Evolutionary Robotics and Perceptual Supplementation: Dialogue Between Two Minimalist Approaches

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Artificial intelligence (AI) is one of the disciplines constituting the interdisciplinary research field cognitive science. Classically, the metaphor of cognition as information processing has served as a bridge principle between AI and other disciplines, and this bridge is unidirectional, i.e. mental phenomena are reduced to abstract computations, physically implemented in the brain (see Fig. 1, a), thereby rendering AI modelling the intellectual core of cognitive science. We want to introduce an alternative interdisciplinary framework that relies on hermeneutic circular integration of sub-disciplines (see Fig1, b), rather than unidirectional reduction, and does not rely on the information processing metaphor as bridge principle, thereby creating space for alternative views of AI and cognition. The three areas forming the cornerstones of the explanatory triangle are phenomenological enquiry (introspection), empirical research and computational modelling.

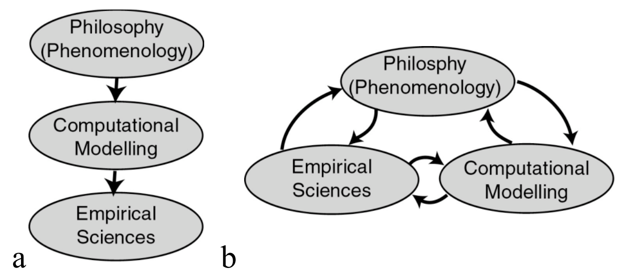

Fig. 1. The two interdisciplinary frameworks

Varela (1996) discusses the reciprocal link between phenomenology and the empirical sciences. Here, we want to focus on the elaboration of the double link between the empirical sciences and computational modelling, considering as a specific example evolutionary robotics and perceptual supplementation. This clarification can be seen as one jigsaw piece in a larger endeavour to establish this alternative explanatory framework. Empirical research in perceptual supplementation (PS) uses devices to “transform stimuli characteristic of one sensory modality (for example, vision) into stimuli of another sensory modality (for example, touch).” (Lenay et al. (2003), p. 2). With this technique, also known as “sensory substitution” (Bach-y-Rita, e.g. (2004)), adaptation to new sensorimotor couplings can be investigated. For instance, in Lenay (2003), the perception of space is analysed, identifying the necessary and sufficient conditions for something to be perceived as distal: Subjects are equipped with just a single photo cell attached to the finger, which controls a tactile stimulator, a minimal PS device. This minimalism, apart from providing methodological advantages, serves to highlight the role of time-extended sensorimotor coordination as the basis of perceptual invariance. The findings are explained through hermeneutic analysis of subjective experience and movement trajectories/performance. The individual consideration of either of the two methods would not have met the profoundness of the explanation thereby gained.

We believe that including computational models into the analysis will lead to an even richer account (as also recognised by the cited group, see Stewart & Gapenne (2004)). Our “house speciality” in the CCNR at the University Of Sussex is Evolutionary Robot-

ics (ER), “a new technique for automatic creation of autonomous robots [...] inspired by the darwinian principle of selective reproduction of the fittest." (Nolfi & Floreano (2000), preface). Typically, the models generated with this approach are deliberately minimal (Beer (2003), Harvey et al. (2006)), in order to remain tractable. They serve as tools for grounding and questioning preconceptions about fundamental aspects cognition. *Most other methods in AI do not include this explicit self-critical factor.* Beer (2003) argues that the minimalism of this method allows us to perform the necessary mental gymnastics to deal with real, dynamical, and context-dependent cognitive performance. A concern frequently uttered is: “Will these models scale up in complexity?” We believe that this desire to complicate ER models arises from the misguided ambition to make them approach the complexity of traditional theories about cognition. In fact, the minimalism of ER matches the minimalism of PS (at least as it is practiced by the Compiègne group), as both have emerged from the need for tractability and controlled settings in explaining complex cognitive phenomena. Furthermore, its inherent embodiment and situatedness makes ER a very suitable modelling technique for findings from PS research. Such models can make behavioural strategies and prior assumptions explicit and control the degree of designer intervention, thereby exploring novel principles of AI design. This is the link from PS to ER. At the same time, they can help to derive theories from empirical findings by means of abstraction. New hypotheses can be generated, influencing the design of further experiments. This is the link in the other direction, from ER to PS.
With ER falling naturally into place, our vision of a new interdisciplinary framework is, in its crude structure, complete. It does not rely on reduction of mental states, but on hermeneutic analysis, in which different disciplines inform and constrain each other. It does not need a metaphor like “cognition as information processing”, but recognises cognition as embodied activity. In this framework, the minimalism of ER and PS is not an obstacle, but a merit on the way to explain human-level cognition.

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