

**BRITISH HCI GROUP ONE-DAY MEETING  
UNIVERSITY COLLEGE LONDON  
AFFECTIVE COMPUTING: THE ROLE OF EMOTION IN HCI  
10th April 1999**

**WHY CAN'T A GOLDFISH LONG  
FOR ITS MOTHER?**

**Architectural prerequisites  
for various types of emotions.**

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**Ideas developed**

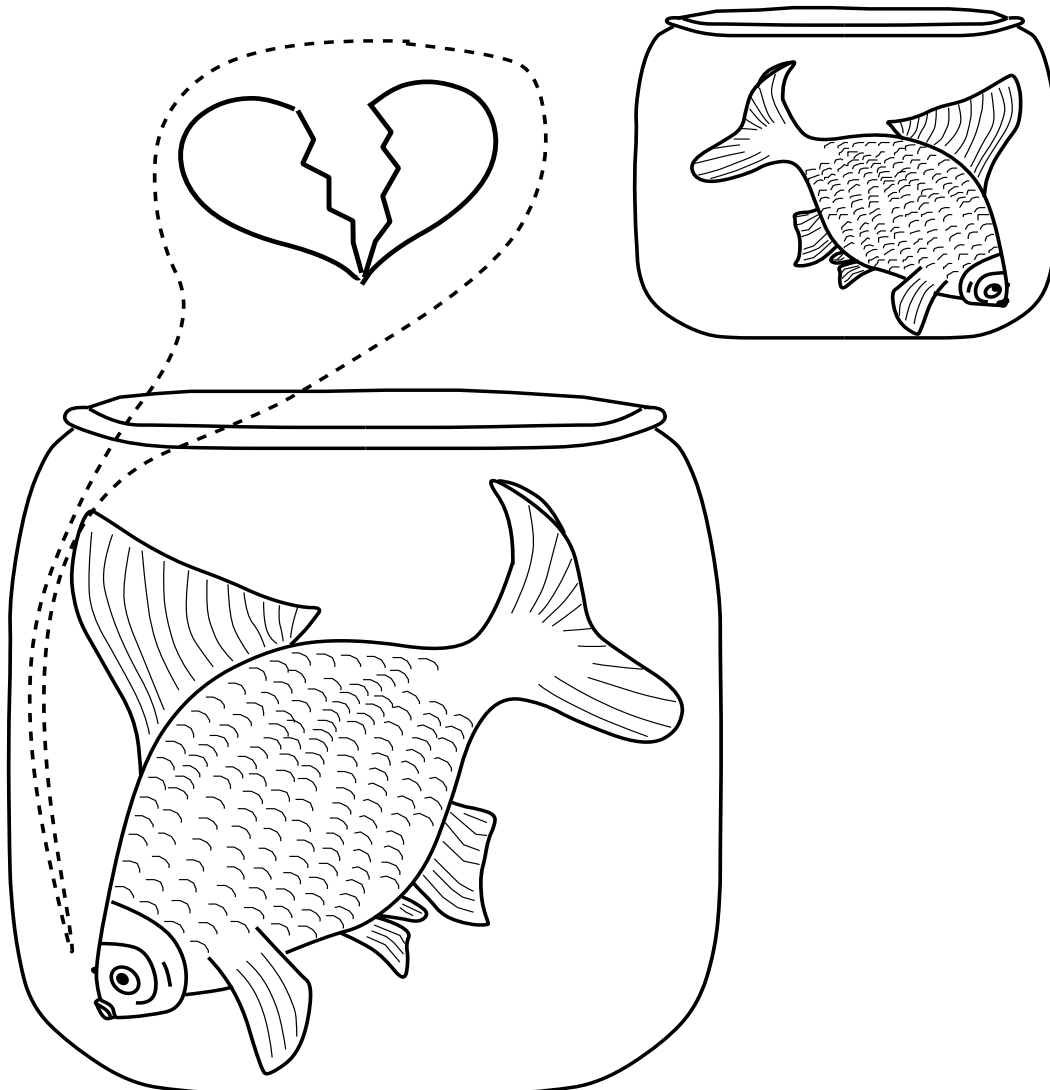
**in collaboration with**

**Steve Allen, Luc Beaudoin,  
Brian Logan, Riccardo Poli,  
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**and others in the**

**COGNITION AND AFFECT PROJECT  
SCHOOL OF COMPUTER SCIENCE  
THE UNIVERSITY OF BIRMINGHAM**

**WHY CAN'T A GOLDFISH  
LONG FOR ITS MOTHER?**



- **Because it cannot make its mouth droop?**
- **Because it lacks tear glands to make it weep?**
- **Because it cannot sigh....?**
- **Because it lacks our proprioceptive feedback...??**

