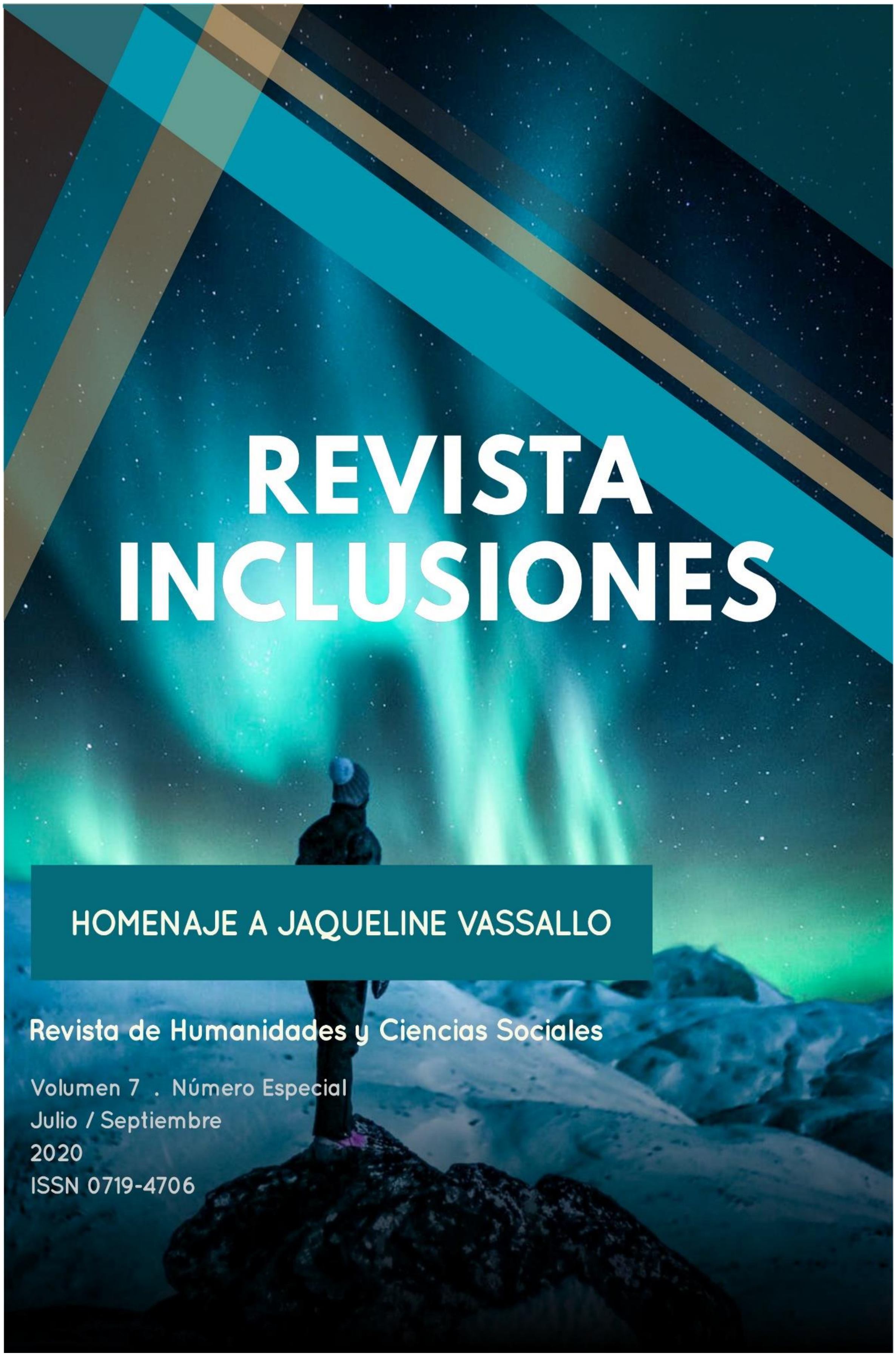

REVISTA INCLUSIONES

HOMENAJE A JAQUELINE VASSALLO

Revista de Humanidades y Ciencias Sociales

Volumen 7 . Número Especial
Julio / Septiembre
2020
ISSN 0719-4706

REVISTA INCLUSIONES
REVISTA DE HUMANIDADES
Y CIENCIAS SOCIALES

CUADERNOS DE SOFÍA
EDITORIAL

REVISTA INCLUSIONES
REVISTA DE HUMANIDADES
Y CIENCIAS SOCIALES

Indización, Repositorios y Bases de Datos Académicas

Revista Inclusiones, se encuentra indizada en:

CATÁLOGO

BIBLIOTECA UNIVERSIDAD DE CONCEPCIÓN

REVISTA INCLUSIONES
REVISTA DE HUMANIDADES Y CIENCIAS SOCIALES

CUADERNOS DE SOFÍA EDITORIAL

ISSN 0719-4706 - Volumen 7 / Número Especial / Julio – Septiembre 2020 pp. 251-259

THE PHILOSOPHICAL FOUNDATIONS OF SCIENTIFIC VISUALIZATION

Dr. Victor Andreevich Kanke
University “MEPhI”, Russia
ORCID ID: 0000-0002-3726-2616
kanke@obninsk.ru
Dr. (C) Nadezhda S. Vinogradova
Moscow State University of Technology, Russia
ORCID ID: 0000-0002-3391-7937
nadivinogradova@gmail.com
Dr. (C) Irina V. Polozhentseva
Moscow State University of Technology, Russia
ORCID ID: 0000-0002-1944-9567
vipperh@yandex.ru
Dr. (C) Vladimir Korotenko
National Academy of Sciences of Kyrgyz Republic, Russia
ORCID ID: 0000-0001-5052-7749
vladk77@gmail.com
Dr. O. A. Togusakov
National Academy of Sciences of Kyrgyz Republic, Russia
ORCID ID: 0000-0003-3091-3911
togusakov@yandex.ru

Fecha de Recepción: 12 de enero 2020 – **Fecha Revisión**: 19 de marzo de 2020
Fecha de Aceptación: 02 de junio de 2020 – **Fecha de Publicación**: 01 de julio de 2020

Abstract

Scientific visualization is analyzed from the perspective of the philosophy of science. In this context, theories by Agustin A. Araya and Viktor A. Kanke are examined. Araya’s scientific visualization theory presents a historical and ontological conception. In his search for the foundations of scientific visualization, based on Edmund Husserl’s phenomenological ideas, Araya stresses the importance of the development of mathematics from Euclidean geometry and its use by G. Galileo in physics to the analytical geometry by R. Descartes further developed in computer graphics. The phenomenon of visualization itself is linked to the status of ontology as a study of reality. To some extent, ontology is supplemented by praxeology which considers the practical aspects of human activity. Kanke examines visualization from the point of conceptual transduction theory. It is characterized by the principles of theoretic representation, the diversity of theoretic representations, the relevance of mature knowledge, and an understanding of knowledge management as a process carried out via the scientific methods. It is found that scientific visualization develops successfully when it accounts for the achievements of not just mathematics and computer science but all modern sciences. The conceptual content of theories and their dynamics are the aspects subjected to visualization. Moreover, the visualization itself exists in organic unity not only with ontology but with other notions of the theory as well.

Keywords

Historical and ontological visualization theory – Theoretic representation principle

Para Citar este Artículo:

Kanke, Victor Andreevich; Vinogradova, Nadezhda S.; Polozhentseva, Irina V.; Korotenko, Vladimir y Togusakov, O. A. The philosophical foundations of scientific visualization. Revista Inclusiones Vol: 7 num Especial (2020): 251-259.

Introduction

Visualization as an area of knowledge dealing with visual information becomes increasingly sophisticated with the development of sciences. It is, therefore, not surprising that its comprehension is associated with significant difficulties[1]. Strictly speaking, visualization is a characteristic feature of all scientific research meaning that its understanding should be based on the generalizations of the achievements of all scientific branches. By definition, such an understanding presents the task of the philosophy of science. The lack of the above-mentioned understanding impedes understanding the various problematic aspects of visualization, of which there are many. In the present article, the philosophical foundations of visualizations are examined through the lens of two scientific conceptions: the historical and ontological visualization theory by Agustin Araya and the conceptual transduction theory by Viktor Kanke.

Methods

A critical comparison of the two theories involves the use of a specific methodology. In this regard, we follow the intertheoretic conceptual transduction theory[2]. It involves the consecutive synthesis of achievements of all branches of science that takes into account both the nature of individual scientific theories and their relationship to each other. If the conception proposed by a researcher to the scientific community corresponds organically to the theory of intertheoretic conceptual transduction, it gets approved. Otherwise, its erroneous foundations that should be attributed to the field of metaphysics rather than the philosophy of science get clarified. The requirement of consecutive synthesis of all scientific achievements appears to be speculative only at first sight. Detailed research allows identifying the philosophers who fit this requirement. In his study, Araya focuses on analytic geometry and phenomenological philosophy. Such an emphasis is quite evidently not enough for understanding visualization as a phenomenon relevant to the entire complex of modern sciences. The theoretical basis of the study is formed by the intertheoretic conceptual transduction theory along with its methods of problematization, discovering new theory, interpreting partially outdated theory, and constructing the lines of related theories. The choice of theory defines the choice of research methods. However, a detailed description of these methods is beyond the scope of the present article since its prime objective is to familiarize the audience with the state of the modern philosophy of science.

