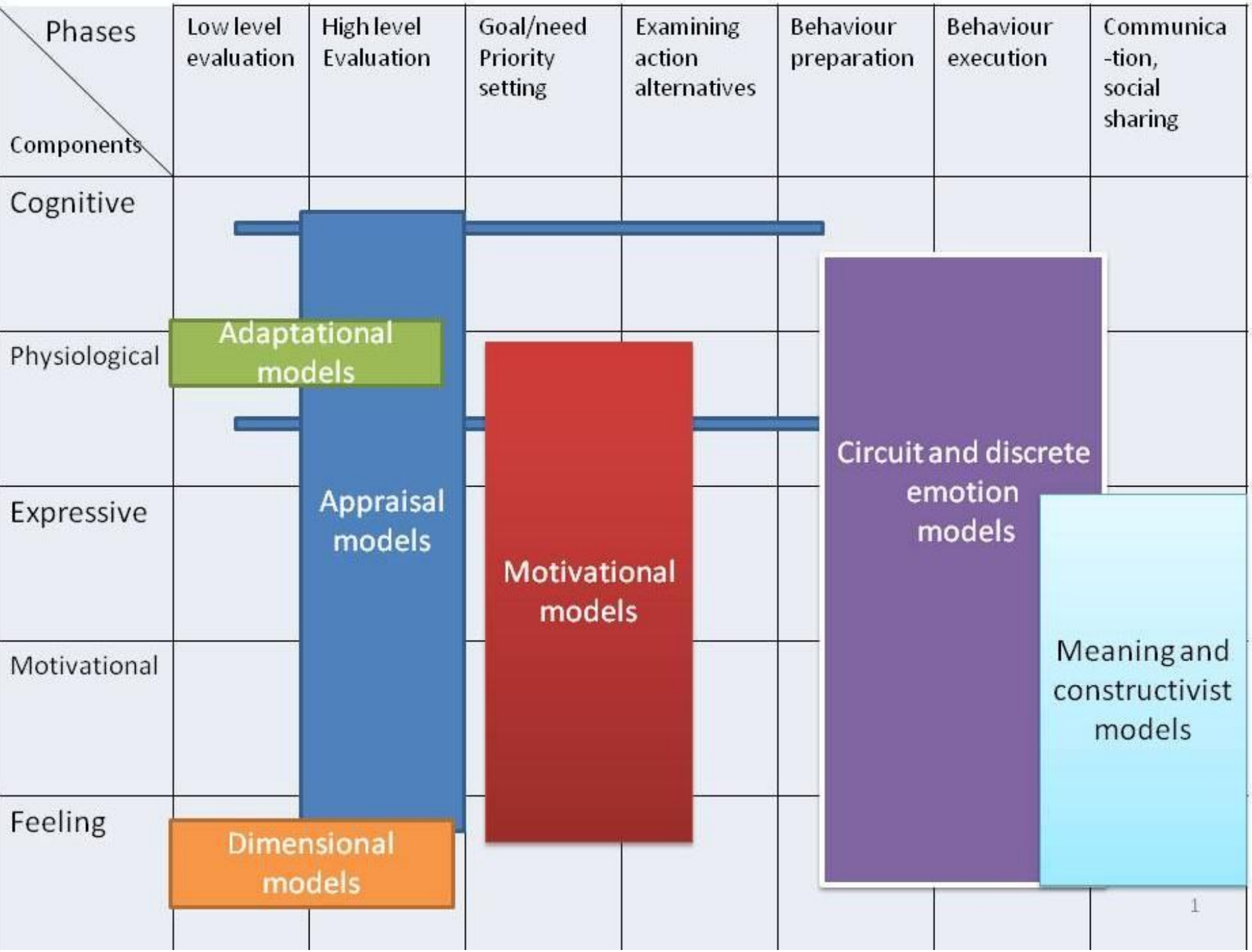
- Typical responses such as fighting or running away and increases in heart rate, skin conductance

**Behavioural response**

Emotion recognition/machine learning (affective computing)
- faces
- body movement
- speech
- text

# Classifying emotion theories by the phase and components they focus upon

- Scherer (2010) – after reviewing emotion theories a classification based upon two classes of criteria
  - Emotion components
    - Neural implementation
    - Conscious feelings
    - Cognitive processes
    - Behavioural responses
  - Emotion phases
    - evaluation
    - Goal/need priority setting
    - Examining action alternatives
    - Behavioural preparation
    - Behavioural execution
    - Communication and social sharing


Phases
Components
Low level evaluation
High level Evaluation
Goal/need Priority setting
Examining action alternatives
Behaviour preparation
Behaviour execution
Communica -tion, social sharing
Cognitive
Physiological
Expressive
Motivational
Feeling
Adaptational models
Appraisal models
Motivational models
Circuit and discrete emotion models
Meaning and constructivist models
Dimensional models

Any Questions?