**No, because:**

- 1. it lacks the appropriate information processing architecture**
- 2. including representational mechanisms, concepts and knowledge.**

# WHAT KIND OF MACHINE CAN HAVE EMOTIONS?

## **PROBLEM:**

**Umpteen different definitions of “emotion”.**  
**in psychology, philosophy, neuroscience . . .**

## **REPHRASE:**

**What are the architectural requirements  
for human-like mental states and processes?**  
**(Never mind the definitions)**

**I.e. collect examples of many types of real phenomena.  
Try to build a theory which explains them all!**  
**Subject to constraints from neuroscience, psychology, biological  
evolution, feasibility, tractability, etc.**

## **ALLOW FOR VARIATION:**

- **Across species,**
- **Within species,**
- **Within an individual during normal development**
- **After brain damage**
- **Across planets (grieving, infatuated, Martians?)**
- **Across the natural/artificial divide**

**PAY LEAST ATTENTION TO EXPERIMENTAL PSYCHOLOGY**

**(Shallow vs Deep science)**

# **Which human-like states and processes? Which real phenomena?**

**Consider the following cases:**

- **YOU ARE:**  
**startled by a loud noise,**  
**frozen in terror as boulder crashes towards you,**  
**nauseated by a horrible smell**
- **YOU ARE:**  
**afraid the bridge you are crossing may give way**  
**relieved that you got to the far side safely**  
**afraid the bridge your child is crossing may give way**  
**worried about what to say during your interview**  
**undecided whether to cancel your holiday in ...**
- **YOU ARE:**  
**infatuated with someone you met recently,**  
**overwhelmed with grief,**  
**riddled with guilt about betraying a friend**  
**full of excited anticipation of a loved one's return**  
**full of longing for your mother,**  
**basking in a warm glow of pride after winning an election.**

**I'll describe different architectural underpinnings for**

**PRIMARY EMOTIONS**

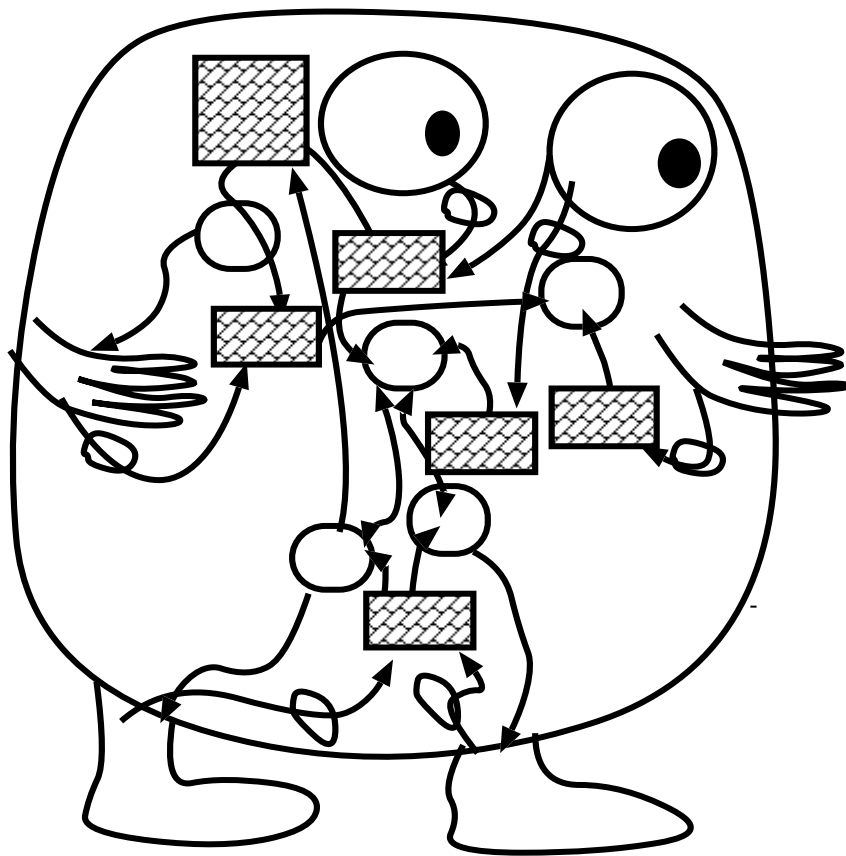
**SECONDARY EMOTIONS (central and peripheral)**

**TERTIARY EMOTIONS (with and without peripheral effects)**

**All have many variants, there's no time to discuss.**

**WHAT SORT OF ARCHITECTURE  
CAN ACCOUNT FOR  
SUCH PHENOMENA?**

**COULD IT BE AN UNINTELLIGIBLE  
MESS?**



Yes, in principle.