Araya's historical and ontological visualization theory

Unfortunately, many authors discussing the philosophical foundations of visualization mainly limit themselves to short remarks that can not be considered consistent and sterling theories. To our knowledge, the only exception to this rule is presented by Araya's study "The Hidden Power of Visualization" issued in the form of an extensive journal article[3], giving Araya the due credit – he managed to give a large philosophical scale relevant for every branch of science to the phenomenon of visualization as a whole.

---

[1] C. R. Johnson, Top Scientific Visualization Research Problems. IEEE Computer Graphics and Visualization Vol: 24 num 4 (2004): 13–17; Ch. Chen, Top 10 Unsolved Information Visualization Problems. IEEE Computer graphics and applications Vol: 25 num 4 (2005): 12–16 y V. Osinska, Informatio et Scientia. Information Science Research Vol: 1 num 1 (2018): 30–39.

[2] V. A. Kanke, Spetsialnaia i obshchaia filosofiia nauki. Entsiklopedicheskii slovar. Moscow: Infra-M. 2018), 227-229.

[3] A. A. Araya, Hidden Side of Visualization. Techné Vol: 7 num 2 (2003): 27–92.

Araya's study comprises three parts. First, he addresses the ideas of authors who, presenting recognized authority in the field of computer visualization, nevertheless avoid substantial philosophical generalizations. The author's desire to account for the achievements of the representatives of computer science is commendable since they have undoubtedly achieved a lot. Araya presents the position of computer science researchers in the form of five principles: 1) the unity between the man and computer, 2) thinking through visualization, 3) the transformation of scientists' thinking, 4) objectification, and 5) naturalism[4]. The principle of objectification involves presenting the phenomenon in a way that would make it visually perceptible, particularly due to its shape, color, and mobility. However, the objectification alone is not enough to represent real phenomena, for it may not correspond to them. The requirement of truthfulness, or the realism of visualization images, presents the content of the naturalism principle.

Seeking a maximal philosophical basis for the above-mentioned principles, on the second stage of his study, Araya refers to the works of German philosopher and phenomenologist Edmund Husserl[5]. Husserl saw the flaw of sciences in the fact that its relation to the world of human life as a totality of sensory given was forgotten. Husserl's program involved not the rejection of science but providing a relevant sensory basis to it. He not only did not deny scientists' thoughtfulness but also tried to present it in an adequate form. He, therefore, paid primary attention to three epochal scientific strategies, namely, Euclidean geometry, Galileo's mathematical physics, and Descartes's analytic geometry. From our viewpoint, Husserl's project did not attract Araya's attention by accident. First, Araya is marked by special attention to geometry that is often correlated with visual images. This provides a reliable entry into the problems of scientific visualization. Second, Husserl's thoughtfulness clearly appeals to Araya. Much like Husserl, Araya strives for philosophical solidity.

The specific characteristic of Euclidean geometry lies in the fact that scientists operate with ideal forms as the ultimate cases of ontological certainties and use the axiomatic method. In the framework of Galilean physics, the world of Euclidean idealizations is combined with the world of material things and empirical dimensions. Mathematics becomes the language of physics. Descartes developed analytical geometry by applying the algebraic methods to geometry. As a result, geometry acquired metric form applicable to any empiric world. Due to first Galileo's and then Decartes's innovations, the visualization of any processes became possible. As noted by Araya, this process multiplies increasingly due to the possibilities of computer technology. Digital incarnation operations allow creating digital bodies and places acting as surfs. "While pixels are individual points on a computer screen, a surf is a collection of pixels on a computer window whose purpose is to realize a geometrical surface representing something"[6]. Thus, according to Araya, the conceptual trend of visualization conditioned by the epoch-making innovations of Euclid, Galileo, and Descartes, culminated in computer visualization. The third stage of Araya's study involves the critical evaluation of the project by Husserl who did not account for the achievements of natural science and technology to a sufficient degree. Araya tries to improve Husserl's phenomenological project by turning to the fundamental ontology of M. Heidegger and the pragmatism of J. Pitt[7].

