Chapter 10

The CHREST Architecture of Cognition: Listening to Empirical Data

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Abstract

This chapter provides an introduction to the CHREST architecture of cognition and shows how this architecture can help develop a full theory of mind. After describing the main components and mechanisms of the architecture, we discuss several domains where it has already been successfully applied, such as in the psychology of expert behaviour, the acquisition of language by children, and the learning of multiple representations in physics. We highlight the characteristics of CHREST that enable it to account for empirical data, including self-organisation, an emphasis on cognitive limitations, the presence of a perception-learning cycle, and the use of naturalistic data as input for learning. We argue that some of these characteristics can help shed light on the hard questions
facing theorists developing a full theory of mind, such as intuition, the acquisition and use of concepts, the link between cognition and emotions, and the role of embodiment.

Introduction

In the last decade, an unprecedented amount of research has attempted to uncover the secrets of the human (and animal) mind. A number of approaches have been used, spanning philosophy, psychology, neuroscience, and computer science. This combined effort of several disciplines and tens of thousands of scientists has produced a formidable amount of new data and theoretical ideas. However, beyond this success in collecting new information, it has been more difficult to develop theories putting together, and thus explaining, large amounts of data, while still offering precise and well-specified mechanisms.

An influential line of research to achieve this goal has been the development of computational architectures that closely simulate human behaviour in a variety of domains. Examples of this approach include ACT-R (Anderson & Lebière, 1998), SOAR (Newell, 1990), and EPAM (Feigenbaum & Simon, 1984). More recently, the computational architecture CHREST (Chunk Hierarchy and REtrieval STructures) (Gobet et al., 2001; Gobet & Simon, 2000; Lane, Cheng, & Gobet, 2000) has simulated data in a number of domains, including expert behaviour, verbal learning, first language acquisition, and implicit learning.

The strength of cognitive architectures is that their implementation as computer programs ensures a high degree of precision and offers a sufficiency proof that the mechanisms proposed can carry out the tasks under study. Closer comparison between the theory’s predictions and actual behaviour, using measures such as eye movements, reaction times, and error patterns, also establish the extent to which the simulation carries out the tasks in agreement with the human data.

The aim of this chapter is to provide an introduction to CHREST, to illustrate the kind of data it has already successfully simulated, and to show what insight it offers on some of the difficult questions facing researchers studying the mind, such as intuition, consciousness, implicit learning, and the link between emotion and cognition. The general approach defended here is that, in order to develop a theory of the mind, one has to use empirical data to constrain the number of possible architectures (see also Newell, 1990). Conversely, the chosen architecture should make new empirical predictions that can be tested and that can be used to further develop it. As we shall see, CHREST has already made new predictions in the field of expert behaviour—predictions that were later supported by empirical data (Gobet & Simon, 2000; Gobet & Waters, 2003).
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