Discussion about Modularity of Mind

Chenhao Zhou
Yuanpei College
Peking University
zhouch@stu.pku.edu.cn

Abstract

Since the "modularity of mind", a new and exciting theory of mind was proposed, it has articulated features not only of speculative cognitive architectures but also of current research in artificial intelligence. Yet this theory is still under debate. This essay would discuss the main opinions of the mind modularity theory, striving to support its rationality from the various fields of cognitive science. The essay also contains the review of its implementation on artificial intelligence. In addition, some counterarguments about the theory are necessarily involved.

1 Introduction

In psychology, theory of mind refers to the capacity to understand other people by ascribing mental states to them [4]. People utilise a theory of mind when analyzing, judging, and inferring others' behaviors. Its development within the first year of life is a major milestone that enables us to comprehend and participate in the social world.

The perspective of "modularity" has loomed large in cognitive science and changed the conceptual and theoretical landscape in this area dramatically. At first Fodor [1] proposed a vertical and modular psychological organization underlying biologically coherent behaviors, such as low-level systems of perception and language. Then other theorists such as Sperber and Wilson [7] contend that the mind is modular through and through, including the high-level systems responsible for reasoning, planning and decision making.

This essay will focus on the mind modularity theory, discussing the specific differences between Fodor and post-Fodorian theorists in Sec. 2. Thus turning to the implementation in domain of artificial intelligence in Sec. 3. Finally in Sec. 4, we illustrate some arguments against the mind modularity theory to make the statements more complete.

2 The mind modularity theory

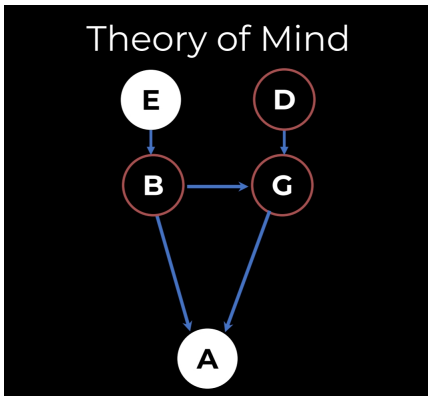

Figure 1: The general structure of Theory of Mind

2.1 Theory of mind

Before the discussion of modularity mind theory, a brief introduction about ToM is necessary. As theory of mind has played a key role in our evolution as a social species capable of large-scale culture, coordination, and cooperation. Possessing a functional theory of mind is considered crucial for human social interactions. Fig. 1 illustrates the general structure of Theory of Mind, which consists of five elements: **E**nvironment, **D**esire, **B**elief, **G**oal, and **A**ction, where only the states of environment and actions are directly observable. And the other components can be accessed only through reasoning.

2.2 Modularity of mind

As for many debates over theory of mind, most psychologists study horizontal processes like memory and information flow. While the perspective of modularity mind was raised, which articulates features not only of speculative cognitive architectures but also of current research in artificial intelligence. Here we will discuss two main branches of mind modularity theory [6].

Modest modularity theory The hypothesis of modest modularity raised by Fodor [1], as we shall call it, has two strands. The first strand of the hypothesis is positive. It says that input systems, such as systems involved in perception and language, are modular. The second strand is negative. It says that central systems, such as systems involved in belief fixation and practical reasoning, are not modular.

While in Fodor's classic introduction to modularity, he lists nine features[1] to better define the modularity. Here the domain specificity is the typical differentiator to the domain-general theory of mind. Some low-level functions including systems for color perception, visual shape analysis, sentence parsing, and so on, seems clear for their domain specificity from Fodor's view. While the high-level systems - inference, planning - involving information integration require more domain-general explanations as Fodor says.

Massive modularity theory The massive modularity assumes that the mind is thoroughly modular. Conspicuously absent from the list is informational encapsulation, the feature most central to modularity in Fodor's account. For this item Richard [5] adjusts that the input systems are modular in a way that requires narrow-scope encapsulation; and that central systems are modular, but only in a way that does not require this feature.

Although there are differences in the definition of central system modularity, the basic functional domains are considered modular. The mind modularity theory gives a hypothesis to successfully support some domain-specific designs in artificial intelligence.

3 Implement the modularity theory on AI

Thoroughly modelling each parts in theory of mind faces some practical problems, however some specific works successfully build a few modularities of mind. A perception-to-behavior architecture in Fig. 2 was developed to support a fully autonomous robot for evaluation [2]. Three layers responsible for perception, cognition and behavior respectively. The bayesian theory of mind approach is implemented for integrating three layers efficiently.

To examine whether it is possible to grow brain-like anatomical modularity, a recent work [3] apply a machine learning method called brain-inspired modular training (BIMT), to a network being trained to solve a set of compositional cognitive tasks. The method BIMT successfully bridges local neural connections via two optimization terms: distance-dependent weight regularization and discrete neuron swapping. Thus the neural modularity as a powerful way for networks to generalize has been shown from this research.

[1]Domain specificity; Mandatory operation; Limited central accessibility; Fast processing; Informational encapsulation; 'Shallow' outputs; Fixed neural architecture; Characteristic and specific breakdown patterns; Characteristic ontogenetic pace and sequencing.

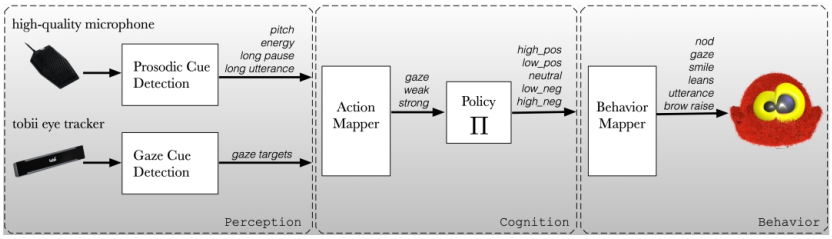

Figure 2: A modular robotic architecture mapping modal information to action decision

4 Debates on modularity of mind

Even with success in modeling computational architecture for mind in AI, there are a number of arguments that disagree with the mind modularity theory. For example, as for the perceptual and linguistic systems, they rarely exhibit the features characteristic of modularity. There appear to be cross-modal effects in perception, which would tell against encapsulation at the level of input systems (e.g., McGurk effect[2]).

Another evidence from functional neuroimaging studies generally suggest that cognitive systems are weakly localized. It is probably implemented in distributed networks of the brain that overlap, rather than discrete and disjoint regions.

In contrast to modular mental structure, some theories posit domain-general processing, in which mental activity is distributed across the brain and can not be decomposed. This theory also receives much supportive evidence from some researches of neural science and cognition.

5 Conclusion

This essay discusses a typical theory of mind: the mind modularity theory, shows its feasibility by reviewing the implementation on AI. However, the success of these deployments of modularity theory is subject to dispute. This theory still needs to be improved from multiple perspectives in different fields.

References

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[2]Subjects watching a video of one phoneme being spoken (e.g., /ga/) dubbed with a sound recording of a different phoneme (/ba/) hear a third, altogether different phoneme (/da/).