DOI: 10.51217/npsyresearch_2023_03_03_04

Nikolaev D.E.

Heuristics Used in Scientific Descriptions of Interaction: Towards the Psychology of Science

Николаев Д.Е.

Эвристики в научных описаниях взаимодействия: На пути к психологии науки

Research Centre "Analytic", Yekaterinburg, Russia

Scholars in various scientific disciplines often employ similar heuristics, which are mental shortcuts that simplify the cognitive load of decision-making. This study demonstrates that physicists, biologists, and psychologists, describing fundamentally different types of interactions, utilize only four universal heuristics. The first one, Hypotheses-non-fingo, involves rejecting scientific descriptions in favor of mathematical ones. The second heuristic, Direct-interaction, entails interpreting phenomena scientifically and describing interactions within a simple framework where one object or subject directly influences another. The third heuristic, Indirect-interaction, proposes a more complex model of interaction by introducing a hypothetical agent mediating the interaction. These three heuristics assume the existence of an external world independent of the perceiving subject. On the other hand, the fourth heuristic, Mind-construct, assumes that we cannot explore a world beyond our own experiences. It suggests focusing on studying the reality existing in the human mind where the outcome of an interaction is not perceived but rather constructed by a person. Although theories employing indirect interaction heuristics appear to be probably the most influential, providing a comprehensive and exhaustive description of phenomena at this level seems challenging. Understanding how scientific theories are constructed can facilitate interdisciplinary and multi-paradigm research. Additionally, it can provide researchers with guidance when interpreting mathematical models of interaction and developing new scientific concepts.

Key words: psychology of science, heuristics, interaction, natural sciences, social sciences

For citation: Nikolaev, D.E. (2023). Heuristics Used in Scientific Descriptions of Interaction: Towards the Psychology of Science. New Psychological Research, No. 3, 70–89. DOI: 10.51217/npsyresearch_2023_03_03_04

Introduction

Tversky and Kahneman (1974) demonstrated that humans, when faced with uncertainty, rely on specific heuristics – mental shortcuts that simplify the cognitive burden of decision-making. Researchers are no exception to this. When attempting to explain something uncertain, they employ thinking patterns that are such mental shortcuts.

Numerous theories and models in various scientific fields describe interaction or impact. In physics, this can be, for example, the interaction between particles or bodies; in chemistry, it is the interaction between chemical elements; in sociology, it is the interaction between social groups. Biology studies focus on the influence of various factors on populations, psychology examines methods of psychotherapy, anthropology of media explores the interaction between content producers and the audience, and arts and humanities research investigates the impact of arts. These concepts vary significantly in content because different types of interaction have different natures. However, descriptions of interaction may be based on similar schemes and models.

The similarity of interaction models in different sciences (if it indeed exists) is certainly not explained by empirical material, as this material will differ across disciplines. The reason may lie in the fact that researchers choose similar ways to describe heterogeneous phenomena when interpreting mathematical models. Einstein (1949, p. 49) noted that this choice is always subjective: "The prejudice – which has by no means died out in the meantime – consists in the faith that facts by themselves can and should yield scientific knowledge without free conceptual construction. Such a misconception is possible only because one does not easily become aware of the free choice of such concepts, which, through verification and long usage, appear to be immediately connected with the empirical material". He believed that physics constitutes a logical system of thought that is constantly evolving and whose basis cannot be derived solely from experiences but can only be attained through free invention (Einstein, 1936). Feynman (1965) also discussed this idea in his lectures when he drew attention to the variety of interpretational schemes as an amazing characteristic of nature.

The thinking of scientists has become one of the subjects of research of the emerging subdiscipline – psychology of science (Feist, 2011). Numerous studies in this field, as well as within the framework of Science and Technology Studies, demonstrate that science is not an entirely formal, rational activity (O'Doherty et al., 2019; Feist & Gorman, 2013). "Psychological principles are at work with all scientific thought and behavior. Simply put, there is a psychology behind science." (Feist, 2006, p. ix).

The purpose of this article is to study the formal aspects of interaction theories (how the interaction acts according to the theory) disregarding the substantive aspects of the interaction concepts (what is its nature). In other words, the aim is to identify the heuristics employed by researchers when developing conceptual interaction schemes in various scientific disciplines.

The study was conducted in two stages. During the first stage, the objective was to identify heuristics used by scholars when describing a specific type of interaction within a particular scientific field. To ensure a comprehensive analysis, an interaction that had been repeatedly described by numerous scientists over a considerable period of time were chosen. Gravity in physics was selected as such an interaction. During the second stage of the study, the goal was to determine whether the heuristics identified in physics were consistent with those used by researchers in other scientific fields. To achieve this, the theories of evolution in biology and development in psychology were chosen. A total of 47 scientific concepts and theories related to interaction across three branches of science were studied.

From the outset, it was evident that this study had inherent limitations regarding its representativeness. Theories and concepts are constantly evolving and undergoing transformation, with new and original approaches regularly emerging. In certain areas of science, these changes occur so rapidly that scholars note: "Paradigms, wholly new ways of going about things, come along not by the century, but by the decade; sometimes, it almost seems, by the month" (Geertz, 2000, p. 188). Given this dynamic nature, selecting theories for analysis will always involve subjectivity. Nonetheless, I have endeavored to include the most significant theories within the list.