---

[4] A. A. Araya, Hidden Side of Visualization… 32-33.
[5] E. Husserl, The Crisis of European Sciences and Transcendental Phenomenology: An Introduction to Phenomenological Philosophy (Evanston: Northwestern University Press, 1970), 405.
[6] A. A. Araya, Hidden Side of Visualization… 69.
[7] A. A. Araya, Hidden Side of Visualization… 84-89

Kanke's conceptual transduction theory

The theoretic representation principle

Araya managed to propose an original theory of scientific visualization. We believe, however, that it has some significant flaws. In this regard, it is time to present an alternative to the historical and ontological theory of visualization, namely, the comprehension of the essence of visualization in the light of conceptual transduction theory. Said theory was developed by Kanke in several dozens of books and composed the leitmotif of the encyclopedic dictionary "Special and General Philosophy of Science" that summarized the results of a study of the conceptual structure of all modern branches of science, including computer science[8].

To describe the content of conceptual transduction theory, we should first refer to the theoretic representation principle that implies that everything a person deals with is only given to them via the theories, i.e. systems of concepts they develop. Considering the principle of theoretic representation, it is reasonable to refer to the philosopher Immanuel Kant who concluded that it is not knowledge that should correlate with objects, but rather objects should correspond to knowledge. "Hitherto it has been assumed that all our knowledge must conform to objects. But all attempts to extend our knowledge of objects by establishing something in regard to them *a priori*, by means of concepts, have, on this assumption, ended in failure. We must, therefore, make trial whether we may not have more success in the tasks of metaphysics, if we suppose that objects must conform to our knowledge"[9]. This conclusion was highly appreciated by the physicist Albert Einstein[10]. Similar conclusions were reached by the prominent American philosophers Norwood Hanson and Willard Quine. Hanson noted that "seeing is a 'theory-laden' undertaking"[11]. Quine considered "all objects as theoretical… Even our most primordial objects, bodies, are already theoretical"[12]. Returning to the ideas of Husserl and Araya, we have to note the fallacy of their theory. Contrary to the theoretic representation principle, they ascended from things to theories.

Having the content of the theoretical representation principle determined, we discover the approach to understanding the phenomenon of visualization. Like all the other factors of human activity, visualization is a representation of people's theories. The specific feature of visualization is that the content of a theory is presented in a form comprehensible via the organs of vision or their substitutes. Human nature involves the ability to present the content of theory in multiple ways rather than one.

The principles of the diversity of theoretic representations and the relevance of mature knowledge

The history of the development of science, as well as of humanity as a whole, indicates that the same theory can be presented in various forms. From our viewpoint, the

---

[8] V. A. Kanke, Spetsialnaia i obshchaia filosofiia nauki. Entsiklopedicheskii slovar (Moscow: Infra-M. 2018), 227-229.
[9] I. Kant, Critique of Pure Reason (London: Palgrave/Macmillan, XXXI, 2007), 22.
[10] A. Einstein, "Reply to Criticisms. In: Schilpp, P.A. Albert Einstein, Philosopher-Scientist". The Library of Living Philosophers" Open Court (1949): 665-688.
[11] N. R. Hanson, Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science (Cambrighe: Cambridge University Press, 1958), 252.
[12] W. V. O. Quine, Theories and Things (Cambridge: Harvard University Press, 1981), 20.

essence of the question under consideration is evident enough: the nature of a human endowed with several senses involves them presenting their theories in various forms that complement each other. A holistic cognitive image is not limited to one form of theoretical representation, it is certainly richer than that. The pluralism of theoretic representation forms is a characteristic feature of human cognition. It is essential to understand that all representations of the theory have the same conceptual unity. The theory itself presents this exact unity on the fundamental conceptual level. Without the theory, all cognitive images lose meaning.

There is a variety of known forms of representations of theory, in particular, the linguistic, mental, emotional, object, behavioral, practical, visual, auditory, and tactile forms. Some forms are organically related to a human having certain sensory organs, namely the visual, auditory, olfactory, and tactile organs. The visualization presents a form of theory representation that mainly relies on the capabilities of the organs of vision. However, this circumstance should not be absolutized in assuming, for instance, that the structure of the visual organs has the decisive importance in the matter of visualization. The whole variety of theories can be visualized, but it happens not so much due to the physiological capabilities of human eyes as it does due to the theoretic relativity of human sensory organs.