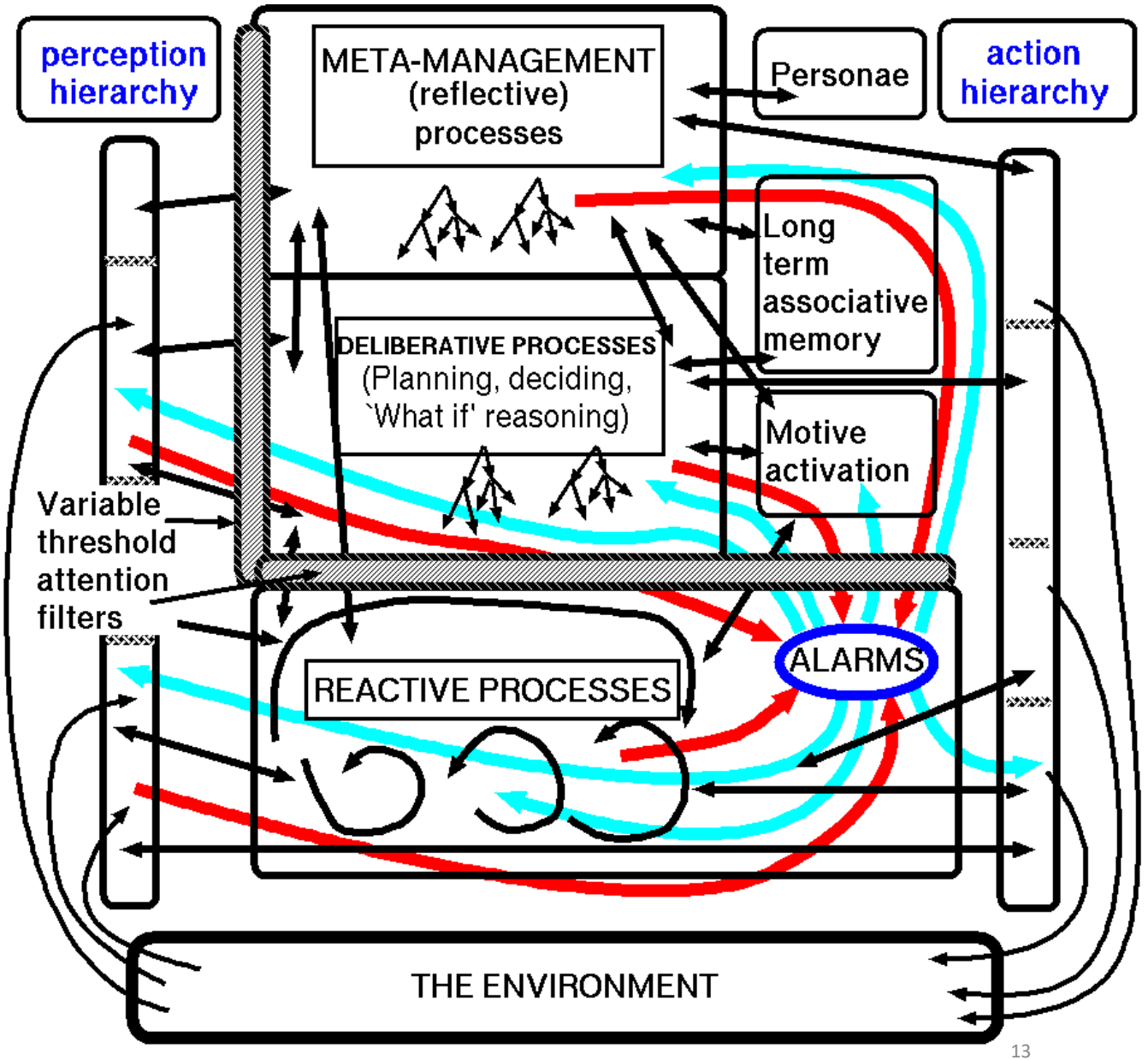
# What is a computational model of emotion?

- Neisser [1963] - critique of psychological modelling. He recognised that computers provide valuable models
  - parallel operation of multiple motives;
  - bored and distracted thinking;
  - other kinds of minimally purposive cognition;
  - unconscious processing;
- Simon (1967) – the first emotion modelling paper
  - interrupts to ongoing serial processes by time-sharing of the processor between main tasks and interrupt mechanisms,
  - goal-management mechanisms
    - satisficing,
    - setting aspiration levels,
    - implementing impatience and discouragement functions,
    - using queues and individual time allocations
    - Making choices among alternatives as responses to multiple criteria