Heuristics in physics

The analysis of the theories and concepts of gravity has led to the identification of four heuristics that have been utilized by scientists since the late 17th century.

The first heuristic may be called Hypotheses-non-fingo (another variant of its name, formulated by Mermin (1989), is Shut-up-and-calculate!). Its appearance is associated with the works of Newton. Despite years of research, Newton was unable to fully comprehend the nature of gravity, leading him to abandon a physical description in favor of a mathematical one. This heuristic involves a fundamental rejection of attempts to explain how interaction acts. Newton (1999, p. 589) wrote: "I have not as yet been able to deduce from phenomena the reason for these properties of gravity, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy… And it is enough that gravity really exists and acts according to the laws that we have set forth and is sufficient to explain all the motions of the heavenly bodies and of our sea". Kline (1980) notices that the critical difference between Newtonian mechanics and the older mechanics was not the introduction of mathematics to describe the behavior of bodies. Mathematics becomes not just an aid to physics in the sense of a convenient, briefer, clearer, and more general language; rather it provided the fundamental concepts. In this case, gravitational force is not the real force in mechanics sense; it is merely a name for a mathematical symbol. Newton (1999, p. 54) expressed this idea when he wrote: "…I use interchangeably and indiscriminately words signifying attraction, impulse, or any sort of propensity toward a center, considering these forces not from a physical but only from a mathematical point of view. Therefore, let the reader beware of thinking that by words of this kind I am anywhere defining a species or mode of action or a physical cause or reason…"

The second heuristic, called Direct-interaction, involves imbuing mathematically described laws with physical meaning. It assumes that two objects directly influence each other without any intermediary involvement. This implies that the interaction model is relatively straightforward and consists solely of two objects interacting with one another. The physical nature of this interaction is described using testable hypotheses – gravity can be explained by the general principles of matter's structure or by certain characteristics of objects. For gravity, direct interaction means action-at-a-distance, where the gravitational force acts instantaneously over a distance between two objects in space. This concept of forces acting at a distance became a defining feature of Newtonianism in the eighteenth century (Henry, 2011). Laplace and Bailly are well-known for their ideas that gravity's action-at-a-distance is a property of matter (Evans, 2002).

The third heuristic, Indirect-interaction, proposes a physical explanation for the interaction by introducing a hypothetical agent. In addition to the two interacting objects, a third element (the interaction carrier) is included in the scientific model. However, this mediating element or its crucial characteristics are often counterintuitive, unobservable, and have not yet been studied by science. They also lack perceptual analogues. As a result, not only does the interaction model become more complex but its mathematical description as well.

Different theories propose different agents for gravitational interaction. Firstly, there is the idea that a special form of matter fills space. It may be corpuscles (Screening theory by Le Sage and theory of Isenkrahe).

Alternative variant – aether (Vortex Theories of Descartes and Huygens), or its modern version – the dark fluid (Zhao & Li, 2010).

Secondly, it is possible that space itself acts as the mediating element due to its possession of special qualities. Einstein explained gravity in his theory of general relativity as the warping of space-time fabric. These ideas have been further developed in various modern theories, with Loop quantum gravity theory being considered one of the most promising (Rovelli & Smolin, 1988; Thiemann, 2007).

Thirdly, an exchange of hypothetical mediating particle (quantum of gravity, graviton) may be responsible for the transmission of gravitation in certain theories, such as String theory (Schmitz, 2019).

The three heuristics considered in this context assume that the corresponding models or theories describe a real fundamental interaction. However, *the fourth heuristic, Mind-construct*, challenges this assumption. It refuses to acknowledge any reality beyond that which is a mental construct formed through an individual's interaction with the surrounding world. Among physicists, such theories have generally been perceived as marginal. Nevertheless, they do exist.

Attempts to unify gravity and three other fundamental interactions have led to the appearance of very specific concepts. They assume that the gravitational interaction (and, moreover, the entire universe) have an informational nature, and the matter and the energy are derivative and manifest themselves as a hologram-like phenomenon. Some theories even go so far as to suggest that this "hologram" can only be created within the observer's perception. Furthermore, it is argued that "there is no reality beyond what can at least be observed" (Thomas, 2015).

These ideas are characteristic of two groups of researchers who embrace the most radical version of the holographic structure of the universe. The first group consists of scientists who follow Bohm and his concept of the Holomovement. The second group comprises physicists who interpret 't Hooft's holographic principle in an extremely broad manner. Wheeler's "it from bit" concept is also widely discussed in this context and implies that "…physics, particularly quantum physics, isn't really about reality, but just our best description of what we observe. There is no "quantum world", just the best description we have of how things will appear to us" (Thomas, 2015).

Philosophers and sociologists of science are actively developing theories within the framework of the Mind-construct heuristic to describe the development of physical knowledge. For example, the concept popularized by Pickering (1999) that elementary particles were "invented" rather than "discovered" has sparked widespread discussion. In his works, Pickering arguing that High Energy Physics, including ideas about the existence of elementary particles that mediate fundamental interactions (bosons), "should be seen as one of the social production of a culturally specific world" (Pickering, 1999).

Through analysis, clear criteria have been identified to determine which heuristic was employed in a particular theory. The absence of scientific meaning in a theory indicates the use of the Hypotheses-non-fingo heuristic. The immediacy of interaction signifies the Direct-interaction heuristic, while mediated interaction characterizes the Indirect-interaction heuristic. Lastly, for the Mind-construct heuristic, it is believed by scholars that the interaction itself and its results can only be studied within the reality created by the mind.