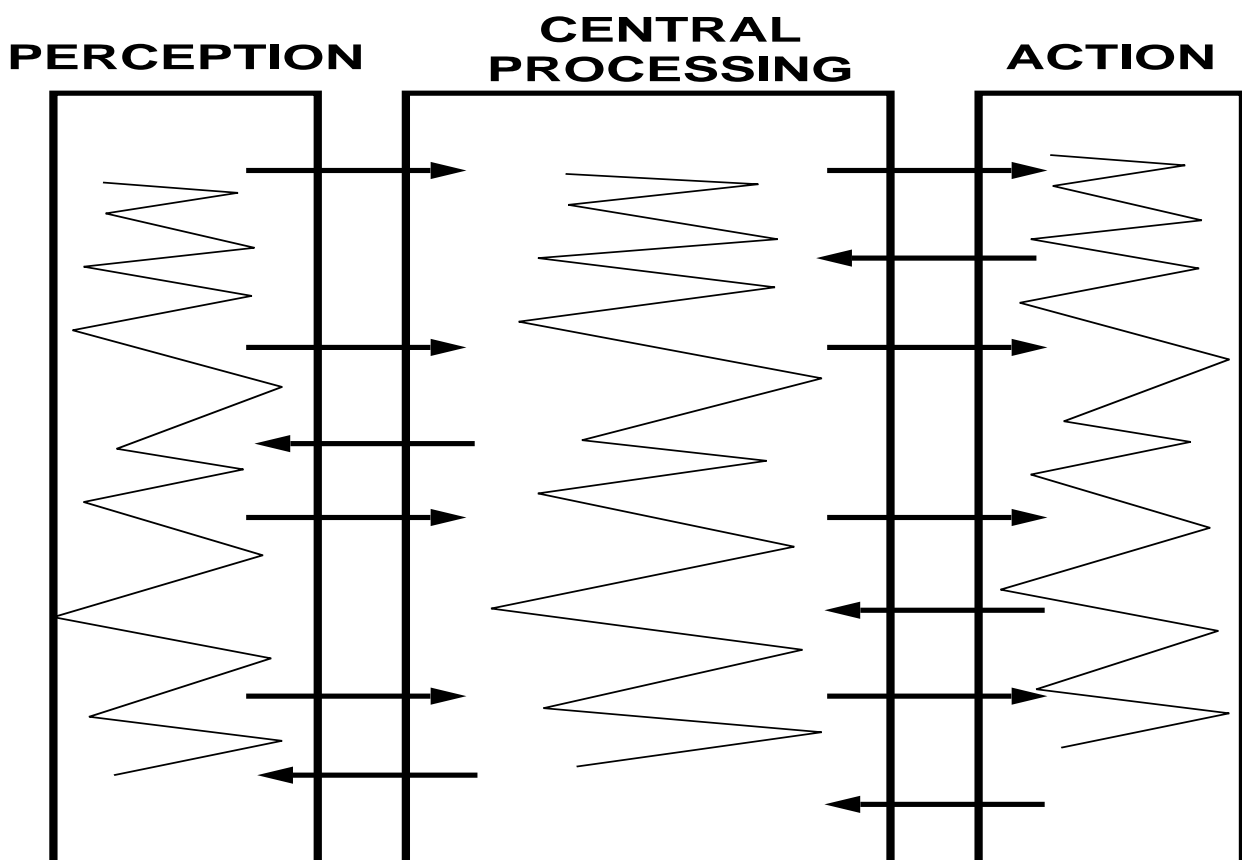
However, it can be argued that evolution could not have produced a totally non-modular yet highly functional brain.

(Compare Nilsson, and Wittgenstein on 'sawdust')

# **TOWARDS A UNIFYING MODULAR THEORY OF BRAIN AND MIND: A BIRD'S EYE VIEW**

**One perspective:**

**THE “TRIPLE PILLAR” MODEL**



**(many variants)  
(Nilsson, Albus)**

**MODULAR does not mean RIGID or INNATE  
Systems can be “nearly decomposable”. Boundaries  
can change with learning and development.**