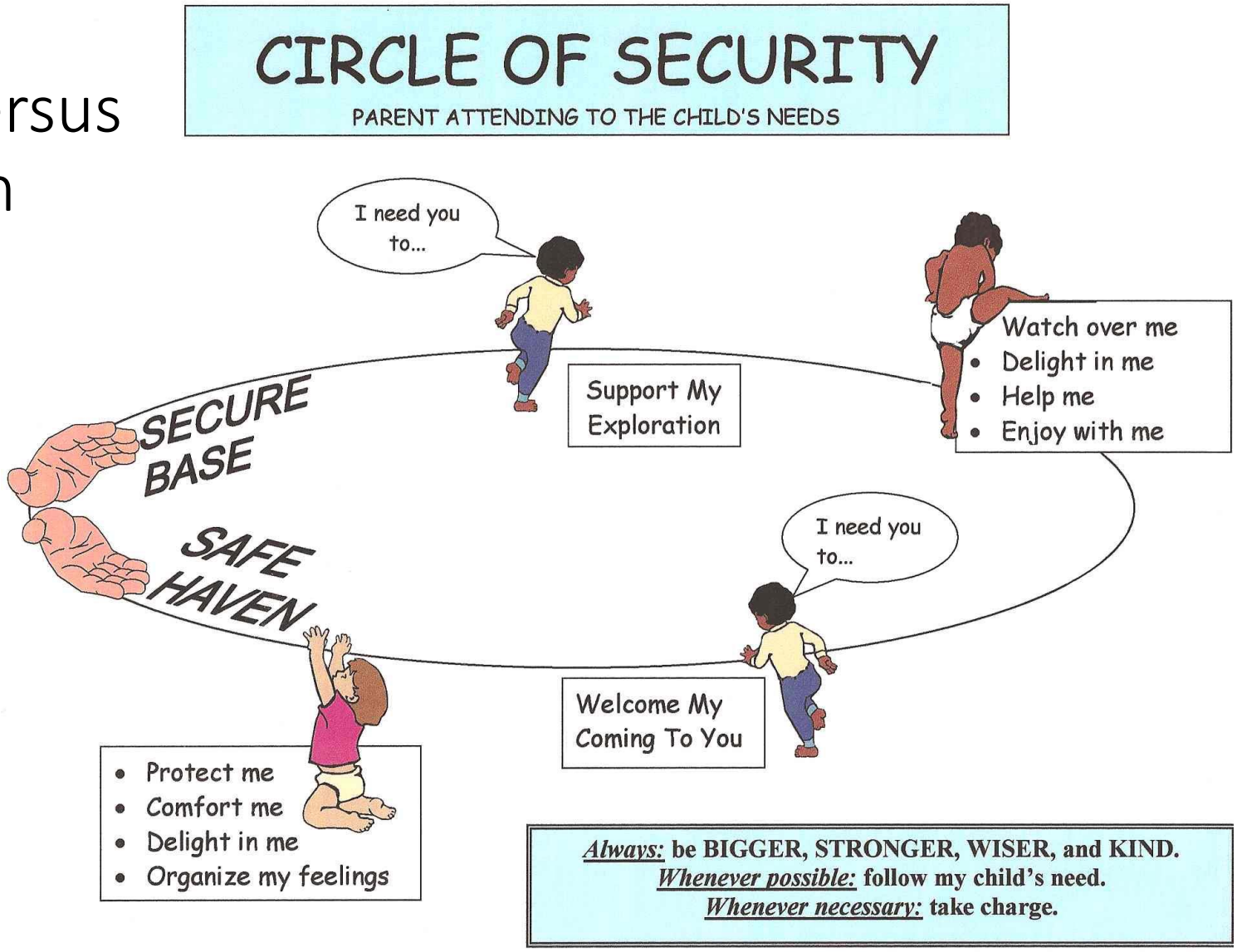
# What is a computational model of emotion?

- A very, very selective review of CME research since Simon (1967)
  - 1990s to 2000s – the Cogaff project
    - Lots of theory from a design base approach to how deliberation should occur
    - The nursemaid scenario
    - My attachment simulation
  - 2015 to 2019 – using ACT-R to model states similar to emotions
    - mindwandering,
    - distraction,
    - depressive rumination
    - meditation