Building upon these criteria, an analysis was conducted on the concepts of interaction (impact) in biology and psychology. This analysis serves two purposes. Firstly, it aimed to validate a correspondence between the heuristics used in significant biological and psychological theories with the heuristics identified in the study of physical models. Secondly, it sought to identify any new heuristics that were not found in physics.

Heuristics in biology

Interaction is as widespread in biology as it is in physics. For example, researchers have been trying to explain the evolutionary process through the influence of certain factors on biological populations. The most developed concepts of evolution include an analysis of the impacts that lead to organism modification ("horizontal changes"), as well as how these changes affect subsequent generations ("vertical changes"). However, many concepts focus solely on one of these two problems.

Obviously, it is more challenging to observe and comprehend changes in evolution and their effects compared to mechanics, for instance. The idea that changes in heritable characteristics of biological populations occur constantly has long competed with the concept of fixed natural types according to a divine plan. For example, Linnaeus "appears to have believed that all animals have come in pairs from divine hands, and that all animal species we observe today have descended from these pairs through an unbroken series of generations. He assumed that none of the natural families that originated in this way has become extinct and that they have never mixed with one another. They have not been perfected, degraded, or modified in any way" (McBirney & Cook, 2009, p. 30). Linnaeus viewed the role of researchers as providing precise terminological descriptions of biological objects and constructing a system of scientific classification. Nevertheless, over time, the evolutionary idea captured people's minds.

The Hypotheses-non-fingo heuristic was utilized in the statistical concept of evolution developed by the Biometric School led by Weldon and Pearson. In heated debates with Mendelians regarding the nature of heredity, organized by the British Association for the Advancement of Science, Welldon (Zoology…, 1904, p. 539) tried to demonstrate the preference (at least temporary) for a mathematical description of inheritance over a biological one: "…until further experiments and more careful descriptions of results were available, it was better to use the purely descriptive statements of Galton and Pearson than to invoke the cumbrous and undemonstrable gametic mechanism on which Mendel's hypothesis rested". The phenomenal success of statistics in various scientific fields, which occurred through their direct involvement, led Biometricians to believe in the possibility of constructing a unified mathematical theory of evolution solely based on statistical laws, disregarding the mechanisms of evolution (Pearson, 1896).

The Direct-interaction heuristic is utilized in the concept of evolution by Geoffroy Saint-Hilaire. His perspective, referred to as "Geoffroyism" by some researchers, can be summarized by a simple framework in which the environment directly influences the heritable characteristics of biological entities. According to Saint-Hilaire, the environment induces organic changes directly during the embryonic stage (Mayr, 1982).

Lamarck also proposed a straightforward solution to the nature of heredity using the Direct-interaction heuristic. His concept suggested that acquired traits could be directly inherited (it is also known as "soft inheritance"). Simultaneously, the environment's influence on organisms is mediated through what corresponds to *the Indirect-interaction heuristic*. The intermediary element in this process is the organism's needs: "Every fairly considerable and permanent alteration in the environment of any race of animals works a real alteration in the needs of that race… Every new need, necessitating new activities for its satisfaction, requires the animal, either to make more frequent use of some of its parts which it previously used less, and thus greatly to develop and enlarge them ; or else to make use of entirely new parts, to which the needs have imperceptibly given birth by efforts of its inner feeling…" (Lamarck, 1963, p. 112)

The Indirect-interaction heuristic is also employed in Darwin's Theory of Pangenesis. This genetic theory (referred to as a "provisional hypothesis" by Darwin) proposes that various traits of an organism have separate and independent corpuscular bases. It was the first comprehensive and internally consistent theory of inheritance (Mayr, 1982). The Germ plasm concept developed by Weismann (1892), which suggests that germ cells contain and transmit heritable information, aligns with this heuristic as well. In Darwin's theory of evolution by natural selection, natural selection acts as a mediating element for the impact of environments on populations. Organisms that are best adapted to their environments have a higher likelihood of survival and reproduction. The Extended evolutionary synthesis adds to the natural selection also developmental processes, operating through developmental bias and niche construction (Laland et al., 2015).

The Indirect-interaction heuristic can be clearly observed in Mendel's (1865) concept of inheritance. He proposed that the essential difference in the development of hybrids could be attributed to a permanent or temporary union of different cell elements. The extended evolutionary synthesis adds inclusive inheritance and emphasizes the role of various mediating agents, including non-genetic physiological and social factors: "Inheritance extends beyond genes to encompass (transgenerational) epigenetic inheritance, physiological inheritance, ecological inheritance, social (behavioural) transmission and cultural inheritance" (Laland et al., 2015).

The Mind-construct heuristic is a characteristic feature of the constructivist approach to human evolution. Constructivist concepts propose that humanity has the ability to independently determine its own path of transformation: "Individuals and societies have enormous flexibility in what they can become, which is largely unconstrained by human biology. This flexibility is reflected in the diversity of behaviors that we observe within and among societies around the world and throughout history. People have almost no instincts and obtain their behaviors through learning and cultural transmission (Wilson, 2009). During the "self-evolution" process, modern technologies make it possible to use both genetic methods, such as modern gene therapy, and non-genetic methods.

