Chapter 4

Modular Representations of Cognitive Phenomena in AI, Psychology, and Neuroscience

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Abstract

Many architectures of mind assume some form of modularity, but what is meant by the term ‘module’? This chapter creates a framework for understanding current modularity research in three subdisciplines of cognitive science: psychology, artificial intelligence (AI), and neuroscience. This framework starts from the distinction between horizontal modules that support all expressed behaviors vs. vertical modules that support individual domain-specific capacities. The framework is used to discuss innateness, automaticity, compositionality, representations, massive modularity, behavior-based and multi-agent AI systems, and correspondence to physiological neurosystems. There is also a brief discussion of the relevance of modularity to conscious experience.
Introduction

Many of the architectures of mind described and referred to in this book assume some form of modularity. But what is considered to define a module varies a great deal both within and across the cognitive science disciplines: artificial intelligence (AI), psychology, and neuroscience. This chapter is not devoted to any one architecture (though I have one too, which I will describe briefly in the Discussion to make my biases clear), but is rather an overview of the concepts and concerns of modularity. It covers all of the above disciplines and shows how they relate to one another and to cognition—or at least to cognitive phenomena such as planning, learning, language, emotions, and consciousness.

My hope is that this chapter will serve as a useful primer—in the best case, a Rosetta stone—for scientists and laypeople trying to get a handle on what the various fields of cognitive science might mean by modularity, and how the modular architectures described in this book and elsewhere might correspond to our common understanding of what minds do. It is important to realize that researchers who are experts in one or more of the areas described below may have no awareness of some of the other areas, and therefore may make no effort to reconcile their own theories with the others. Consequently, this chapter contains some substantial redescription in an effort to put these theories into a common framework for comparison.

Modularity in Psychology

Criteria for Modularity

I will begin with an extremely simple definition of modularity from the psychological literature, due to Flombaum et al. (2002):

Modularity is the thesis that the mind contains independent input systems that, when engaged, are restricted in the types of information that they can consult.

This definition is useful for two reasons. First, it introduces a very clean criterion for modularity: that some part of the mind does not have access to some other part of the mind, or at least not its “information.” Given this simple criterion, anyone who accepts the idea of implicit knowledge or unconscious behaviour has
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