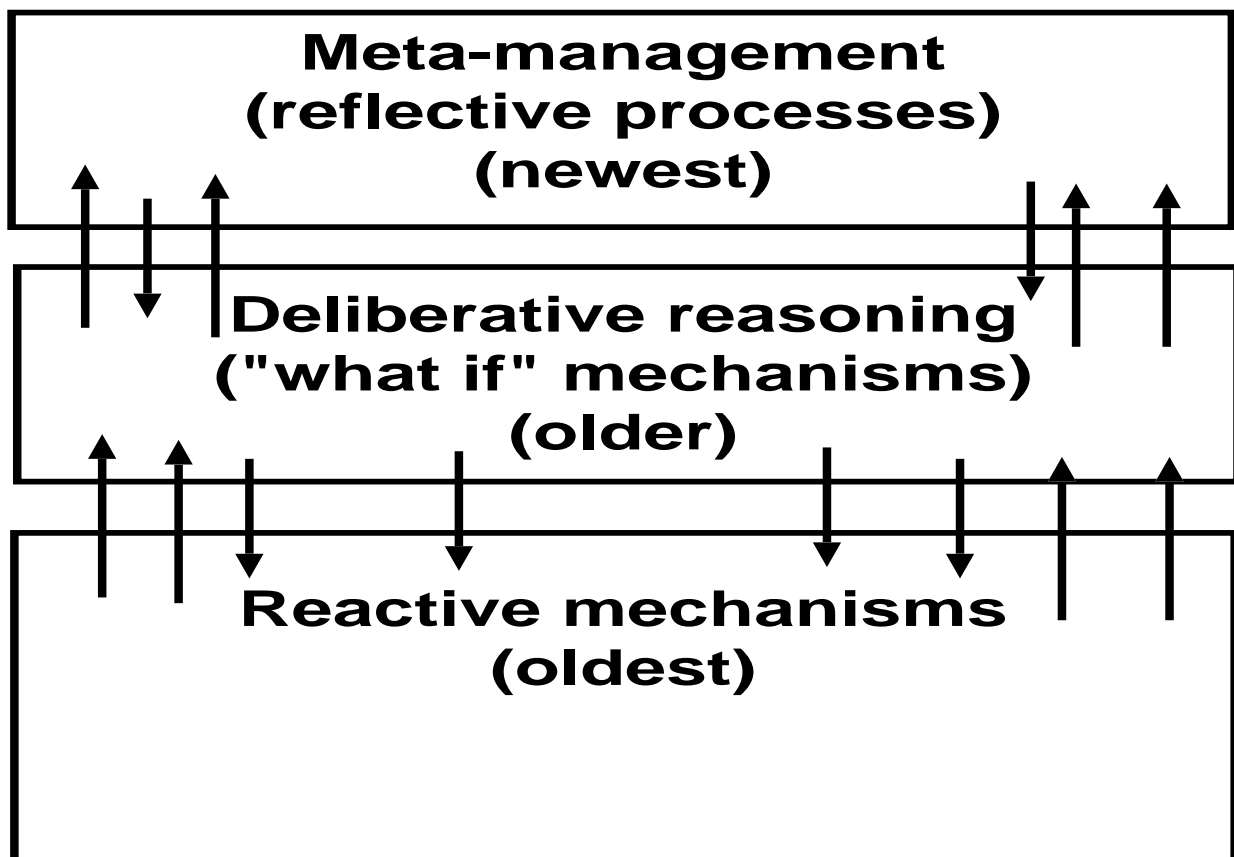
# SENSING AND ACTING CAN BE ARBITRARILY SOPHISTICATED

- On simple models sensors and motors are mere transducers.
- More realistically, they can have sophisticated information processing architectures.
  - E.g. perception and action can be hierarchically organised with concurrent interacting sub-systems.
- Perception goes far beyond segmenting, recognising, describing what is “out there”. It includes:
  - providing information about *affordances* (Gibson, not Marr),
  - directly triggering physiological reactions (e.g. posture control, sexual responses)
  - evaluating what is detected,
  - triggering new motivations
  - triggering “alarm” mechanisms
  - . . . . .

AN EXTENSION OF GIBSON’S THEORY:

