Some key ideas from:
"Natural and artificial meta-configured altricial information-processing systems"
Jackie Chappell and Aaron Sloman
International Journal of Unconventional Computing, 3,3,pp 211–239 2007,
http://www.cs.bham.ac.uk/research/projects/cosy/papers/#tr0609

INCOMPLETE DRAFT (May 25, 2010): will be updated.

Developmental trajectories for competences

Aaron Sloman and Jackie Chappell
Computer Science and Biosciences University of Birmingham
http://www.cs.bham.ac.uk/~axs/
http://www.ornithology.bham.ac.uk/academicstaff.htm#Dr_Jackie_Chappell

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These PDF slides are in our "WONAC" directory
http://www.cs.bham.ac.uk/research/projects/cogaff/talks/wonac
(Originally slides for Workshop on Natural and Artificial Cognition 2007)

Life is information processing

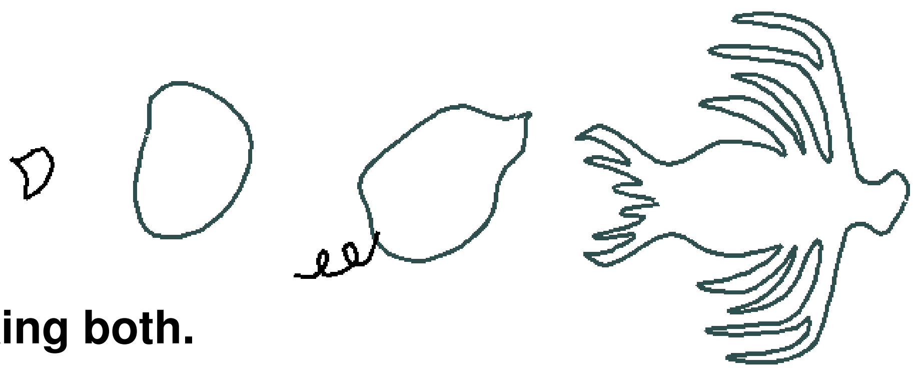
The world contains: matter, energy, information

Organisms acquire and use information, in order to control how they use matter and energy

Somehow evolution produced more and more sophisticated information processors: one challenge is to understand that process.

We need to understand

- **the structure of design space**
- **the structure of niche space**
- **trajectories in design space,**
- **trajectories in niche space,**
- **the many complex feedback loops linking both.**



"Theories of everything" – physics alone cannot do it

we also need

"Theories of everything informational – Natural and artificial."

That includes theories of possible forms of development of competences.

We need to understand the environment

Many of the requirements for biological information-processing (including cognitive systems) arise from distinctive features of the environment.

We need to understand the environment

Many of the requirements for biological information-processing (including cognitive systems) arise from distinctive features of the environment, including:

- The complexity and detailed structure of the environment;

  including what sorts of things are fixed, and what changes, and on what time scales,

- The processes that can and cannot occur in it;
  - including processes in which several objects interact in complex ways,

    e.g. the insides of an old fashioned clock
  - including processes that are not observable without the use of highly specialised physical technology, e.g. some of the insides of a digital watch

- Complexity that arises from various sources

  physical,
  chemical,
  topological,
  geometrical,
  social .... and other structures and processes.

- The presence of other information-processors in the environment.

  Requires the ability to acquire and use information about things that acquire and use information.
  Requires meta-semantic competences: coping with referential opacity.

- Some arises from the features of previously evolved and previously learnt competences.

See also: “Diversity of Developmental Trajectories in Natural and Artificial Intelligence”
`http://www.cs.bham.ac.uk/research/projects/cosy/papers/#tr0704`

Layered Learning Competences

The environment has layers of complexity

Different layers

- layering of what's in the world
- layering of accessibility to perceivers, thinkers

