Evolutionary robotics models in the interdisciplinary study of embodied time perception

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A recent study by Cunningham et al. (Cunningham et al., 2001, Psychological Science, 12, p. 532) has shown that human subjects adapt to delayed visual feedback in a visuomotor task both behaviourally and experientially, i.e., the behaviour is altered in such a way that successful performance on the task relies on the presence of a visual delay (negative after-effect) and that the experience of simultaneity is re-adjusted to incorporate the visual delay. This adaptation effect is similar to those observed in experiments with visual displacements, but contrasts with earlier experiments with sensory delays, in which no such adaptation occurred (e.g., Smith and Smith, 1962, Perception and Motion, Saunders).

This discrepancy (i.e., adaptation in some situations but not in others) suggests that adaptation to sensory delays does not proceed automatically, on the basis of statistical properties of sensory inputs, but is contingent on the performed behaviour and the associated sensorimotor dynamics. Artificial Life and Evolutionary Robotics simulation models are proven tools in the study of non-linear sensorimotor dynamics, which are difficult to understand intuitively. In particular, our earlier work (Di Paolo et al., 2008, New Ideas in Psychology, forthcoming; Rohde, 2008, PhD Thesis, University of Sussex; Rohde and Di Paolo, 2007, ECAL 2007, p. 193, Springer) argues and demonstrates how Evolutionary Robotics simulation models can contribute to the scientific study of human sensorimotor adaptation.

In a combined experimental and evolutionary robotics modelling study, we have tested the (unconfirmed) hypothesis put forward by Cunningham et al. (Cunningham et al., 2001, Psychological Science, 12, p. 532) that adaptation to sensory delays occurs if there is time-pressure on the task (Rohde, 2008, PhD Thesis, University of Sussex; Rohde and Di Paolo, 2007, ECAL 2007, p. 193, Springer). On the basis of data analysis of both the artificial model agents' and the experimental subjects' sensorimotor recordings we revised our hypothesis: We now believe that, apart from time pressure, the task needs to feature a systematic link between present motion and future sensation over a longer time span in order to make the task predictable.

This new hypothesis will be tested using a combined Evolutionary Robotics modelling and experimental psychophysics approach proposed and applied in (Rohde, 2008, PhD Thesis, University of Sussex) that aims at formalising and explaining the sensorimotor invariances associated with perceptual experience of time and simultaneity. We argue that the contingent relation between function and underlying mechanisms inherent in Evolutionary Robotics simulations helps to identify general dynamical principles and fundamental sensorimotor invariances across viable solutions. In this aspect, the approach taken is more general and less biased, even though also less transparent than related approaches like robotic forward model learning (e.g., Tani, 1996, IEEE Trans. SMC (B), 26, p. 421). This novel methodological framework, which is characterised by a close match between simulation model and minimalist empirical experiment, can be applied to other problems of perceptual experience and opens up new powerful avenues for interdisciplinary research that uses Artificial Life methods to study of human perception and cognition in the closed sensorimotor loop.