

Urszula M. ŻegleńDepartment of Cognitive Science
Nicolaus Copernicus University
e-mail: zeglen@umk.pl
ORCID: 0000-0003-3855-3615**Marcin Koszowy**Laboratory of the New Ethos
Warsaw University of Technology
e-mail: marcin.koszowy@pw.edu.pl
ORCID: 0000-0001-5553-7428

**INTRODUCTION.
SOME NEW APPROACHES
TO KNOWLEDGE REPRESENTATION
IN MULTIDIMENSIONAL PERSPECTIVE:
FROM THEORY THROUGH EXPERIENCE
TO SCIENTIFIC PRACTICE**

Abstract. This special issue offers a multidimensional perspective on the recent inquiries into knowledge representation. Multidimensionality exposes the complexity of knowledge representation and helps distinguish between different approaches and research tools. On the one hand, the presented research focuses on the theoretical and empirical aspects of knowledge representation (taking into account cognitive processes and capacities, including linguistic skills needed to generate and express knowledge); on the other, the articles included in the issue discuss the practical discourse, analyzing actions from the point of view of cognitively oriented semantics and the scientific practice broadly understood. The issue consists of five papers that show how certain ideas in the research area of knowledge representation inspired the authors to look for new approaches to modelling concepts and practical reasoning, constructing theory of signs using the tools of data science, and dealing with cognitive artifacts in scientific practice and its dynamics. What these approaches have in common is their attempt at capturing the multidimensionality of knowledge representation in such a way that integrates them. Our goal is to emphasize some innovative aspects of those approaches with respect to the dynamics of knowledge representation in both the cognitive system and scientific practice.

Keywords: knowledge representation, multidimensionality, dynamics of cognitive systems, scientific practice.

The problem of knowledge representation has grown into a vast literature in epistemology, philosophy of mind, cognitive psychology, cognitive science, cognitive linguistics, computer science, and many other research

fields. This present small collection consists of five papers presenting original approaches to knowledge representation from different angles that go beyond just one single research dimension. The selected papers try to somewhat integrate the dimensions on which they are focusing. Our objective is to demonstrate how certain ideas functioning in this research area inspire their authors to look for new approaches in order to solve newly emerged problems.

We do not intend to discuss the controversy between representationism (which has determined the research in cognitive science since the 1950s.) and anti-representationalism (that started in the 1990s.). None of them is uniform, yet they have many faces. We also do not provide the definitions of knowledge representation. However, we assume that our cognitive system creates knowledge and therefore is able to create concepts, judgments and more complex cognitive structures, to perform reasoning and build theories. From the cognitive point of view, the study of knowledge representation requires just a reference to the cognitive system, which for cognitive neuroscientists is our brain; for philosophers, if it is the brain, then it is conceived in relation to the mind or, more broadly, to the embodied mind. Generally speaking, this means that the sensorimotor processes taking place in our body are constitutive elements of cognitive processes we are concerned with here.

Nevertheless, this is not the only approach to the embodied mind. The stream of embodiment has a number of roots, among which there are James Gibson's ecological psychology (1979), William James' approach to emotion and subjectivity (see e.g. Kühle 2017) or Maurice Merleau-Ponty's phenomenology, but also – when first-person experiences are taken into account – it has its roots in Edmund Husserl's phenomenology and Martin Heidegger's existential phenomenology. This “phenomenological turn” initiated by Francesco Varela, Eleonore Rosch and Evan Thompson (1992) resulted in the naturalization of phenomenology, one of the forms of which is neurophenomenology (see e.g. De Preester 2002; Zahavi 2004; Gallagher 2012; Ataria 2020). The embodied approach, developed in various currents and trends of cognitive science, is extremely abundant and varied. The revision of the classical disembodied approach to the mind, cognition and its tools has led many cognitive scientists and empirically oriented philosophers to abandon classical theories burdened with false metaphysics (see e.g. Varela, Rosch and Thompson 1992; Lakoff and Johnson 1999). The notion of representation has completely changed its meaning, and in the radical theories (as e.g. in van Gelder 1995; Beer 1997; Chemero 2009) it has been rejected.

Moreover, if we considered those issues historically and systematically, we would see a wide variety of approaches to the cognitive system in various trends of epistemology and philosophy of mind. In the embodied approach, the agent itself can be treated as a cognitive system that operates in the world and interacts with its environment. In order to act, the agent must acquire knowledge about the world, be able to store it and use it effectively. In the naturalistic approach, the cognitive system is understood much more broadly, and then the concept of an “agent” includes not only a human entity, but also an animal, a robot or an autonomous computer programme among others. As far as the agent is concerned, we have at our disposal extremely vast literature and numerous innovative research projects in computer science, bioinformatics, communication science, and many other scientific domains related to business, economy or industry. Considering the complexity of the system, we have to deal not only with multi-layered systems, but also with multi-agent ones. Hence, there are many definitions of the concept of an “agent” as well as typologies of the “agent” category. Yet, our focus here is on the human cognitive system. It is a human being who creates knowledge. In some strictly determined approaches, as for example Tim van Gelder’s, where the cognitive system is defined as the set of independent variables which can change in time (van Gelder 1998: 615), the cognitive agent is not itself a system in the aforementioned sense, but rather an object whose properties can form a system (ibidem: 619). Then the cognitive agent instantiates cognitive systems at any given time. This change of system states is essential to emphasize the dynamics of the system. It can even be said that only such a system is able to operate in the world.