Human-like understanding r
layered learning producing

- layers of competence

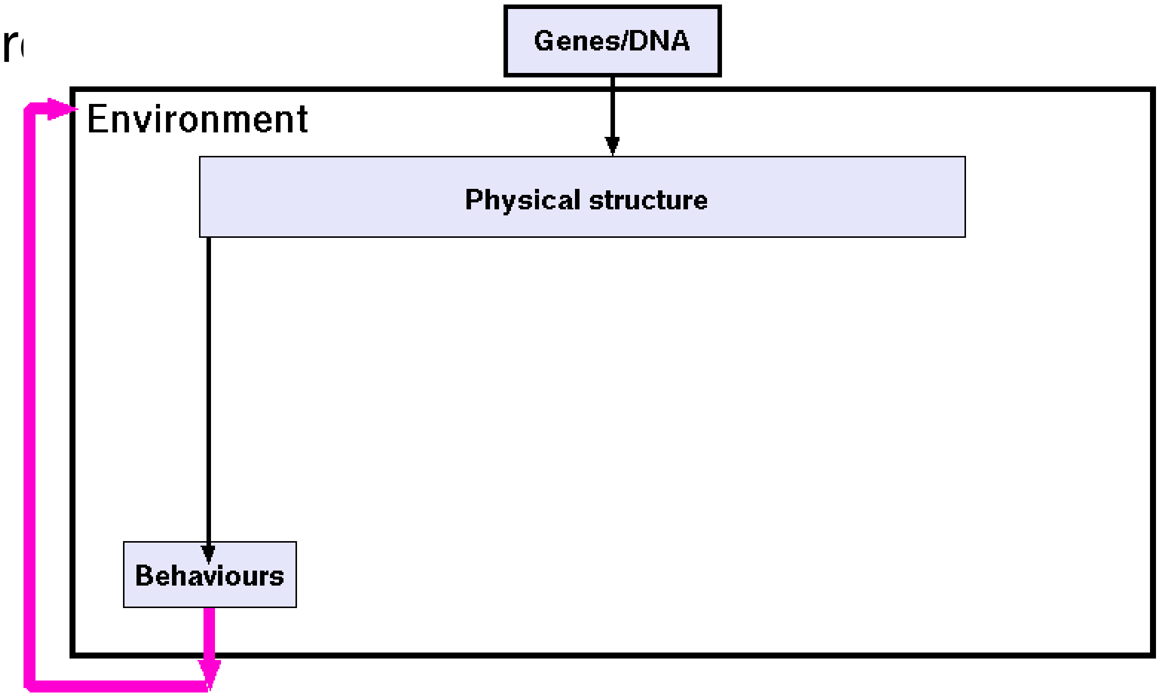
of varying complexity

The diagram shows a relatively simple (insect-like?) case, where most of a behaviour is genetically determined, though the process of development may be very complex and play a role – the same role in all members of the species.

Example: adaptable reflexes.