Furthermore, Maturana-Romesin and Mpodozis (2000, pp. 301–302) suggest in their theory of evolution through natural drift that even our way of thinking about ourselves and the world can influence evolutionary processes: "In this history the history of living systems on earth, at least with the appearance of us human beings as languaging animals, reflection about living and self consciousness as awareness of self awareness have become part of what happens in the biosphere and, hence, of the flow of the natural phylogenic drift that makes it, the biosphere, moment after moment a continuously changing present. That is, now what we human beings think about ourselves and about the world we live, has become part of the medium in which the systemic history of the biosphere occurs. Both our vision and our blindness counts now in the flow of biological evolution".

No other variants of heuristics were identified when analyzing theories of evolution apart from these four mentioned above.

Heuristics in psychology

In psychology, interaction is used to describe various phenomena – personality development, socialization, communication, motivation for study and work, psychotherapeutic intervention, etc. This research aims to examine the heuristics used in personality development concepts and broader theories that include development models.

The Hypotheses-non-fingo heuristic was utilized by Watson in his methodological behaviorism concept. When discussing what psychology should study, Watson advocated (1913, pp. 163–164) for abandoning the consideration of how the mind acts and instead focusing on behavior: "The time seems to have come when psychology must discard all reference to consciousness; when it need no longer delude itself into thinking that it is making mental states the object of observation. We have become so enmeshed in speculative questions concerning the elements of mind, the nature of conscious content (for example, imageless thought, attitudes, and Bewusseinslage, etc.) that I, as an experimental student, feel that something is wrong with our premises and the types of problems which develop from them. There is no longer any guarantee that we all mean the same thing when we use the terms now current in psychology". He proposed describing psychological impact through the conditioned reflex "stimulus-reaction" scheme, which lacks psychological meaning (environmental reductionism).

The idea of reducing mental phenomena to reflex production was not a find of behaviorists. Researchers from the School of Physiology of the Central Nervous System (Pavlov, Bekhterev, and Sechenov) proposed this approach earlier. To some extent, certain cognitive neuroscientists who attempt to study mental and social phenomena, including interaction, through the examination of neural networks can be considered modern followers of this school (Newman-Norlund et al., 2007; Yang et al., 2022). Although technologically these two approaches differ significantly, both are characterized by biological reductionism.

The Direct-interaction heuristic is used to describe interaction within various approaches such as psychophysics (Fechner, Weber), psychic mechanics by Herbart, the Associationist School, experimental psychology of Wundt, structural psychology of Titchener, Gestalt psychology, and Bandura's social learning theory. In each of these approaches, the impact is described by a simple scheme using concepts that have psychological meaning. Mental changes occur either as a result of the direct impact of some elements of the mind on others, or as a result of the direct impact of external factors. For example, in Herbart's concept, ideas interact directly with each other (attracting or repelling) and thereby form more complex ideas. In psychophysics, external influence on the sense organs directly leads to the formation of subjective sensations.

The Indirect-interaction heuristic. Georgian and Soviet psychologist Uznadze (1966) called "the postulate of directness" as an assumption unconsciously accepted by scholars that consciousness can be directly influenced by the environment or some elements of consciousness itself. In his works, he insisted that such an impact is organized in a more complex manner, with the assistance of an agent that does not completely relate to either the environment or mental structures. He proposed considering activity as a potential candidate for this intermediary role.

Other researchers propose alternative options. In psychoanalysis, elements of the unconscious act as such a mediating factor (first of all, defense mechanisms). In Jung's analytical psychology, elements of the collective unconscious, known as archetypes, serve this role. Vygotsky's cultural and historical psychology identifies cultural means such as language and signs as mediating factors. Tolman's behaviorist-cognitive concept introduces the cognitive map as a mediating factor. Miller, Galanter, and Pribram's concept includes the plan and image as mediators. Various cognitive theories, such as Witkin's field dependence concept and Kirton's Adaptation-Innovation theory, propose cognitive styles as mediating agents. In Existential Psychology, meaning acts as a mediator.

The Mind-construct heuristic was used by Kelly (1992) in Personal construct theory. The basic point of his theory suggests that a person's psychological processes are channeled by how they anticipate events through their interpretations. Kelly draws parallels between everyday human life and the scientific activities of researchers. In both cases, individuals construct hypotheses and then assess their adequacy. Kelly argues that individuals differ from one another in their construction of events. The same heuristic was used in Piaget's theory of cognitive development (Piaget, 1954). In his works he shows how the forms of intellectual activity are constructed at different stages of personality development alongside the construction of the world in one's mind. Bruner (1991) similarly utilized this heuristic in his theory on the narrative construction of reality.

No other variants of heuristics were identified when analyzing theories on personality development apart from these four mentioned above.

Discussion

The results of the study reveal that scholars in various scientific fields, such as physics, biology, and psychology, employ the same heuristics when describing interaction (see tabl.1). The conceptual schemes of interaction remain unchanged, regardless of the nature of the interaction or whether mathematical formalism is used or disregarded in the description. However, each branch of science exhibits distinct characteristics in terms of applying these heuristics.

