Chapter 1.4
Reconstructing Human Intelligence within Computational Sciences:
An Introductory Essay

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ABSTRACT

This chapter outlines a possible research program for computational systems representing humanlike intelligence. After a short historical introduction, a possible theoretical framework is described showing how it is possible to integrate heterogeneous disciplines like neurobiology, psychology and phenomenology within one and the same computational framework. Concrete examples are given by reconstructing behavioural (Morris) and phenomenal semiotics (Peirce) with the aid of formal theories. The author hopes to improve the interdisciplinary discussion about adaptive computational models of humanlike intelligence through a unified theoretical framework.

THE PROBLEM

The term "intelligence" and especially "human intelligence" (HI), is used in many different disciplines, especially in psychology, but is still more fuzzy than clear. The rise of modern computational sciences induces still more terminological fuzziness. But for scientists, it is an

interesting question whether and how it is possible to reconstruct and model the fuzzy phenomenon of "human intelligence" within computational sciences. In this essay I try to establish a unified formal framework based on modern Science Theory to relate all the known theoretical aspects of human intelligence within one unified view, not as a final answer, but as a research program. The format of an essay is due to the fact that the nature of the problem does not allow a complete answer, but deserves, nevertheless, an embracing, unifying framework.

HISTORICAL INTRODUCTION

At the time of this writing, the term *intelligence* is highly loaded with different associated meanings which are deeply rooted in history and spread over a multitude of disciplines. As the ethologist Marc D. Hauser states it, "… no one has managed to delineate the key symptoms of intelligence in humans, let alone operationalize the concept for cross-species comparisons …." (Hauser, 1996, 112). This judgement is shared by other researchers in the field of intelligence, such as the authors of the book, *Die Entdeckung der Intelligenz — oder Können Ameisen denken?* (The Discovery of Intelligence — Can Ants Think?). The authors stress the point that all the factors that are involved in the multifaceted phenomenon of intelligence are still not really known, and, therefore, one should not start with a too narrow definition in the beginning (Cruse, Dean, & Ritter, 1998, 21). Very similar is the statement of Rolf Pfeifer and Christian Scheier in *Understanding Intelligence* (Pfeifer & Scheier, 1999, 6ff). But, how can we start then? Historically, philosophy was first in trying to understand intelligence as part of human behaviour and self-experience. Although these philosophical works have been highly influential to many new developments in modern sciences, I will discuss this only occasionally when I am describing some of the modern

scientific contributions later on. From the point of view of science, a good starting point can be the rise of *modern experimental psychology.* This happened in 1879 when Wundt founded his famous psychological laboratory in Leipzig (Germany) with forerunners like Herbart and Fechner. This beginning was very influential; it led, along with others, to the movement of *behaviouristic psychology,* mainly in the USA (e.g., J.B.Watson, E.L.Thorndike, I.P.Pawlow, E.R.Guthrie, C.L.Hull and B.F.Skinner; see Bower &Hilgard, 1981) during the first half of the 20th century. By restricting allowed facts to observable behaviour and observable properties of the environment, behaviourism tried to reconstruct biological systems by the interplay of stimuli and responses. As more results became available, the limits of this approach were exposed. The method to explain behaviour constrained to stimuli and responses was on account of the inherent complexity of the observed behaviour not really feasible (e.g. , Chomsky, 1959). During that time the knowledge was increasing that overtly observable behaviour is rooted in the physiological, and especially neurological, machinery. When the movement of behaviourism was slowly declining, a new, more differentiated movement began to rise from the midst of the twentieth century: *Modern Etholog*y (*ethos* — Greek: behaviour). Tinbergen and K. Lorenz are known as the founders of this new movement, which is based on the work of several forerunners. They used the concept of behaviour like the behaviourists but they tried to look at the whole picture of an organism: the observable behaviour, the underlying neuronal mechanisms, the growth process, endogenous and learned behaviour, structural similarities between individuals, species, etc. (Eibl-Eibesfeldt, 1980; Immelmann, Barlow, Petrinovich, & Main, 1982). Human ethology was part of the general ethology thus demonstrating the continuity of the phenomenon of human behaviour with non-human behaviour as well as the individual characteristics of human behaviour different from all other spe-

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