**Different sub-systems use different affordances, and different ontologies.** (Evidence from brain damage.)

**ANOTHER COMMON  
ARCHITECTURAL PARTITION  
(functional, evolutionary)  
THE “TRIPLE LAYER” MODEL**



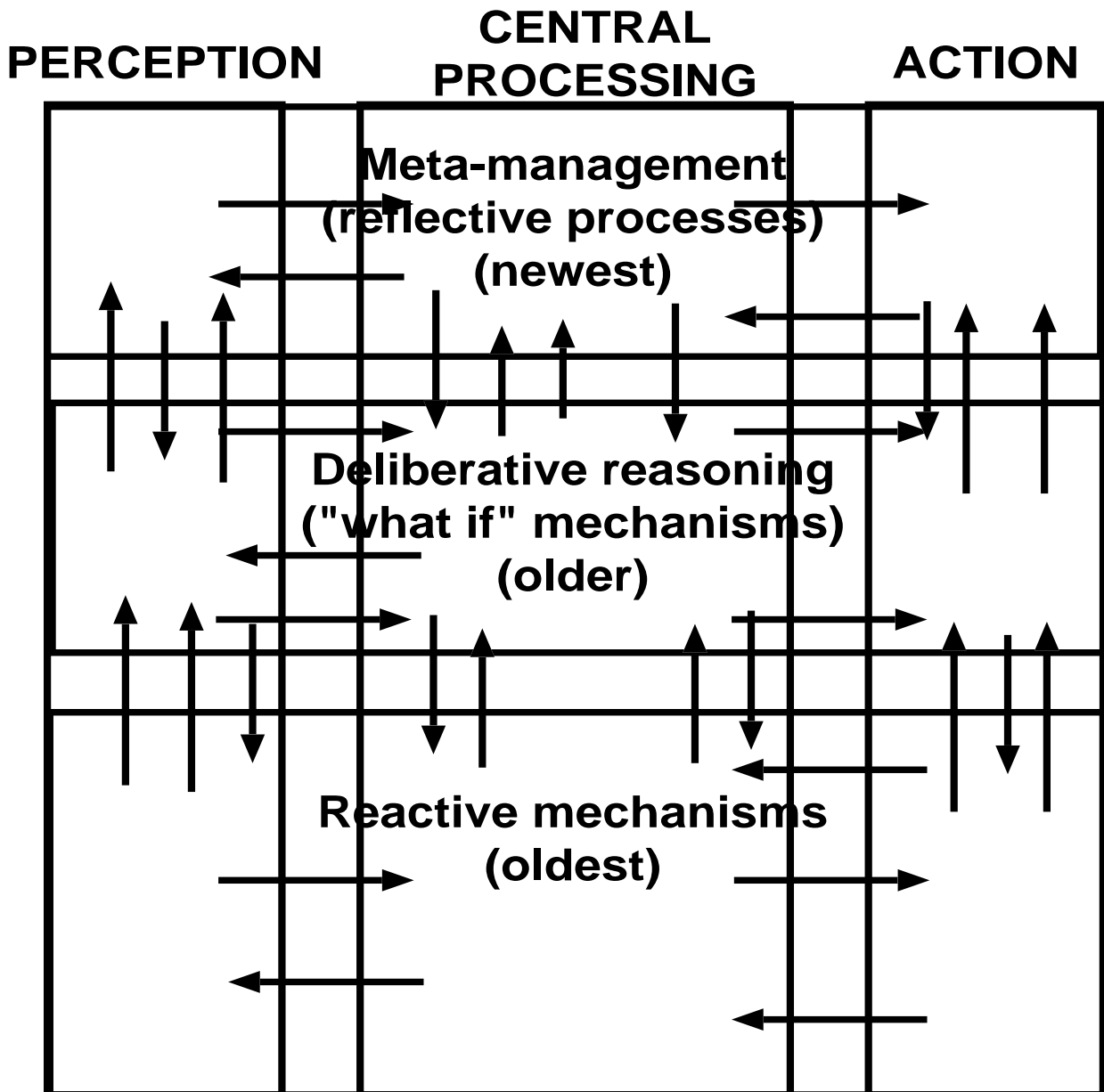
**(many variants – especially third layer)**