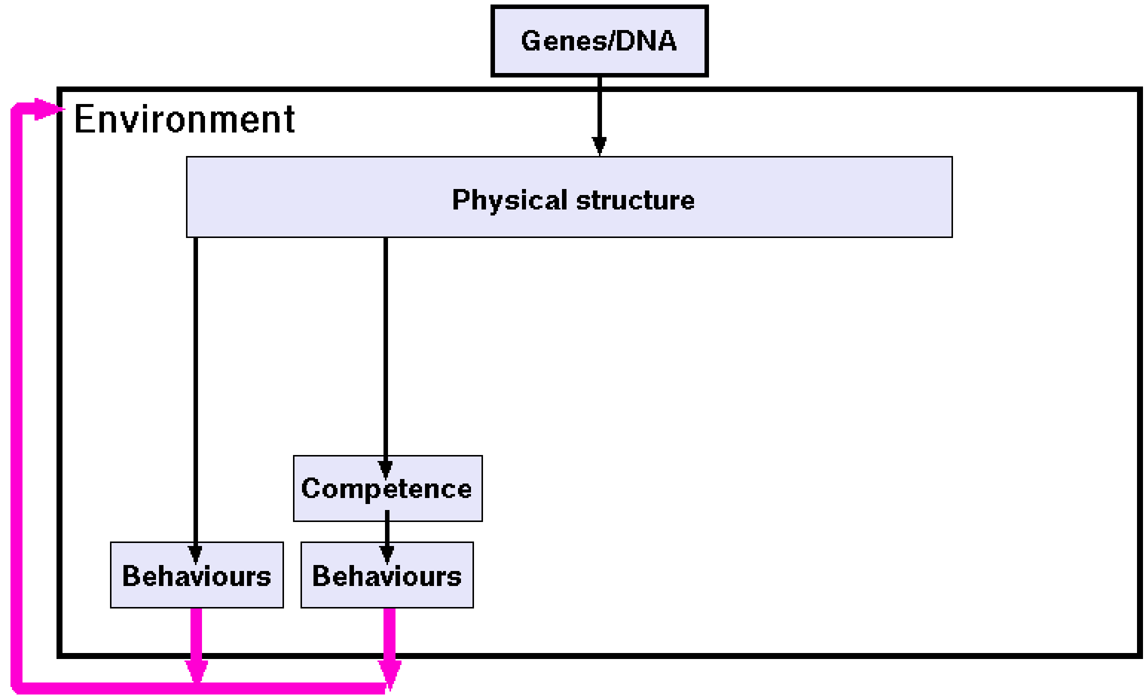
See IJUC 2007 article

with Jackie Chappell

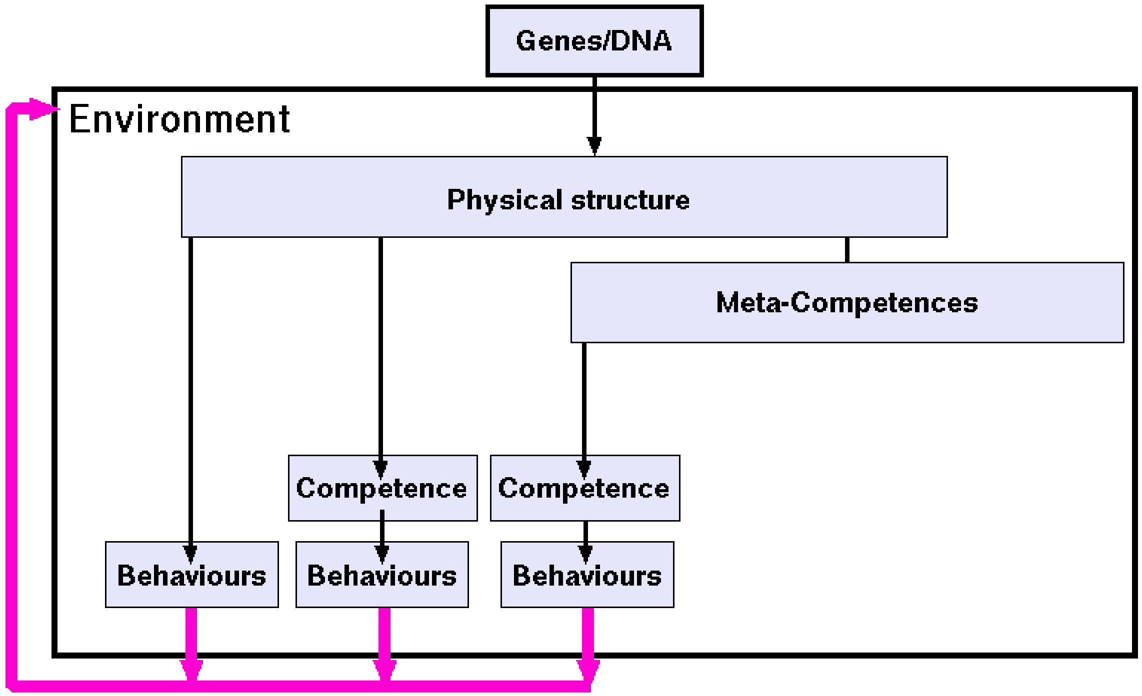


`http://www.cs.bham.ac.uk/research/projects/cosy/papers/#tr0609`
Natural and artificial meta-configured altricial information-processing systems

