FEEL & WANT node: Motivation and Emotion

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Motivation and Emotion

- Emergence of affective ‘representation’ and predictive capabilities (ESR7)

- Affective modulation of embodied higher-level cognition (ESR8)
Motivation and Emotion

- **Emergence of affective ‘representation’ and predictive capabilities (ESR7)**
  - “How can an embodied agent make use of its perception of own body-internal/homeostatic states (in addition to perception with the external environment) in structuring its cognition and behaviour?”

- **Affective modulation of embodied higher-level cognition (ESR8)**
Motivation and Emotion

- **Emergence of affective ‘representation’ and predictive capabilities (ESR7)**
  - “How can an embodied agent make use of its perception of own body-internal/homeostatic states (in addition to perception with the external environment) in structuring its cognition and behaviour?”

- **Affective modulation of embodied higher-level cognition (ESR8)**
  - “How can high(er) levels of cognition be grounded in and informed by low(er)-level affective mechanisms?”
Grounding (Higher) Cognition in Affective Mechanisms

1. Modelling Affective Mechanisms,
2. Integrating Affective Mechanisms in Cognitive Architectures
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Bio-inspired approach to 1.
Bio-constrained approach to 2.
Grounding (Higher) Cognition in Affective Mechanisms

• **Simulating:**
  – (Artificial) Metabolism
  – Reward Prediction Error Learning

• **Interfacing:**
  – Metabolism and Sensorimotor activity
  – reward learning circuitry and abstract representation circuitry

• **Integration:**
HIS focus:

(red arrows)

Simulating and interfacing ‘wanting’ (see Swanson 2005, Berridge 2003) network:

- Metabolic/homeostatic processes
- Brain-body interface (Hypothalamus)
- Corticolimbic processes (AMG, OFC, VTA)
- Higher cognitive areas (DLPFC)
Cognition and Emotion

... according to somatic theories of emotion – emerge from multiple levels of homeostatic bodily self-regulation

E.g. Damasio: nature has “built the apparatus of rationality not just on top of the apparatus of biological regulation, but also from it and with it”
Energy Autonomy

Minimalist exploration of integrative dynamics:
- *anticipation via energy constraint*

Montebelli et al. (2008, 2009)
Energy Autonomy

A Simulated Artificial Metabolism —
Modelling Microbial fuel cell dynamics

Melhuish et al. (2006)  Montebelli et al. (in preparation)
Energy-Motivational Autonomy

- Interfacing metabolic and sensorimotor dynamics:

Lowe et al. 2008, Lowe et al. (in preparation).
Metabolically constrained sensor-motor strategies

Investigating *Agent-Environment Interactive Dynamics vs Agent Internal (Neurophysiological) Dynamics* and impact on modes of sensorimotor embodiment
Metabolically constrained sensor-motor strategies

Varying the artificial metabolic constraint on motor output can induce bifurcations in agent-environment interaction dynamic.
Motivational Autonomy


Uses population coding to generate non-monotonic sensitivity to stimulus input

(see Lowe, Humphries, Ziemke 2009)
Motivational Autonomy

Neurobiologically inspired *Reward Prediction (Error) Learning Algorithms*

(Lowe, Mannella, Ziemke, Baldassarre 2009)
Motivational Autonomy
Continuous Time Reward Prediction Learning/Pavlovian Conditioning Network

Model alternative to TD model of:
pavlovian 1st, 2nd order conditioning, acquisition-extinction-reacquisition effects:
Lowe, Mannella, Ziemke, Baldassarre (in preparation)
Mental Autonomy

Interfacing reward learning circuitry with a dynamic field theoretic model of spatial working memory:

1. Identification of the core neural structures (see Lowe & Ziemke 2010)

2. Capturing the neural dynamic interface of the core hypothesized structures for online learning (see Lowe, Duran & Ziemke, submitted)
Mental Autonomy

Exploration of the reversal learning hypothesis of the Iowa Gambling Task using:

- reward prediction learning
- dynamic field modelling
- neural dynamic interfacing

See Lowe and Ziemke 2010, Duran, Lowe and Ziemke, submitted
Mental Autonomy and Development

Identification of parameters critical to continuity between infants and adults – similar to Thelen et al. 2001 seminal modelling of A not B developmental parameters – via a quantitative/qualitative comparison of IGT performance (our model vs Bechara et al. 1994 canonical data).
Mental Autonomy – sequences of learning

Modelling the Van den Bos et al. 2006 rat IGT
Mental Autonomy:
Simulation, Planning and Anticipation

'Simulation' feedback loop

'Sequence' feedback loop

OFC

Reward Learning Network

Perceptual Field

(Sub-network 1: coarse neural field)

(Sub-network 2: reservoir)
Interesting Further Research Issues

Role of energy autonomy and reward learning in:
  – Sequence learning
  – Navigation
  – Modes of sensorimotor embodiment

Modelling of specific emotional activity re:
  – Emotion (action) centres
  – Holistic emotional dynamics
RobotDoc resources