**Reactive systems can be highly parallel, very fast, and use analog circuits.**

**Deliberative mechanisms are inherently slow, serial, knowledge-based, resource limited.**



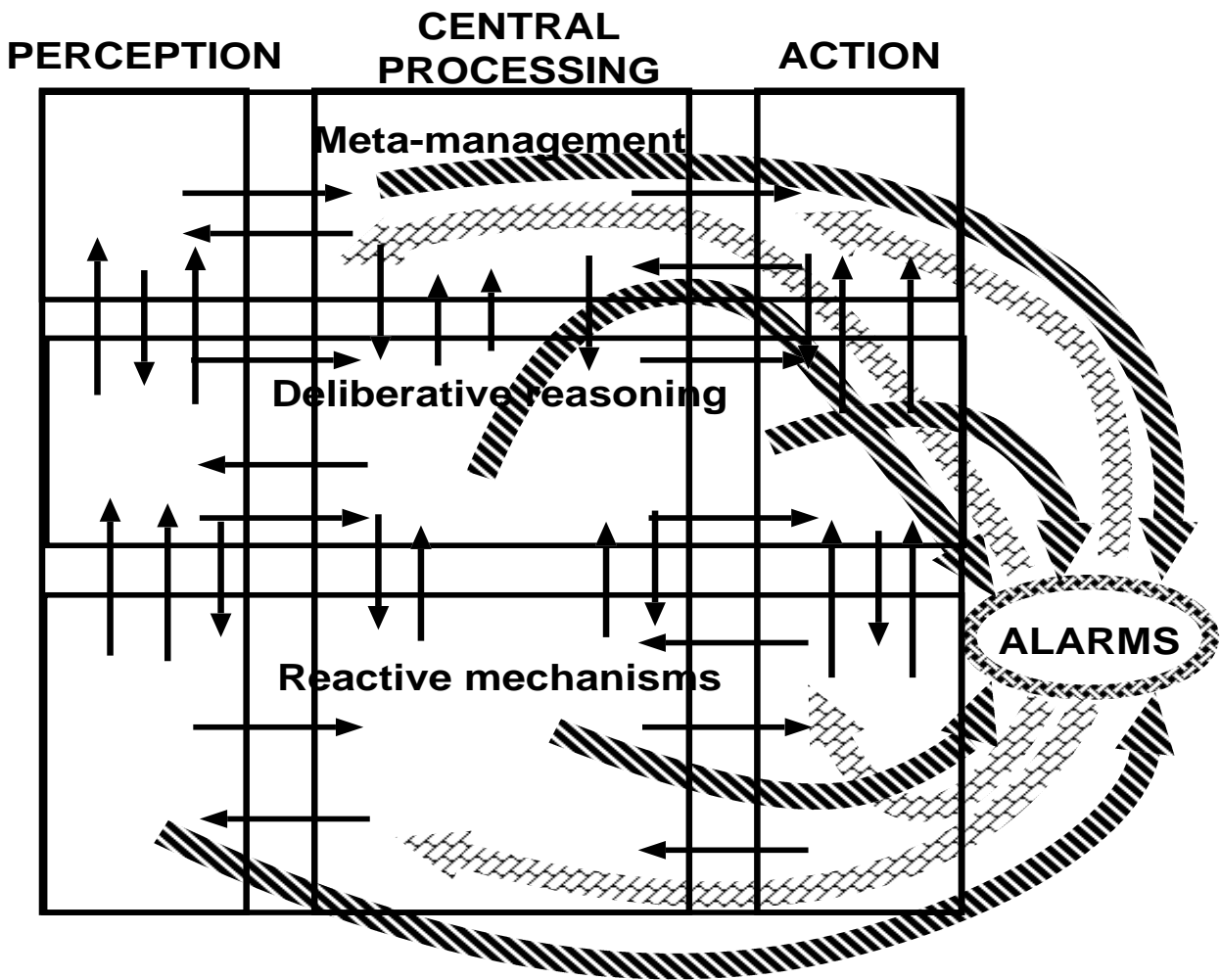
**COMBINING THE VIEWS:  
LAYERS + PILLARS = GRID**  
A grid of co-evolving sub-organisms,  
each contributing to the niches  
of the others.



As processing grows more sophisticated, so it can  
be come slower, to the point of danger.

**FAST, POWERFUL,  
“GLOBAL ALARM SYSTEM”  
NEEDED**

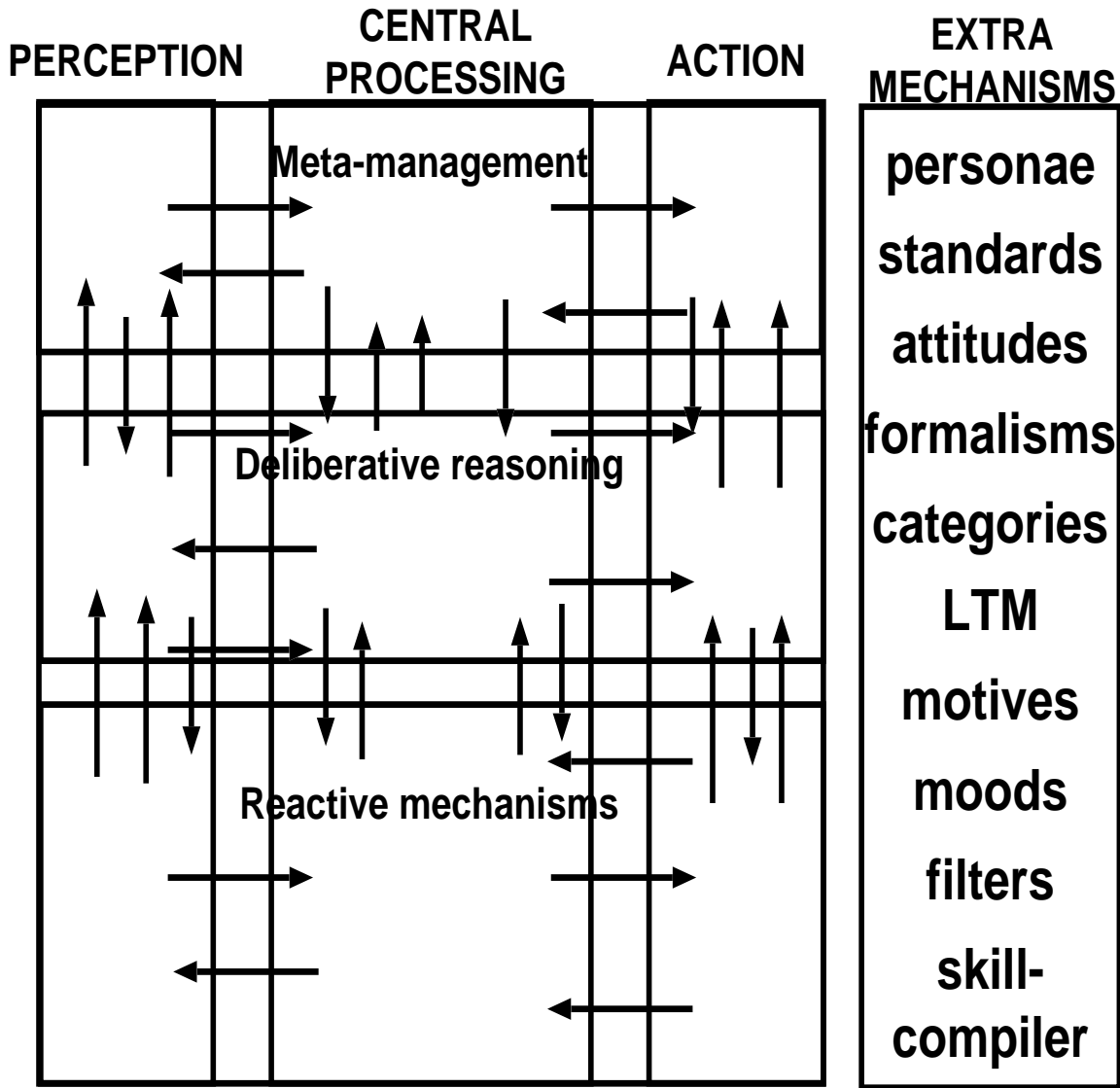
IT WILL INEVITABLY BE STUPID!