# Sloman's H-Cogaff architecture



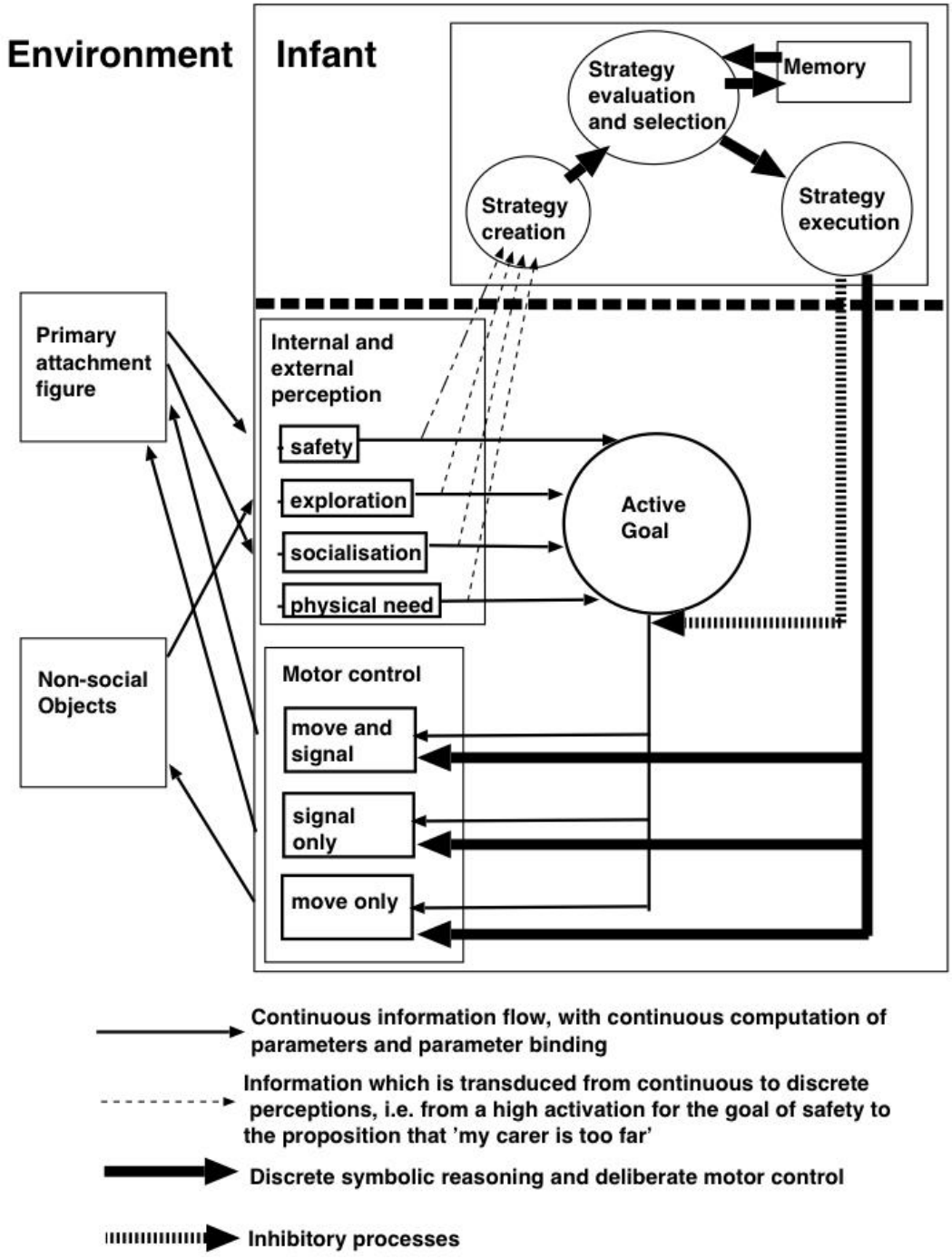
# Security versus exploration



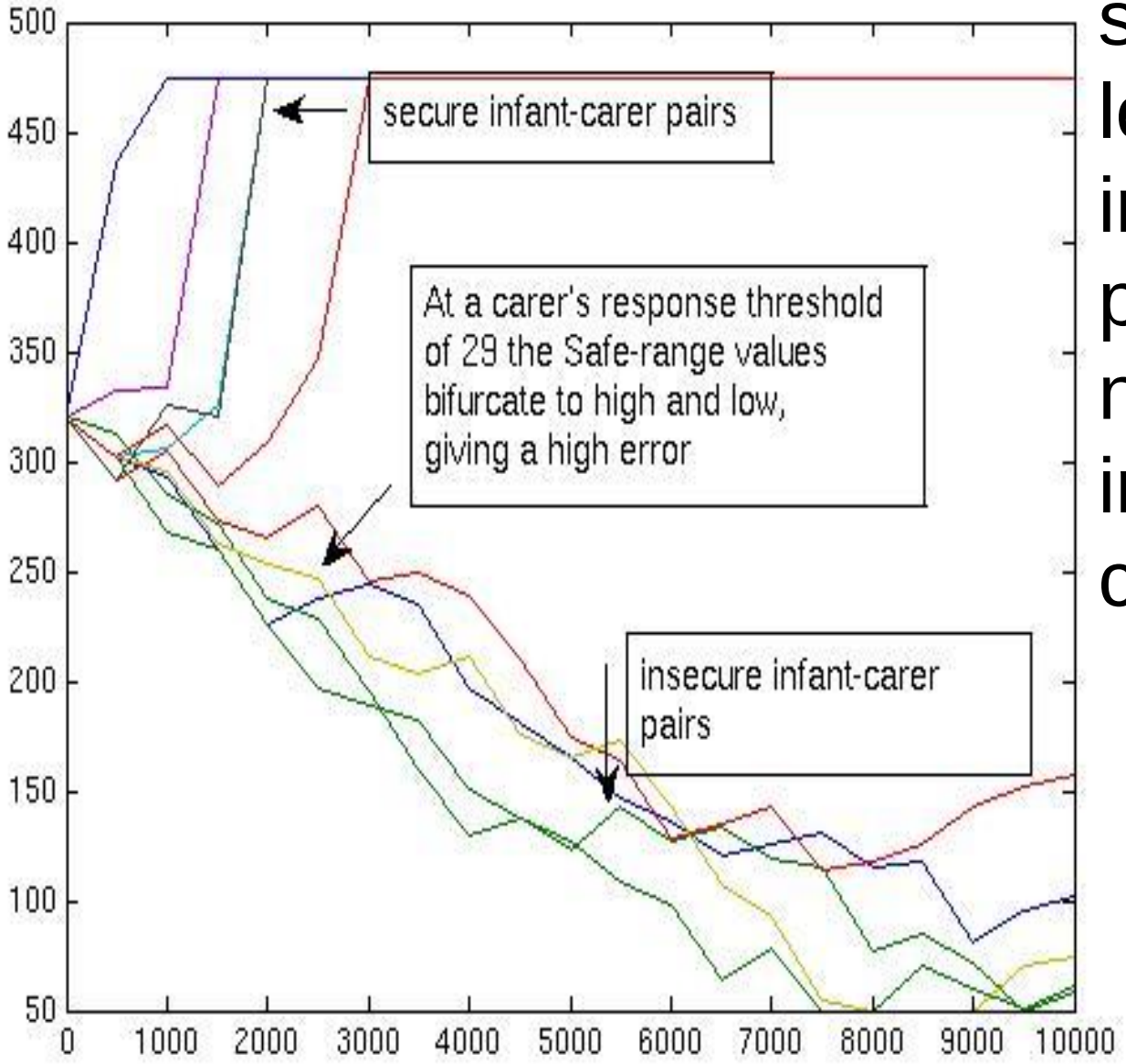

(Figure from Marvin et al 2002)

# An architecture to simulate real world empirical data

- Which goal will be activated?
- How effective was the last attempt to activate that goal
- Which goal will be most effective next time?



# Computational experiments

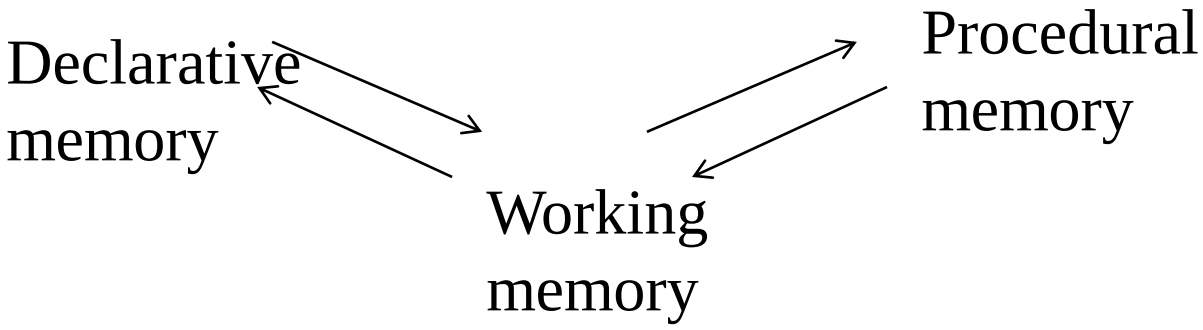



- same carer sensitivity leads to two infant outcome patterns with no intermediate cases

Any Questions?

# Integrative Models For Representing Knowledge – and Problem Solving

- ACT-R - combines declarative and procedural knowledge




- Whole architecture centred around a working memory ‘buffer’
- This is an integrated course – ACT-R will not just be mentioned in the Problem Solving lecture – but also in Lectures on Knowledge , Cognitive Modelling and Cognitive Architectures