Table 1. Theories or concepts and used types of heuristics

Theory or concept	***Type of heuristics***
Gravitation concepts and theories in physics	
I. Newton's law of universal gravitation	The Hypotheses-non-fingo heuristic
P.-S. Laplace's concept	The Direct-interaction heuristic
J. Bailly's concept	
Screening theory by G.-L. Le Sage	The Indirect-interaction heuristic
C. Isenkrahe's screening theory	
Vortex Theory of R. Descartes	
Vortex Theory of C. Huygens	
Dark fluid theory of Hongsheng Zhao	
Theory of general relativity of A. Einstein	
Loop quantum gravity theory	
String theory	
Holomovement concept by D. Bohm	The Mind-construct heuristic
J. Wheeler's "it from bit" concept	
A. Pickering's concept of social nature of elementary particles	
Theories and concepts of evolution in biology	
Statistical concept of evolution of Biometric School (R. Weldon and K. Pearson)	The Hypotheses-non-fingo heuristic
Concept of evolution by É. Geoffroy Saint-Hilaire	The Direct-interaction heuristic
Soft inheritance concept of J.-B. Lamarck	
Environmental influence concept by J.-B. Lamarck	The Indirect-interaction heuristic
Germ plasm concept of August Weismann	
Darwin's Theory of Pangenesis	
Darwin's theory of evolution by natural selection	
G. Mendel's inheritance concept	
Extended evolutionary synthesis	

Constructivist concept to human evolution Theory of evolution through the natural drift	The Mind-construct heuristic
Personality development concepts and theories in psychology	
J. Watson's methodological behaviorism School of Physiology of the central nervous system (I. Pavlov, V. Bekhterev, I. Sechenov) Cognitive neuroscience	The Hypotheses-non-fingo heuristic
Psychophysics (G. Fechner, E. Weber) Psychic mechanics by Johann Herbart The Associationist School concept Experimental psychology of W. Wundt Structural psychology of E. Titchener Gestalt psychology, Social learning theory by A. Bandura	The Direct-interaction heuristic
Psychoanalysis C. Jung's analytical psychology L.S. Vygotsky's cultural and historical psychology Activity theory of A. Leont'ev, S. Rubinstein and A. Luria, D.N. Uznadze's psychology of set Behaviorist-cognitive concept of E. Tolman Concept of G. Miller, E. Galanter and K. Pribram Field dependence concept by H. Witkin Adaptation-Innovation theory of M. Kirton	The Indirect-interaction heuristic
G. Kelly's psychology of personal constructs J. Piaget's theory of cognitive development J. Bruner's theory of the narrative construction of reality	The Mind-construct heuristic

For instance, *the Hypotheses-non-fingo heuristic* in the case of Newton's law of universal gravitation takes the form of a dynamic law – an exact equation that enables precise calculations. In more complex scenarios, statistical laws are employed to describe interactions. In biology and psychology, the second alternative prevails. Furthermore, while physical laws can be directly expressed in mathematical language within this heuristic, psychology differs in this regard. The regularities discovered in psychology are often linked not directly to mathematics but rather to physiology or cognitive neuroscience, which are perceived as more natural and exact science disciplines than psychology.

The Direct-interaction heuristic encounters more challenges in physics compared to psychology and biology. This can be attributed to the difficulties involved in scientifically explaining phenomena such as action-at-a-distance. Such problems arise both in theories related to gravity and electromagnetism.

The Indirect-interaction heuristics in physics suggests potentially observable objects as mediating elements. In contrast, unobservable factors play an intermediate role in psychological interactions. Some biological theories also adopt this choice of an unobservable mediator.

The Mind-construct heuristic in physics deals with the mind of an observer who constructs both the interaction between two external objects and its results. In biology and psychology, the situation is different. The concepts we have considered assume that the observer and the object of influence are the same person or the same group of human beings.

In contemporary scientific theories, there is a tendency to employ either the Indirect-interaction or the Mind-construct heuristic. The other two heuristics offer an overly simplistic perspective on interaction and fail to align with current trends. Advanced theories diverge in their selection of a mediating agent or in their explanation of how the human mind constructs the interaction.

Although the theories using the Indirect-interaction heuristic are probably the most influential, a fully comprehensive description of the phenomenon at this level seems difficult. This can be clearly seen in the example of physical theories, describing how gravity acts. When researchers state that the intermediate agent of the interaction between two bodies is either the graviton or the space-time continuum, this is only the first level of description. The second level arises when scholars question how the interaction between a body and the graviton (or between a body and spacetime) occurs. Describing this interaction using Hypotheses-non-fingo or Direct-interaction heuristics is possible, but it simplifies the physical worldview by reducing it to mathematical formalism or an explanation like "this is just a property of matter". The description via the Indirect-interaction heuristic appears to be more appropriate. Consequently, a second-level intermediate element emerges in the interaction scheme. It mediates the interaction between a body and the graviton (or between a body and spacetime). Once again, questions arise regarding how this intermediate element interacts with other objects (the third level of description). This process continues repeatedly, resulting in an infinite recursion where attempting to describe interaction at one level necessitates introducing into the scheme new mediating elements, interaction of which also needs to be described.

Conclusion

In this article, it is shown that in various scientific disciplines such as physics, biology, and psychology, researchers employ common heuristics when describing interactions. The first heuristic, known as Hypotheses-non-fingo, entails the rejection of scientific explanations in favor of mathematical ones. The second heuristic, Direct-interaction, involves the scientific interpretation of phenomena and the description of interactions within a simplistic framework where one entity directly influences another. The third heuristic, Indirect-interaction, presents a more intricate model of interaction by introducing a hypothetical agent that mediates the interaction. These three heuristics presuppose the existence of an external world that is independent of the perceiving subject. Conversely, the fourth heuristic, Mind-construct, posits that our exploration is confined to our own experiential realm and we cannot transcend it to comprehend the external world. It suggests directing our focus towards studying the reality of the human mind where the outcome of interactions is not perceived but rather constructed by individuals. Although theories employing indirect interaction heuristics appear to be probably the most influential, providing a comprehensive and exhaustive description of phenomena at this level seems challenging.

