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Review

Physics of mind: Experimental confirmations of theoretical predictions

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Abstract

What is common among Newtonian mechanics, statistical physics, thermodynamics, quantum physics, the theory of relativity, astrophysics and the theory of superstrings? All these areas of physics have in common a methodology, which is discussed in the first few lines of the review. Is a physics of the mind possible? Is it possible to describe how a mind adapts in real time to changes in the physical world through a theory based on a few basic laws? From perception and elementary cognition to emotions and abstract ideas allowing high-level cognition and executive functioning, at nearly all levels of study, the mind shows variability and uncertainties. Is it possible to turn psychology and neuroscience into so-called "hard" sciences? This review discusses several established first principles for the description of mind and their mathematical formulations. A mathematical model of mind is derived from these principles. This model includes mechanisms of instincts, emotions, behavior, cognition, concepts, language, intuitions, and imagination. We clarify fundamental notions such as the opposition between the conscious and the unconscious, the knowledge instinct and aesthetic emotions, as well as humans' universal abilities for symbols and meaning. In particular, the review discusses in length evolutionary and cognitive functions of aesthetic emotions and musical emotions. Several theoretical predictions are derived from the model, some of which have been experimentally confirmed. These empirical results are summarized and we introduce new theoretical developments. Several unsolved theoretical problems are proposed, as well as new experimental challenges for future research.

Keywords: Physics of mind; Dynamic logic; Emotions; Cognition; Dual hierarchy; Knowledge instinct; Aesthetic emotions; Psychology; Language; Conscious; Unconscious; Symbols; Beautiful; Musical emotions; Evolution; Meanings of life; Purpose; Learning; Language emotionality; Prosody

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1. What is physics of the mind?

The basic method of physics consists in describing the widest range of reality using as few principles as possible. The first step of developing a physical theory is the identification of fundamental laws and the development of their corresponding mathematical formulations. From these basic elements, the physicist derives a theory to explain a large portion of the Universe without contradicting any known facts. The theory must prove useful in providing unexpected theoretical predictions, which can be verified experimentally. These either confirm or disconfirm the theory.

Until recently, it seemed that it would not be possible to develop a psychology while using the rigorous methods of physics. The mind seemed too vague to be described using the same methods as the other usual objects of physics. This review demonstrates that it is in fact possible to identify few principles that can serve as a foundation for a mathematical theory of mind accounting for a wide range of psychological data. We show that such a theory makes several verifiable predictions, some of which have been experimentally demonstrated. It can serve to explore new areas of research and to explain many psychological facts, which may otherwise be difficult to understand.

This review presents mathematical models of several basic elements of the physics of mind, including perception and cognition, concepts and emotions, instincts and learning. It also clarifies the distinction between conscious and unconscious aspects of mind and provides a clear description of the mental hierarchy, which extends from objects in the physical world to abstract ideas in the mental realm. The physics of mind and its related mathematics are further extended toward the dual hierarchy of interactions between cognition and language, and a significant part of the review is concerned with new development in linguistics regarding emotions of sounds within languages and their cognitive functions. We also touch upon some aspects of high-level cognition, these include data and theory concerning emotions of the beautiful and a controversial idea about the meaning of life. The physics of mind is further extended to explain the importance of emotional prosody in speech, as well as musical emotions, their cognitive functions and the evolution of music from animal cries to contemporary music. The function of music is a topic that Aristotle, Kant, and Darwin [3,16,25] considered to be one of the greatest mysteries in human life, which would have to be explained by future scientists. Our theory explains cognitive functions of music, the enjoyment of sad music as being a fundamental part of cultural evolution. It also provides an account for the emotions of beauty as related not to forms of objects, but to the meaning of life. In this way, it comes closer to the ideas of Aristotle and Kant rather than contemporary aesthetics.

The physics of mind does not contradict existing knowledge, it explains several psychological facts poorly understood previously, and it makes a number of unexpected experimentally verifiable predictions. The review discusses a set of theoretical predictions that has been experimentally confirmed. Among these confirmed predictions count the mechanisms of perception and those of cognition, as well as the roles of consciousness and unconsciousness in the process of cognition. We propose a mathematical model of the mind that overcomes computational complexity and specifies the fundamental interaction between cognition and language in humans. Computational complexity has interfered with attempts in modeling the mind through work in artificial intelligence and machine learning since the 1960s. A mathematical theory overcoming this difficulty is described. This difficulty is related to the Gödelian difficulty in logic. Logical thinking, which used to be considered as the foundation for modern science, cannot in fact be used as a foundation for psychology, and thus a significant part of both theoretical and experimental psychology needs to be reconsidered. The physics of mind models mathematically psychological mechanisms at the functional level. The functional theory has been partly related to neural mechanisms, and some of these relations have been experimentally confirmed. This review discusses several of these predictions, which open vast areas for future research.

2. The fundamental principles of mind

In this section, we introduce the fundamental principles of the mind-brain, which constitute the building blocks of our theory. These initial principles include instincts, concepts, emotions, perception, behavior, cognitive hierarchy, and aesthetic emotions. They are tied together by the principle of the *knowledge instinct* and by a mathematical theory of *dynamic logic*. In the next section, we formulate mathematically each of these elements and their interrelations. We then proceed to demonstrate that they constitute a simple coherent explanation for a wealth of psychological data and to unfold their explanatory power.

Instincts are mechanisms of survival controlling for vital parameters (e.g., temperature, energy, sleep, reproduction). For a wide range of reasons and even though it has served several pioneers in biology (e.g., [25,64]), modern

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