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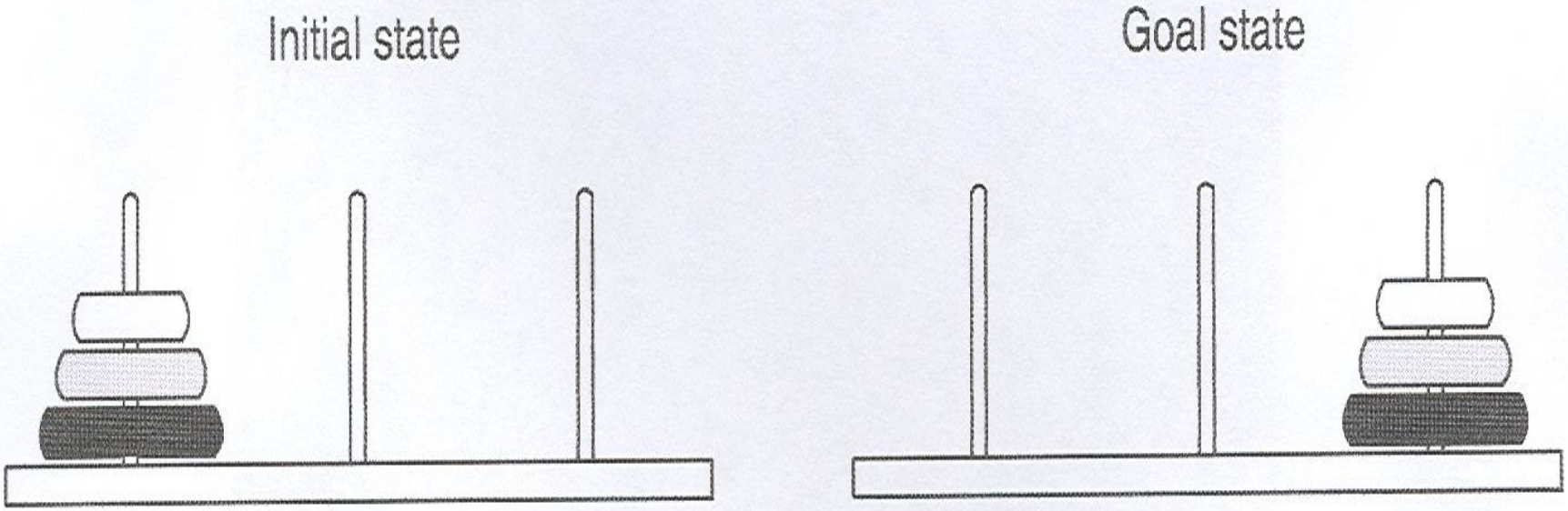
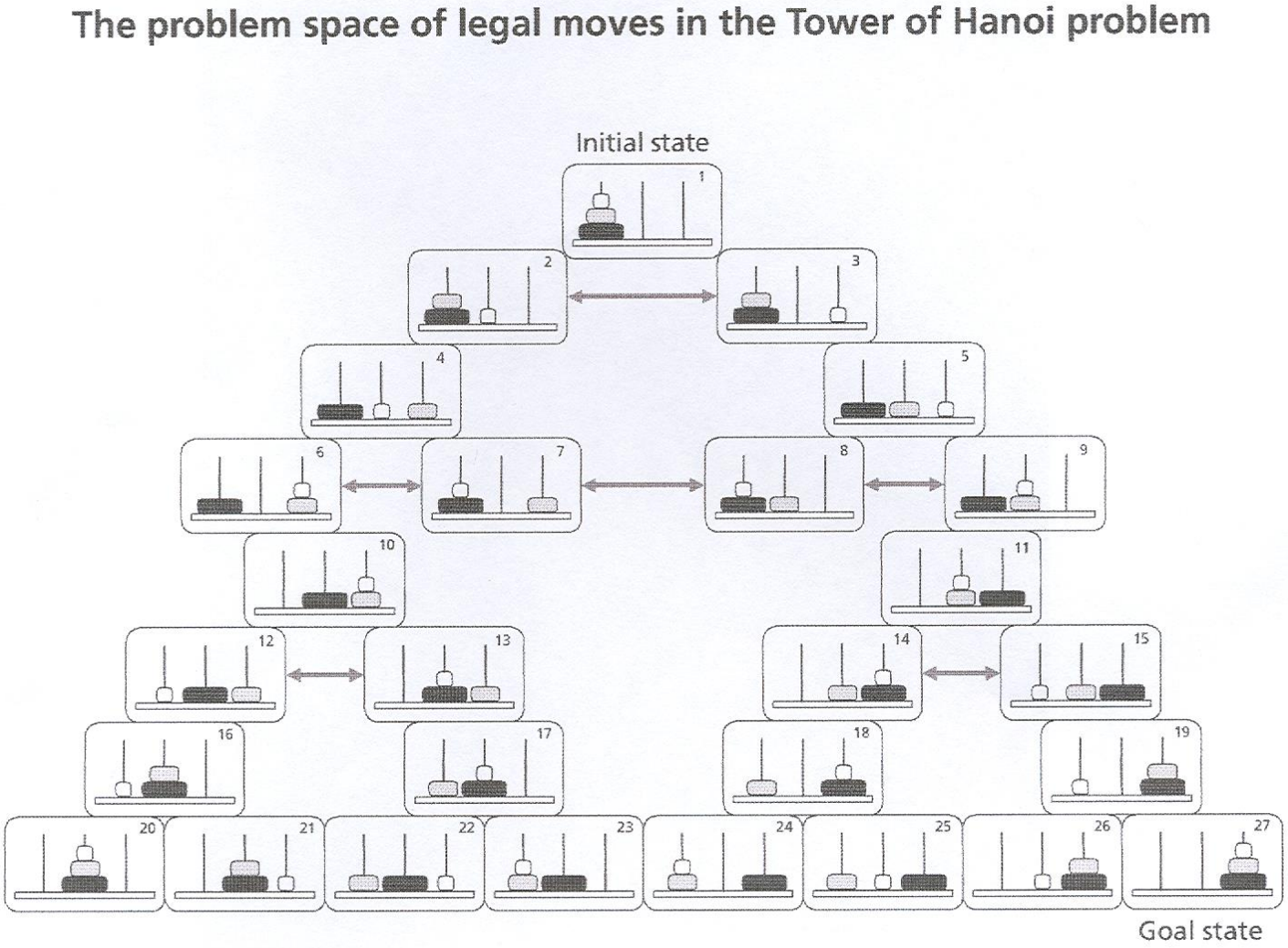
# The initial state and goal state in the Tower of Hanoi problem