References

Bruner, J. (1991). The Narrative Construction of Reality. *Critical Inquiry, 18*(1), 1–21.

Einstein, A. (1936). Physics and Reality. *Journal of the Franklin Institute, 221*(3), 349–382.

Einstein, A. (1949). Autobiographical Notes. In P.A. Schilpp (Ed.), *Albert Einstein. Philosopher–Scientist* (pp. 1–94). N.Y.: MJF Books.

Evans, J. (2002). Gravity in the Century of Light. Sources, Construction and Reception of Le Sage's Theory of Gravitation. In M. Edwards (Ed.), *Pushing Gravity: New Perspectives on Le Sages Theory of Gravitation* (Chp. 2, pp. 9–40). Montreal: Apeiron.

Feist, G.J. (2006). *The psychology of science and the origins of the scientific mind.* New Haven: Yale University Press.

Feist, G.J. (2011). Psychology of Science as a New Subdiscipline in Psychology. *Current Directions in Psychological Science, 20*(5), 330–334. DOI:10.1177/0963721411418471

Feist, G.J., Gorman, M.E. (Eds.). (2013). *Handbook of the psychology of science.* N.Y.: Springer Publishing.

Feynman, R. (1965). *The character of physical law.* Cambridge, MA: M.I.T. Press.

Geertz, C. (2000). *Available light: Anthropological reflections on philosophical topics.* Princeton, NJ: Princeton University Press.

Henry, J. (2011). Gravity and and De gravitatione: The development of Newton's ideas on action at a distance. *Studies in History and Philosophy of Science, 42*, 11–27. DOI:10.1016/j.shpsa.2010.11.025

Kelly, G. (1992). *The Psychology of Personal Constructs*, *The psychology of personal constructs, Vol. 1. A theory of personality; Vol. 2. Clinical diagnosis and psychotherapy.* London: Taylor & Frances/Routledge.

Kline, M. (1980). *Mathematics. The Loss of Certainty.* New York: Oxford University Press.

Laland, K.N., Uller, T., Feldman, M.W., Sterelny, K., Müller, G.B. (…) Odling-Smee, J. (2015). The extended evolutionary synthesis: its structure, assumptions and predictions. *Proceedings. Biological sciences, 282*(1813), 20151019. DOI:10.1098/rspb.2015.1019

Lamarck, J.B. (1963). *Zoological Philosophy.* N.Y.: Hafner Publishing Company.

Maturana–Romesin, H., & Mpodozis, J. (2000). The origin of species by means of natural drift. *Revista Chilena de Historia Natural, 73*, 261–310. DOI:10.4067/S0716–078X2000000200005

Mayr, E. (1982). *The Growth of Biological Thought: Diversity, Evolution, and Inheritance.* Cambridge, Massachusetts: Harvard University Press.

McBirney, A., & Cook, S. (2009). *The philosophy of zoology before Darwin: a translated and annotated version of the original French text by Edmond Perrier.* Rotterdam: Springer Netherlands.

Mendel, G. (1865). Versuche über Plflanzen–hybriden. *Verhandlungen des naturforschenden Ver–eines in Brünn. IV*, 3–47.

Mermin, N.D. (1989). What's Wrong with this Pillow? *Physics Today, 42*(4), 9. DOI:10.1063/1.2810963

Newman-Norlund, R.D., Noordzij, M.L., Meulenbroek, R.G.J., Bekkering, H. (2007). Exploring the brain basis of joint action: coordination of actions, goals and intentions. *Social neuroscience*, *2*(1), 48–65. DOI:10.1080/17470910701224623

Newton, I. (1999). *The Principia: mathematical principles of natural philosophy / Isaac Newton; a new translation by I. Bernard Cohen and Anne Whitman assisted by Julia Budenz.* Oakland, CA: University of California Press.

O'Doherty, K.C., Osbeck, L.M., Schraube, E., & Yen, J. (2019). *Psychological Studies of Science and Technology.* DOI:10.1007/978–3–030–25308–0

Pearson, K.I. (1896). Contributions to the mathematical theory of evolution. Note on reproductive selection. *Proceedings of the Royal Society of London, 59*, 300–305. DOI:10.1098/rspl.1895.0093

Piaget, J. (1954). *The Construction of Reality in the Child.* New York: Basic Books.

Pickering, A. (1999). *Constructing Quarks: A Sociological History of Particle Physics*. Chicago: University of Chicago Press.

Rovelli, C. & Smolin, L. (1988). Knot theory and quantum gravity. *Physical Review Letters, 61*(10), 1155–1158. DOI:10.1103/PhysRevLett.61.1155

Schmitz, W. (2019). *Particles, Fields and Forces: A Conceptual Guide to Quantum Field Theory and the Standard Model*. Springer (online edn.).

