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Understanding the Complexity of the Mind

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Cognitive science is an interdisciplinary field which aims to understand the mind. Pioneering research over the past 60 years has yielded significant advances in describing the architecture of cognition. However, we suggest that the rate of progress seen in the last century may not be sustainable. While a central feature of natural phenomena is their redundancy, the defining feature of the mind is its complexity. Future research efforts may meet with diminishing returns, as informational redundancy in cognitive processes becomes increasingly difficult to identify.

According to Algorithmic Information Theory (AIT), scientific understanding is furthered by exposing greater levels of redundancy in observational data. The goal of the scientist is to craft a model which can describe a dataset in the most concise terms. These models are called *theories*. The more compression a theory achieves, the greater its value (see Chaitin, 2007, for an overview of AIT). For example, Kepler's heliocentric model of the heavens is considered superior to Ptolemy's geocentric model, because it manages to describe astronomical observations in terms of three simple mathematical laws rather than a convoluted set of epicycles. AIT demonstrates that data compression is the *only* systematic means for generating predictions based on prior observations (Chaitin, 2007). All successful predictive systems are approximations of algorithmic induction. All useful contributions to human knowledge work by coaxing people into modifying their inductive strategies so that they better approximate algorithmic induction.

The efficacy of science can be traced back to its utility in facilitating the development of concise descriptions of the natural world. The scientific method of proposing a hypothesis, gathering observational data and then evaluating the predictive accuracy of the hypothesis provides a powerful means of identifying informational redundancy and hence converging on a succinct description of a phenomenon. Over the past few centuries, this technique has proven so successful that it seems intuitive that it should deliver in any domain to which it is applied. However, AIT does not corroborate this intuition.

Science works best when there are trivial patterns to be identified in a set of data. For example, if the orbits of the planets are monitored over a period of time, then redundancy quickly emerges in the observations. However, in cases where it is impossible to reduce a dataset, then no scientific theory can have any predictive power. Consider for example, a roulette wheel. In this case, the numbers which emerge are random. If one wants to represent the sequence of numbers then one has no option but to describe the full set. Because there is no redundancy, it is not possible to develop an elegant theory which exploits patterns in the data. In other words, it is not possible to *explain* the numbers which emerge from a roulette wheel.

The question now arises: is cognition a phenomenon to which science can be usefully applied? Unlike the roulette wheel, the architecture of the mind is not random. And unlike natural phenomena such as the motion of celestial bodies, it seems unlikely to be trivial. The brain may present a type of phenomenon which algorithmic information theorists refer to as 'deep' (Bennett, 1988): one whose reducibility can never be exhausted by finite computational means. As greater levels of redundancy within a deep object are identified and extracted, the part which is left behind becomes less amenable to simplification. It becomes increasingly difficult to identify further redundancy: greater resources must be expended to make gains, and the theories which emerge have diminishing explanatory value. As a result, no matter how much effort is expended in unraveling the architecture of a deep object, the process of understanding it can never be completed.

Is the mind a deep object? Theoretical findings in mathematics and computer science suggest that a fundamental limitation of knowledge is reached when a system attempts to process itself (e.g. Gödel's incompleteness theorems, Turing's halting problem). Given that a language cannot be strongly semantically self-representational, then it seems unlikely that the language of understanding could be applied to and exhaust itself. In this case, the irreducible complexity of the mind would have to be acknowledged as a form of fundamental axiom, to be assumed rather than explained away.

We speculate that future developments in information theory could place the intractable complexity of the mind at the centre of a new understanding of reality. Rather than being viewed as something external to knowledge, the assumption of this complexity might be recognized as the foundation relative to which all of our understanding is expressed, thereby undermining the meaningfulness of the goal to 'understand' the complexity of the mind.

References

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