Logic and Abstraction as Capabilities of the Mind.

Reconceptualizations of Computational Approaches to the Mind.

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Abstract

Computational approaches to mind are constrained by the view of machines as symbol processors. Language is one of our dominant modes of expression and as a symbolic system it is a natural candidate for use in the reproduction or imitation of the human mind. Within language inheres a bias towards rationality, which is only one of the many integral capabilities of mind. Human beings also possess another fundamental capability that cannot be reduced to symbolic logic manipulation, i.e., abstraction or the capability to recognize schemas or gestalt. Schemas are abstractions of strongly connected elements of cognition that activate based on salient elements of a particular context. Our schemas function in part as auto-completion processors, allowing us to perceive a gestalt. In the paper we will investigate the nature of abstraction in detail, its entwinement with logical thinking, and the general role it plays for the mind. We find that non-logical capabilities are not only important for input processing, e.g., perception, but also for output processing. Human beings jointly use abstraction and logics for thinking and also use analytic and embodied capacities for acting. We will show this interplay on the basis of examples. To this end we will follow the philosophical analyses of Heidegger and Polanyi to elaborate the fundamental difference between abstraction and logics and how they come together in the mind. Each of their approaches facilitates recognition of *contextualized* focal entities that evoke meaning within cognition. If computational approaches to mind are to be successful, they must be able to recognize meaningful and salient elements of a context and engage in abstraction. It must be able to imagine, to volitionally blend abstractions and elements of abstractions in novel ways that allow it to recognize emergent gestalt contexts rather than a series of distinct symbolic elements. And it must be able to discern the validity of these blendings in ways that, in humans, arise from a *sensus communis*.

Extended Abstract.

Traditional approaches to artificial intelligence (AI), which aim at reproducing the capabilities of the mind, adopted symbolic processing model in attempting to reproduce or imitate human intelligence. We recognize this if we look at the logical programming languages that had been used for this purpose, e.g., Prolog or Lisp. Considering how we use language—a symbolic system—to express our intelligence, it seemed reasonable to apply it to computational systems as a way of expressing their intelligence. Language is a dominant mode of sharing our abstractions with one another, and syntax provides a structure for its expression. Our syntactically structured lexicon conforms to a shared logic that enables semantic transformation and understanding. Our preferences toward understanding accord with rationality, derived from the historicity and reinforced by the utility of the applied logic of the scientific method. We have a bias towards a rational mode of thought and rational expression of thought in language. But rational thinking is only one of many elements and capabilities of mind.

Behind such thinking we find the idea that we can simulate the mind in a similar way as we simulate a chess player by computer programs. Doing so, we overlook that the way a chess player and a computer approach chess playing are completely different. The human player employs not only sequential logic and his symbolic processing capabilities, but also other capabilities that are described by a connectionist model of cognition. Rather than work through the numerous logical and sequential permutations of possible moves, the human player will recognize larger (i.e., schematic) patterns among the pieces of the chessboard and make his moves based on experience gained over a lifetime of playing. Human players will “feel” what is the correct move for maintaining an advantage or overcoming a disadvantage, using their intuitive sense derived from schemas based on their long lasting practice.

Human beings (and not only they) possess one fundamental capability that cannot be reduced to symbolic logic manipulation, i.e., abstraction or the capability to develop and employ schemas or recognize gestalt. Whatever elements are missing from the context will be filled in by the schemas humans have developed through the repeated exposure to similar stimulus as part of our lived experience. Schemas are abstractions of strongly connected elements of cognition that activate based on salient elements of a particular context. Part of the way in which our schemas function is as auto-completion processors, allowing us to perceive a gestalt. These capabilities become apparent in human abstraction. Although abstraction can be analyzed in terms of logic, e.g., looking for common features, we cannot reduce it to a formal logical process. Abstraction is fundamentally related to schema theory and gestalt theory.

In the paper we will investigate its nature in detail. Moreover, non-logical capabilities are not only important for input processing, e.g., perception, but also for output processing. In the same way as human beings jointly use abstraction and logics for thinking, they also use analytic and embodied capacities for acting. Thus, they can perform actions according to instructions but also directly based in embodied capacities. Elite athletes are examples of this latter capacity. Their repeated practice of the same bodily movements trains their neural networks to carry out those movements without needing to engage their capacity for logic and rational thinking.

Heidegger and Polanyi have referred to the described difference in their philosophical approaches. We will follow their analyses to elaborate the fundamental difference between abstraction and logics and how they come together in the mind. The interplay can also be explicated on the basis of paradoxes such as the heap paradox where the approaches of schematic processing and symbolic processing conflict with each other. There are already approaches that rely on gestalt theory, however, they are mainly applied in robotics and not incorporated in the philosophy of mind or computational approaches to the mind.

We will show how these fundamental processes of abstraction etc. on the one hand and logical inference on the other work together referring to insights gained from Heidegger and Polanyi such as the distinction of *present-at-hand* and *ready-to-hand*, and *focal* and *subsidiary awareness*, respectively. Each of their philosophical approaches facilitates recognition of context in which the salient element of focus is situated. It is the *contextualized* focal entity that is essential for and evokes meaning within cognition and, hence, understanding in a way that integrates schematic abstract thinking with sequential logic.

The two schemata even work together in mathematics where we also find an extensive use of abstraction (in the sense that we use here). One example is the abstraction of topological structures, expressed by topological axioms, gained from the analysis of real numbers and other analytic structures. It was Frege who pointed at the fact that particularly the usage of symbols opens up new ways of analysing the developing structures, e.g., by gestalt-oriented abstraction.

If computational approaches to mind are to be successful, they must include the ability to recognize the salient elements of a context that are meaningful. Recognition of symbols is insufficient. The successful computational mind must be able to engage in abstraction and meta-abstraction including self-awareness. It must be able to imagine, to volitionally blend abstractions and elements of abstractions in novel ways that allow it to recognize different gestalt contexts rather than a series of distinct symbolic elements. And it must be able to discern the validity of these blendings in ways that, in humans, arise from a *sensus communis*.

We conclude that the mind is an emergent phenomenon that is grounded in the brain and influenced by its functions. Abstraction is an emergent capability of the brain, so that it cannot be reduced to physical functions. The emergent qualities of mind include the qualities of consciousness, as well as the capacities for feeling, imagination and volition as which they become present to the mind as part of the meta-abstraction of self-awareness. We find abstraction and logic as prominent features of the mind that must be considered to move towards a computational comprehension of the human mind.