With all the specific features of various representations of theories, they are all interconnected with each other. In any system, every part gives evidence of the other. A linguistic representation testifies of a visual image, which, in turn, gives evidence of an auditory representation, and so on. Each presentation, however, has a relatively independent meaning. Any attempt to abandon it, the visual image, in particular, leads to the impoverishment of the theory, which is, of course, unacceptable.

In conclusion of the present part of the article, we should note the fundamental difference between Kanke's theory and Araya's conception. In his desire to identify the phenomenon of visualization, Araya moves along the track of formal sciences: Euclidean geometry → the mathematical part of Galileo's physics → Descartes's analytic geometry → computer graphics. Kanke's approach is essentially different. He argues that visualization is an organic part of any scientific theory and the more developed the theory is, the more informative is its visualization. It is erroneous to assume the formal sciences dominate the visualization world. This world implies the comprehensive expression of interdisciplinary relationships. Moreover, ontology should not be opposed to other representations of the theory. Visualization is organically connected not only with the world of objects but also with the mentality of a person, their language and practice.

Conceptual transduction versus ascension to abstractions and idealizations

What is it exactly that should be visualized? This is the key question of the entirety of the scientific visualization theory. Our answer to it is obvious: it is the scientific theory in all its richness. This answer follows directly from the theoretic representation principle. With all its relevance, it implies taking the mechanism of the interrelation of the concepts of the theory into account. If the essence of this mechanism is misunderstood the visualization will ultimately be not successful enough. In Araya's visualization theory the mechanism of theory functioning was expressed insufficiently. Following Husserl's argument, Araya paid primary attention to the ways of producing geometric idealizations. A scientific theory is, therefore, understood as ascension to the idealizations. Following that line of reasoning, many scientists in their attempts to express the essence of scientific theories argue that these theories present a kingdom of abstractions and idealizations. In our opinion, this approach is largely erroneous. Abstractions and idealizations are used in every theory but do not present the essence of scientific theories, expressed by scientists managing the concepts of the theories and the theories themselves using special methods.

According to the theory developed by Kanke, the management of knowledge is performed with the use of the methods of intratheoretic and intertheoretic transduction. The essence of axiological theories, particularly technology, medicine, and economics, are people, the subjects. The essence of natural sciences, for example, physics, chemistry, and biology are the objects, particularly the elementary particles and organisms. In the above-mentioned theories, the essence is understood via the management of principles, laws, and variables in accordance with certain methods. Deduction is a method of transition from the overall principles to the specific laws and variables. Adduction is a method of acquiring facts via observation and experiments. Induction is a method for finding the average values of variables, as well as the laws and principles that are not hypothetical, i.e. deductive, but real. Abduction is a method for updating deductive principles on the verge of a new cycle of intratheoretic knowledge. Following one after another, the cycles of intratheoretic knowledge lead to the development of theories.

Along with managing concepts scientists also manage theories. The cycle of intertheoretic transduction takes place through the use of four methods. The method of problematization ensures identifying the problems (issues) of theories. Discovery allows overcoming the identified problems through the creation of a new theory. A new theory is a key to renewing a partially outdated theory. Thus, the use of the interpretation method allows for an old theory to be updated and appear in science in a new form. Physicists do not completely abandon Newtonian mechanics, biologists do not leave Darwin's theory behind, and economists do not reject Smith's theory. New theories combined with the renewed ones form the lines of related theories, or ligatheories. The examples of this type of theories include the Dirac-Einstein-Maxwell electrodynamics, the Marx-Riccardo-Smith labor cost theory, and the Habermas-Gadamer-Dilthey hermeneutics.

Thus, the visualization should express the tread of scientific knowledge that is methodologically expressed by the following two sequences: intratheoretic transduction – deduction → adduction → induction → abduction; intertheoretic transduction – problematization → discovery → interpretation → the systematization of theories.

Scientific knowledge culminates in ligatheories, each of them combining related theories, for instance, physical, biological, psychological, or sociological, into a single whole. The links existing between the ligatheories are commonly called interdisciplinary. The essence of such links lies in the fact that one ligatheory is considered the main one (the acceptor) and the other is seen as the auxiliary one (the donor). The donor theory is examined not on its own but in the frame of reference of the acceptor theory, i.e. as its symbol. For example, the physics of phenomena is accounted for in biophysics only to the extent it is relevant for the biological process, meaning that physics is examined as a symbol of biology.