MANY VARIANTS POSSIBLE.

E.g. one alarm system or several?  
(Brain stem, limbic system, ...???)

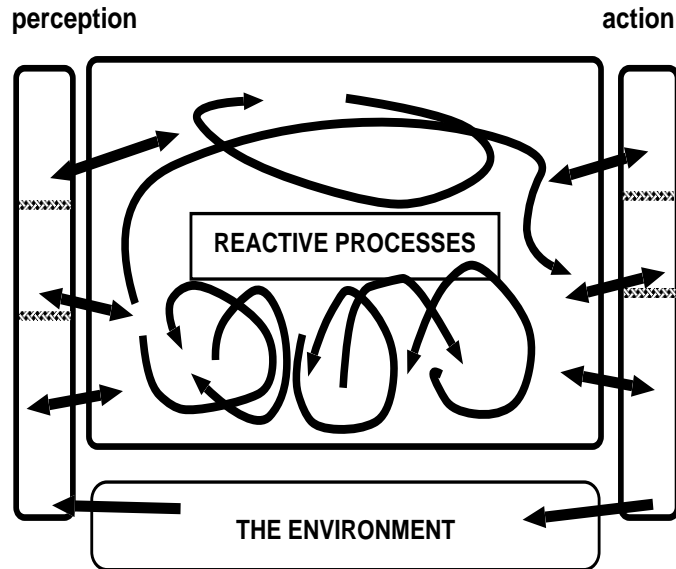
**ADDITIONAL COMPONENTS**  
(No time to discuss)



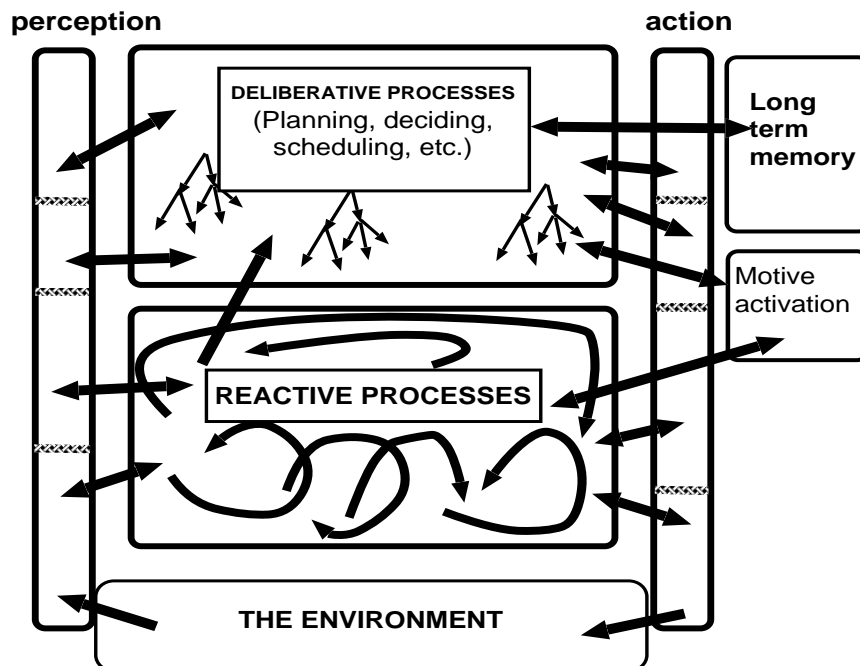
MANY PROFOUND IMPLICATIONS  
 e.g. for kinds of development  
 kinds of perceptual processes  
 kinds of brain damage  
 kinds of emotions

# NOT ALL PARTS OF THE GRID ARE PRESENT IN ALL ANIMALS

How to design an insect?