# Tower of Hanoi problem space



# Tower of Hanoi – ACT-R versus human performance

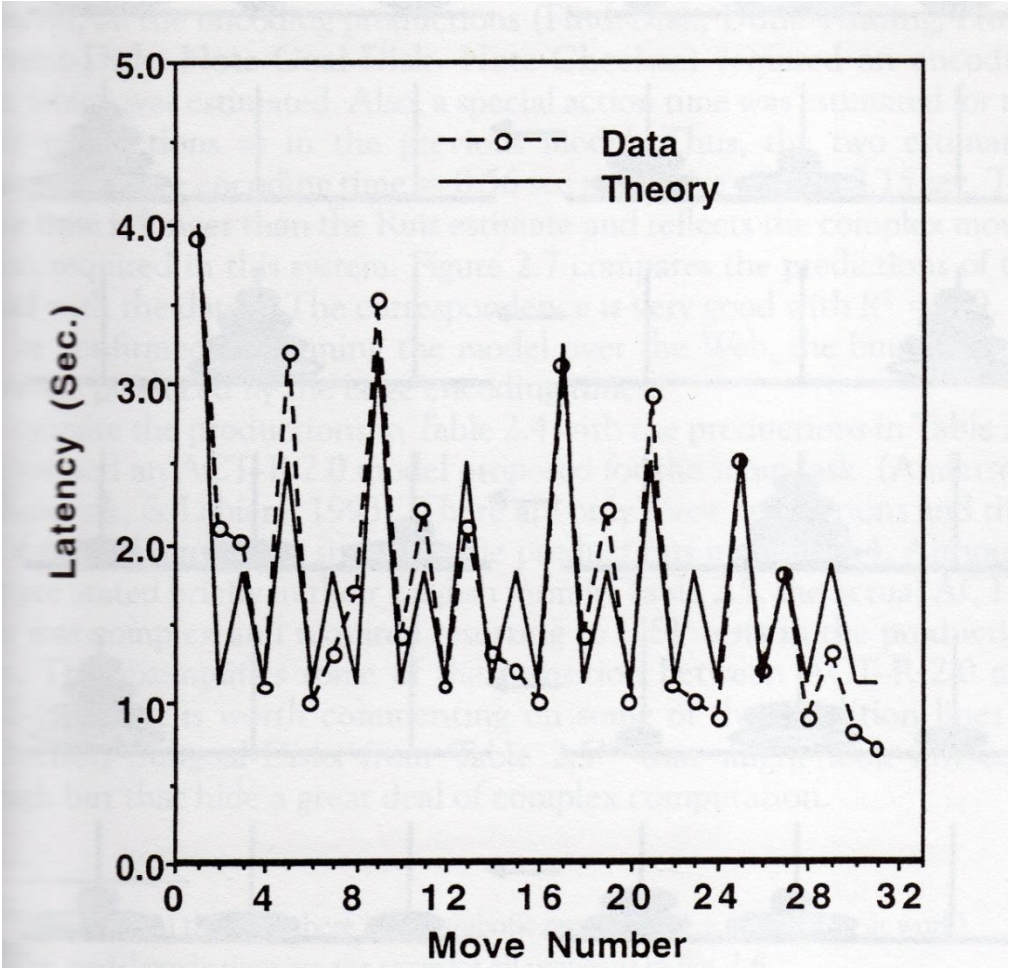



FIG. 2.5. Data from Ruiz (1987) and the ACT–R simulation.