Finally, it is time to identify the structure of the formal theories, i.e. the linguistic, logical, mathematical, computer, and philosophical conceptions. Their characteristic feature is that they present the forms of generalizations of the basic, i.e. the natural and axiological, sciences. By identifying their common features, researchers ensure their development and offer them for further use to the representatives of the natural and axiological sciences. The true structure of the formal sciences is only revealed if the researcher is able to both ascend from the natural and axiological theories to the formal concepts and descend back. This condition is often not accounted for by those interpreting the nature of the formal sciences. They are surprised that there are no numbers, points, straight lines, and planes in the real world. There is indeed no number three as such in the real world. However, there are three physical bodies, three hares, three countries. There is a one-to-one correspondence between all these triples of objects and this exact condition represents the number three. There are no points in the world as such, but there are point formations, such as, for example, the centers of mass of mechanical systems in the form they take in classical mechanics. Thus, it ultimately turns out that the formal sciences are no further from reality than the natural and axiological sciences.

Results and Discussion

The article examines two relevant concepts of scientific visualization, one of them developed by Araya and the other by Kanke. Araya presents a historical and ontological conception and seeks an organic connection between the phenomenon of visualization and ontology. Another line of his thought focuses on the formal sciences that are predominantly geometric. The structure of sciences is understood by him mainly as an ascent to idealizations and the consecutive transition to the ontological image of existence. In terms of philosophy, Araya most closely follows the views of the phenomenologist Husserl.

In his development of the conceptual transduction theory, Kanke presented a different theoretical option for understanding scientific visualization. Its base level is composed of three fundamental provisions: the principles of theoretic representation, the diversity of theoretic representations, and the relevance of mature knowledge. All the above-mentioned principles are relevant to interpreting the phenomenon of scientific visualization. The principle of theoretic representation inevitably leads us to the conclusion that scientific visualization is a representation of people's theories. The content of a theory is then presented in a form comprehensible via the visual organs. According to the principle of diversity of theoretic representations, the absolutization of scientific visualization and its separation from other representations of theories is wrongful. Scientific visualization presents an organic part of the system of theoretic representations. Following the principle of the relevance of mature knowledge, the representations of a variety of different developed theories are recognized as the highest forms of visualization. The lack of recognition of this particular circumstance leads to the cultivation of a rather naive view that is insufficient for a thorough understanding of scientific visualization.

Finally, we focus specifically on the subject of visualization. According to our position, primary attention in the course of scientific visualization should be paid to the visual presentation of the methods of the intertheoretic and intratheoretic transduction, i.e. deduction, adduction, induction, abduction, problematization, discovery, interpretation, and systematization.

Conclusion

Scientific visualization occupies a prominent place in modern science but its understanding meets certain difficulties. There is an acute shortage of theories that organically express the conceptual status of scientific visualization. As demonstrated in the present study, this status is shaped by the conceptual transduction theory. With human eyes, a person sees the conceptual content of theories, and no part of it cannot be observed via the operations of visualization. Of course, the value of visualization should not be exaggerated. For all its merits, it is no more than one representation of conceptual transduction. Other representations of it may be the subject of new research articles.

References

Araya, A.A. Hidden Side of Visualization. Techné Vol: 7 num 2 (2003): 27–92.

Chen, Ch. Top 10 Unsolved Information Visualization Problems. IEEE Computer graphics and applications Vol: 25 num 4 (2005): 12–16.

Einstein, A. Reply to Criticisms. In: Schilpp, P.A. Albert Einstein, Philosopher-Scientist. The Library of Living Philosophers. Open Court (1949): 665-688.

Hanson, N.R. Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science. Cambrighe: Cambridge University Press. 1958.

Husserl, E. The Crisis of European Sciences and Transcendental Phenomenology: An Introduction to Phenomenological Philosophy. Evanston: Northwestern University Press. 1970.

Johnson, C.R. Top Scientific Visualization Research Problems. IEEE Computer Graphics and Visualization Vol: 24 num 4 (2004): 13–17.

Kanke, V.A. Spetsialnaia i obshchaia filosofiia nauki. Entsiklopedicheskii slovar. Moscow: Infra-M. 2018.

Kant, I. Critique of Pure Reason. London: Palgrave/Macmillan, XXXI. 2007.

Osinska, V. Informatio et Scientia. Information Science Research Vol: 1 num 1 (2018): 30–39.

Quine, W.V.O. Theories and Things. Cambridge: Harvard University Press. 1981.

CUADERNOS DE SOFÍA
EDITORIAL