Add a deliberative layer, e.g. for a monkey?



**THESE LAYERS EXPLAIN  
PRIMARY, SECONDARY, TERTIARY EMOTIONS  
Different architectural layers support  
different sorts of emotions,  
and help us define  
AN ARCHITECTURE-BASED  
ONTOLOGY OF MIND**

**Different animals will have different mental ontologies**

**Humans at different stages of development will have different mental ontologies**

**The REACTIVE layer with GLOBAL ALARMS supports “primary” emotions:**

- being startled
  - being disgusted by horrible sights and smells
  - being terrified by large fast-approaching objects?
  - sexual arousal? Aesthetic arousal ?
- etc. etc.

**The DELIBERATIVE layer enables “secondary” emotions (cognitively based):**

- being anxious about possible futures
  - being frustrated by failure
  - excitement at anticipated success
  - being relieved at avoiding danger
  - being relieved or pleasantly surprised by success
- etc. etc.

**THE THIRD LAYER**  
enables  
**SELF-MONITORING,**  
**SELF-EVALUATION**  
and  
**SELF-CONTROL**

AND THEREFORE ALSO LOSS OF  
CONTROL (PERTURBANCE)  
(and qualia!)

**This makes possible “tertiary” emotions, through having and losing control of thoughts and attention:**

- Feeling overwhelmed with shame
  - Feeling humiliated
  - Aspects of grief, anger, excited anticipation, pride,
  - Being infatuated, besotted
- and many more *typically HUMAN* emotions.

**NOTES:**

**1. Different aspects of love, hate, jealousy, pride, ambition, embarrassment, grief, infatuation can be found in all three categories.**

**2. Remember that these are not STATIC states but DEVELOPING processes, with very varied aetiology.**

**SOCIALLY IMPORTANT  
HUMAN EMOTIONS  
INVOLVE RICH CONCEPTS  
AND KNOWLEDGE  
and  
RICH CONTROL MECHANISMS  
(architectures)**

- **Our everyday attributions of emotions, moods, attitudes, desires, and other affective states implicitly presuppose that people are information processors.**

- **To long for something you need to know of its existence, its remoteness, and the possibility of being together again.**

- **Besides these *semantic* information states, longing also involves *control* states.**

ONE WHO HAS DEEP LONGING FOR X DOES NOT MERELY OCCASIONALLY THINK IT WOULD BE WONDERFUL TO BE WITH X. IN DEEP LONGING THOUGHTS ARE OFTEN *uncontrollably* DRAWN TO X.

- **Physiological processes (outside the brain) may or may not be involved. Their importance is normally over-stressed by experimental psychologists under the malign influence of the James-Lange theory of emotions. (Contrast Oatley, and poets.)**

## CONCLUSION: THE SCIENCE

- **Much of this is conjectural – many details still have to be filled in and consequences developed (both of which can come partly from building working models, partly from multi-disciplinary empirical investigations).**
- **An architecture-based ontology can bring some order into the morass of studies of affect (e.g. myriad definitions of “emotion”).**

COMPARE THE RELATION BETWEEN THE PERIODIC TABLE OF ELEMENTS AND THE ARCHITECTURE OF MATTER.

- **This can lead to a better approach to comparative psychology, developmental psychology (the architecture develops after birth), and effects of brain damage and disease.**
- **It will provide a conceptual framework for discussing which kinds of emotions can arise in software agents that lack the reactive mechanisms required for controlling a physical body.**



# **CONCLUSION: HCI ENGINEERING**

**HCI Designers need to understand these issues:**

- (a) if they want to model human affective processes,**
- (b) if they wish to design systems which engage fruitfully with human affective processes,**
- (c) if they wish to produce teaching/training packages for would-be counsellors, psychotherapists, psychologists.**

**For more details, see the Cognition and Affect project papers**

**<ftp://ftp.cs.bham.ac.uk/>**

**[pub/groups/cog\\_affect/0-INDEX.html](ftp://ftp.cs.bham.ac.uk/pub/groups/cog_affect/0-INDEX.html)**

**COLLABORATORS ALWAYS WELCOME**