# Tower of Hanoi – ACT-R versus human performance -

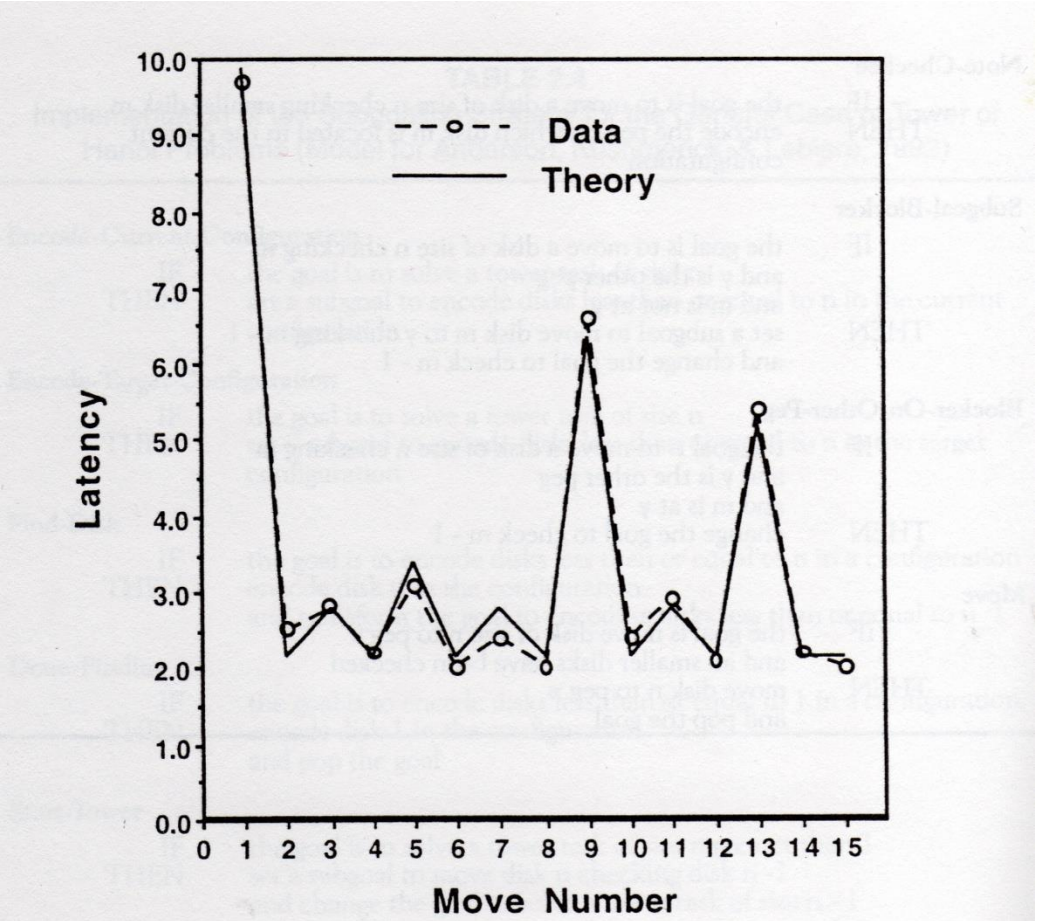



FIG. 2.7. Data from Anderson, Kushmerick, and Lebiere (1993) and the ACT–R simulations.

- This work done by Anderson's group at Carnegie Mellon

Any Questions?

# Recent simulations using ACT-R and PRIMS

- Distraction
    - Paying attention vs distraction in ACT-R
    - Visual distraction in visual vs memory tasks in PRIMS
- Depressive rumination
    - Rumination as an attractor state in PRIMS
        - self-referential, poorly controlled and narrowly focused
    - Rumination in ACT-R linking to failures in inibition and biases
- Meditation
    - Focused meditation vs dispersed mind-wandering
    - Similar to ‘funnelling’ in models of rumination
    - When meditation strongly activated it stops emotional spiralling

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  - Paying attention vs distraction in ACT-R
- Taatgen, N.A., Katidioti, I., Borst, J., and Vugt, M.K.v., (2015) A model of distraction using new architectural mechanisms to manage multiple goals.
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- Vugt, M.K.v., Velde, M.v.d, and ESM-MERGE Investigators (2018) How does rumination impact cognition: A first mechanistic model.
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- Velde, M.v.d, Vugt, M.K.v., and Taatgen, N.A., (2018) Modelling the Effect of Depression on Working Memory.
  - Rumination in ACT-R linking to failures in inibitino and biases
- Moye, A. S. & van Vugt, M., (2019) A computational model of focused attention meditation and its transfer to a sustained attention task
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