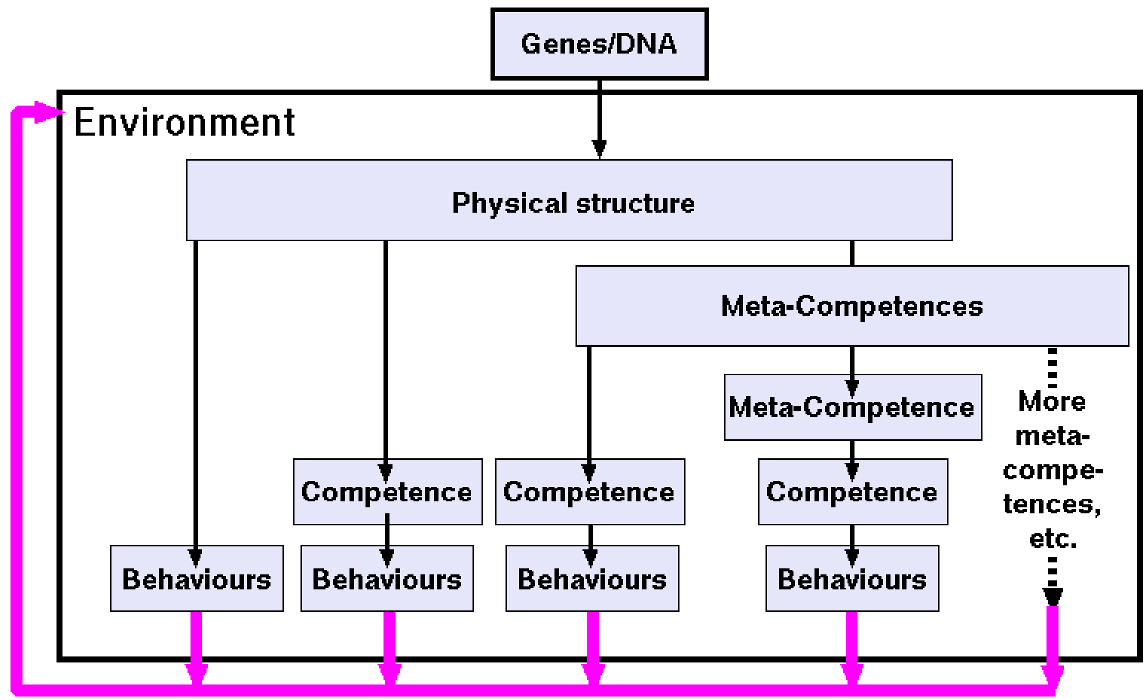
Meta-competences 2



Meta-competences 3



Meta-competences 4



Implications of pre-verbal competences in animals and young children

Competences of pre-verbal humans and some non-verbal animals

e.g. planning

appear to require the use of ‘internal languages’ that have structural variability and compositional semantics,

but need not have the linear forms or applicative syntax of human and logical languages.

If that is correct, most current theories of both the evolution of language and language learning in humans must be wrong.

Sloman and Chappell in BBS 2007

For more detail see:

`http://www.cs.bham.ac.uk/research/projects/cogaff/talks/#glang`

`http://www.cs.bham.ac.uk/research/projects/cogaff/81-95.html#43`

Virtual machines and biological evolution

Biological evolution seems to have "discovered" the need for virtual information-processing machines long before we did and probably has produced far more types than we have as yet seen the need for.

Self-monitoring, self-modifying, self-extending systems need to make use of virtual machines.

Dave Clark at MIT 'The knowledge layer' in intelligent networks.

Challenges for neuroscience

- layers of virtual machines,
- how are they grown and when
- physiology $\rightarrow$ VM or vice versa?

Deep problems for theoretical biology

- how are specifications for virtual machines are represented in the genome
- including virtual machines that construct new virtual machines
- how did all this evolve

The common biological basis of adult human intelligence

CONJECTURE

almost all human adult cognitive competence builds on and grows out of

- very general biologically-based, culture-neutral competences
- developed through interaction with the environment in the first few years of life,

CONJECTURE

all attempts by AI developers to implement adult-like human competences without going via that route will be very brittle and severely bounded in scope.

Making non-empirical discoveries

An unnoticed aspect of the learning that goes on as a young child explores and plays in a complex 3-D environment.

making discoveries that at first appear to be purely empirical, but which, if the learner has an appropriate information-processing architecture, can later be seen to be non-empirical,

i.e. more like theorems of geometry, topology, arithmetic, etc. This ability to alter the epistemic status of acquired information provides the basis for flexibility and creativity that are not possible in learners that can only use empirical/statistical learning mechanisms. (E.g. Bayesian nets which are now so popular?)

Example: if your slippers are on the floor with their soles on the floor and you are standing next to them you cannot get your feet into them simply by sliding your feet around on the floor. (There are hundreds, or perhaps thousands, more ‘toddler theorems’.)

Example: if you have three adjacent coins in the same column of a chess board you cannot rearrange them by purely diagonal moves so that they end up in the the abutting locations in the adjacent column. (Not even if the chess board is infinite...)

Explaining how such toddler discoveries can be transformed from empirical to non-empirical discoveries will require developing new forms of representation and new information processing architectures for intelligent machines.

GC-5 Architecture of Brain and Mind

A grand challenge – one of the UKCRC's grand challenges for computing research, described in

`http://www.cs.bham.ac.uk/research/projects/cogaff/gc`

- To increase our understanding of the brain and mind
  - drawing on philosophy, neuroscience, developmental psychology, linguistics, animal behaviour, evolutionary theory, ...
  - exploiting CS concepts - architectures, virtual machines, parallel processing, and so on
- To test our understanding
  - by implementing computer and robot models

  To design and build ...
  - a robot capable of a range and sophistication of behaviour equivalent (in some sense) to that of an infant
- Using a collection of approaches:
  - Top down
  - Bottom up
  - Middle out
  - ......