Thiemann, T. (2007). Loop Quantum Gravity: An Inside View. In: I.O. Stamatescu, & E. Seiler (Eds.) *Approaches to Fundamental Physics. Lecture Notes in Physics* (Vol. 721, pp. 185–263). Heidelberg: Springer. DOI:10.1007/978–3–540–71117–9_10

Thomas, R. (2015, December 18). It from bit? Retrieved from https://plus.maths.org/content/it–bit

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*, 1124–1131. DOI:10.1126/science.185.4157.1124

Uznadze, D.N. (1966). *The Psychology of Set*. N.Y.: Consultants Bureau Publ.

Watson, J.B. (1913). Psychology as the Behaviorist Views it. *Psychological Review, 20*, 158–177.

Weismann, A. (1892). *Das Keimplasma: eine Theorie der Vererbung*. Jena: Fischer.

Wilson, D.S. (2009). Evolutionary Social Constructivism: Narrowing (but Not Yet Bridging) the Gap. In J. Schloss, & M. Murray (Eds.), *The Believing Primate: Scientific, Philosophical, and Theological Reflections on the Origin of Religion* (pp. 318–338). Oxford (online edn.). DOI:10.1093/acprof:oso/9780199557028.003.0017

Yang, B., Karigo, T., & Anderson, D.J. (2022). Transformations of neural representations in a social behaviour network. *Nature, 608*, 741–749. DOI:10.1038/s41586–022–05057–6

Zhao, H. & Li, B. (2010). Dark fluid: A unified framework for modified Newtonian dynamics, dark matter, and dark energy. *Astrophysical Journal, 712*(1), 130–141. DOI:10.1088/0004–637X/712/1/130

Zoology at the British Association. (1904). *Nature, 70*, 538–541.

Information about the author

Dmitry E. Nikolaev, ANO "Research Centre "Analytic", Yekaterinburg, Russia; bld. 38a, Lenin Ave., Yekaterinburg, Russia, 620219; *dnpsy2019@gmail.com*

Николаев Д.Е.

Эвристики в научных описаниях взаимодействия: На пути к психологии науки

Исследовательский центр "Аналитик", Екатеринбург, Россия

Исследователи в различных научных дисциплинах часто используют идентичные эвристики, которые представляют собой мысленные сокращения, упрощающие когнитивную нагрузку при принятии решений. Это исследование демонстрирует, что физики, биологи и психологи, описывая принципиально разные типы взаимодействий, используют четыре универсальные эвристики. Первая из них, которая может быть названа «Hypotheses-non-fingo», предполагает отказ от научных описаний в пользу математических. Вторая эвристика, «Прямое взаимодействие», предполагает научную интерпретацию явлений и описывает взаимодействие в рамках простой структуры, в которой один объект или субъект непосредственно влияет на другой. Третья эвристика, «Непрямое взаимодействие», предлагает более сложную модель, предполагающую введение в рассмотрение гипотетического агента, опосредующего взаимодействие. Эти три эвристики предполагают существование внешнего мира, независимого от воспринимающего субъекта. Напротив, четвертая эвристика, «Ментальный конструкт», предполагает, что мы не можем исследовать мир за пределами нашего собственного опыта. Это подразумевает сосредоточение внимания на изучении реальности, существующей в человеческом сознании, когда результат взаимодействия не воспринимается, а скорее конструируется человеком. Хотя теории, использующие эвристику «Непрямое взаимодействие», кажутся в современной науке, вероятно, наиболее влиятельными, предоставление всестороннего и исчерпывающего описания явлений на этом уровне представляется сложной задачей. Понимание того, какими эвристиками пользуются исследователи при построении научных теорий, может облегчить разработку методологии междисциплинарных и мультипарадигмальных исследований. Кроме того, это предоставляет исследователям некоторые ориентиры при интерпретации математических моделей взаимодействия и разработке новых научных концепций.

Ключевые слова: психология науки, эвристики, взаимодействие, естественные науки, социальные науки.

Для цитирования: Николаев, Д.Е. Эвристики в научных описаниях взаимодействия: На пути к психологии науки // Новые психологические исследования. 2023. № 3. С. 70–89. DOI: 10.51217/npsyresearch_2023_03_03_04

Литература

Bruner, J. The Narrative Construction of Reality // Critical Inquiry. 1991. Vol. 18. No. 1. P. 1–21.

Einstein, A. Autobiographical Notes / In P.A. Schilpp (Ed.), Albert Einstein. Philosopher–Scientist. New York: MJF Books, 1949. P. 1–94.

Einstein, A. Physics and Reality // Journal of the Franklin Institute. 1936. Vol. 221. No. 3. P. 349–382.

Evans, J. Gravity in the Century of Light. Sources, Construction and Reception of Le Sage's Theory of Gravitation / In M. Edwards (Ed.), Pushing Gravity: New Perspectives on Le Sages Theory of Gravitation. Montreal: Apeiron, 2002. Chp. 2. P. 9–40.

Feist, G.J. Psychology of Science as a New Subdiscipline in Psychology // Current Directions in Psychological Science. 2011. Vol. 20. No. 5. P. 330–334. DOI:10.1177/0963721411418471

Feist, G.J. The psychology of science and the origins of the scientific mind. New Haven: Yale University Press, 2006.

Feist, G.J., Gorman, M.E. (Eds.). Handbook of the psychology of science. New York: Springer Publishing, 2013.

Feynman, R. The character of physical law. Cambridge, MA: M.I.T. Press, 1965.

Geertz, C. Available light: Anthropological reflections on philosophical topics. Princeton, NJ: Princeton University Press, 2000.

Henry, J. Gravity and and De gravitatione: The development of Newton's ideas on action at a distance // Studies in History and Philosophy of Science. 2011. No. 42. P. 11–27. DOI:10.1016/j.shpsa.2010.11.025

Kelly, G. The Psychology of Personal Constructs, The psychology of personal constructs, Vol. 1. A theory of personality; Vol. 2. Clinical diagnosis and psychotherapy. London: Taylor & Frances/Routledge, 1992.

Kline, M. Mathematics. The Loss of Certainty. New York: Oxford University Press, 1980.

Laland, K.N., Uller, T., Feldman, M.W., et al. The extended evolutionary synthesis: its structure, assumptions and predictions // Proceedings. Biological sciences. 2015. Vol. 282. No. 1813. P. 20151019. DOI:10.1098/rspb.2015.1019

Lamarck, J.B. Zoological Philosophy. New York: Hafner Publishing Company, 1963.

Maturana–Romesin, H., Mpodozis, J. The origin of species by means of natural drift // Revista Chilena de Historia Natural. 2000. No. 73. P. 261–310. DOI:10.4067/S0716–078X2000000200005

Mayr, E. The Growth of Biological Thought: Diversity, Evolution, and Inheritance. Cambridge, Massachusetts: Harvard University Press, 1982.

McBirney, A., Cook, S. The philosophy of zoology before Darwin: a translated and annotated version of the original French text by Edmond Perrier. Rotterdam: Springer Netherlands, 2009.

Mendel, G. Versuche über Plflanzen–hybriden // Verhandlungen des naturforschenden Vereines in Brünn. 1865. Vol. IV. P. 3–47.

Mermin, N.D. What's Wrong with this Pillow? // Physics Today. 1989. Vol. 42. No. 4. P. 9. DOI:10.1063/1.2810963

Newman-Norlund, R.D., Noordzij, M.L., Meulenbroek, R.G. et al. Exploring the brain basis of joint action: coordination of actions, goals and intentions // Social neuroscience. 2007. Vol. 2. No. 1. P. 48–65. DOI:10.1080/17470910701224623

Newton, I. The Principia: mathematical principles of natural philosophy. Isaac Newton; a new translation by I. Bernard Cohen and Anne Whitman assisted by Julia Budenz. Oakland, CA: University of California Press, 1999.

O'Doherty, K.C., Osbeck, L., Schraube, E. et al. Psychological Studies of Science and Technology. 2019. DOI:10.1007/978–3–030–25308–0

Pearson, K.I. Contributions to the mathematical theory of evolution. Note on reproductive selection // Proceedings of the Royal Society of London. 1896. Vol. 59. P. 300–305. DOI:10.1098/rspl.1895.0093

Piaget, J. The Construction of Reality in the Child. New York: Basic Books, 1954.

Pickering, A. Constructing Quarks: A Sociological History of Particle Physics. Chicago: University of Chicago Press, 1999.

Rovelli, C., Smolin, L. Knot theory and quantum gravity // Physical Review Letters. 1988. Vol. 61. No. 10. P. 1155–1158. DOI:10.1103/PhysRevLett.61.1155

Schmitz, W. Particles, Fields and Forces: A Conceptual Guide to Quantum Field Theory and the Standard Model. Springer (online edn.), 2019.

Thiemann, T. Loop Quantum Gravity: An Inside View / In I.O. Stamatescu, E. Seiler (Eds.), Approaches to Fundamental Physics. Lecture Notes in Physics. Heidelberg: Springer, 2007. Vol. 721. P. 185–263. DOI:10.1007/978–3–540–71117–9_10

Thomas, R. It from bit? // Plus. URL: https://plus.maths.org/content/it–bit (дата обращения: 10.07.2023).

Tversky A., Kahneman, D. Judgment under uncertainty: Heuristics and biases // Science. 1974. Vol. 185. P. 1124–1131. DOI:10.1126/science.185.4157.1124

Uznadze, D.N. The Psychology of Set. New York: Consultants Bureau Publ., 1966.

Watson, J.B. Psychology as the Behaviorist Views it // Psychological Review. 1913. Vol. 20. P. 158–177.

Weismann, A. Das Keimplasma: eine Theorie der Vererbung. Jena: Fischer, 1892.

Wilson, D.S. Evolutionary Social Constructivism: Narrowing (but Not Yet Bridging) the Gap / In J. Schloss, M. Murray (Eds.), The Believing Primate: Scientific, Philosophical, and Theological Reflections on the Origin of Religion. Oxford (online edn.), 2009. P. 318–338. DOI:10.1093/acprof:oso/9780199557028.003.0017

Yang, B., Karigo, T., Anderson, D.J. Transformations of neural representations in a social behaviour network // Nature. 2022. Vol. 608. P. 741–749. DOI:10.1038/s41586–022–05057–6

Zhao, H., Li, B. Dark fluid: A unified framework for modified Newtonian dynamics, dark matter, and dark energy // Astrophysical Journal. 2010. Vol. 712. No. 1. P. 130–141. DOI:10.1088/0004–637X/712/1/130

Zoology at the British Association // Nature. 1904. Vol. 70. P. 538–541.

Сведения об авторе

Дмитрий Е. Николаев, АНО Исследовательский центр «Аналитик», Екатеринбург, Россия; 620219, Россия, Екатеринбург, пр. Ленина, 38а; *dnpsy2019@gmail.com*