Our actions in the world require a prior plan in which we consider various options in our reasoning (see more in: Bratman 1987). Our plans usually take the form of scenarios which depend on our intended goals or the means to achieve them, and thus looking for a job is different than looking for a nice place for summer holidays. In our reasoning we consider various potential choices, made according to our preferences adapted to our needs or desires and real possibilities. Approaching reasoning from the point of view of the rules of logic is not sufficient or even inadequate for accomplishing such complex tasks thus, among other things, an account of practical reasoning is needed. This requires extending the research to pragmatics, taking into account our motivations, goals and expectations as well as different external conditions of our actions.

This collection focuses, on the one hand, on the empirical approach to knowledge representation which explores further cognitive processes and capacities, including linguistic skills needed to generate and express know-

ledge, and on the other hand – on our practical discourse, both in analyses of actions from the point of view of cognitively oriented semantics and from a broadly understood scientific practice. But also in the theoretical perspective an appropriate conceptual framework is sought to take into account many levels of cognitive activity of the agent. In this wide perspective, we intend to refer to scientific practice known from the science and technology studies and to extend the presented approach to the application of new research tools to dynamics of knowledge representation.

Let us first outline some problems of knowledge representation, starting with a very simple assumption, according to which knowledge in objective terms consists of propositions or in the case of cognitizer it consists of beliefs. Those propositions and beliefs, within a traditional semantic approach, are based on concepts. Even if we reject this approach with the assumption of composibility (for propositions), the role of concepts in knowledge representation cannot be ignored. However, the standard semantic approach does not seem to be sufficient for doing full justice to grasping the complexity of concepts. We do not intend to repeat various definitions of concepts or review their already acknowledged theories (see e.g. Hampton 1999; Margolis and Laurence 1997, 2019). We are mainly interested in the cognitive aspect here. We ask the following questions: how concepts are represented in our cognitive system? What kind of processes (or cognitive capacities) underlie concepts, or in other words – lead to their formation? On what mechanisms are the concepts formed? We cannot also ignore the essential (philosophical) questions, such as: What is a concept? What is its nature (or status)? Is it of a mental character – as, for instance, in Jerry Fodor's psychosemantics (1987) – or abstract – as for example in the case of different approaches proposed e.g. by Christopher Peacocke (1992, 2004) and by Edward N. Zalta (2001)? Fodor's psychosemantics was elaborated in the frame of his representational (computational-symbolic) theory of mind. In his modular model of mind (Fodor 1983), concepts are treated like atoms (tokens) which are independent from the cognitive capacities of the individual, or more precisely – of the cognitive system. But how to emphasize the dynamics of the system? How to show multiple relationships among concepts? The atomic approach to concepts comes into conflict with semantic holism which was rejected by Fodor (Fodor and Lepore 1992).

These earlier symbolic approaches have proved insufficient in the light of cognitive neuroscience and neurocognitive linguistics. Unlike in logical semantics, in cognitive science theories of mental (e.g. Fauconnier 1985) or conceptual spaces (e.g. Gärdenfors 2000, 2014) are created for modelling concepts. Peter Gärdenfors in the quoted monography *Conceptual Spaces:*

The Geometry of Thought (2000) presented a significant framework for multidimensional modelling of mental representations through geometrical and topological structures. The overriding methodological goal was to integrate different research approaches. Geometric modelling in the field of cognition has, however, much longer history. It is worth recalling René Thom's research on perceptual geometry, initiated in the 1970s. and continued by his successors. Since the 1990s, the neurogeometrical turn has dated back to the development of neurogeometry (with its neurogeometrical algorithms), which deals with modelling the functional architecture of primary visual areas (see Petitot 2014). Looking from the cognitive perspective of knowledge representation, researchers refer to vector, network or neurofuzzy models which have many interesting applications beyond the traditional understanding of knowledge representation. According to the standard research in cognitive science, there are local conceptual representations in the structure of the brain as it is in modular theories (e.g. Fodor 1983) or distributed in the neural network as it is in connectionist theories (e.g. Churchland and Sejnowski 1992). However, in these standard approaches, the neurodynamics of the brain is not always included there. Therefore, researchers are still looking for a suitable model for the cognitive system. Which model should be adopted for specific purposes in studies of knowledge representations? How should these goals and approaches be integrated? The answers to these questions are still the subject of controversies.

Many of these questions that refer to the representation of concepts are raised by Włodzisław Duch in his opening paper in our collection, entitled "Concept representation and the geometrical model of mind". In today's neurocognitive research at the neural level, concepts are treated as specific neural structures which are activated in cognitive processes. However, the discussion of the location of concepts on the mental level, where certain contents are encoded, is closer to considering them from the epistemological and psychological perspective. In our considerations on knowledge representation we assume that the issue of concepts must be explored on many levels of the cognitive system. Then, the basic neural level must be distinguished from the mental level, related to the signals coming from the outside (i.e. from the body through the sensory channels or in a wider sense – from the external environment of the individual), and on the macro-level – related to the agent's behaviour. This, of course, is very simplified here. Even if we wanted to analyze the concept traditionally and in connection with language as the meaning of a word, its computational model would be based on spreading neural activation in layered networks. We are dealing with internal processes at the neural level and these processes are not

accessible to the agent. Moreover, they are dynamic. Here, cognitive scientists move from the symbolic (Newell and Simon 1976), through connectionist (e.g. Churchland 1989; Churchland and Sejnowski 1992) to the dynamic approach (e.g. Duch 1997; Bartsch 1998; van Gelder and Port 1995; van Gelder 1998). In turn, plasticity and dynamics of the cognitive system – i.e., our brain – are its essential features. From the neuroscience perspective, cognitive processes involving concepts are the results of global bioelectrical activation of the brain (Duch 1997). The brain contains very extensive dynamic networks of connections. Today’s research covers not only fragments of neural structures in the brain, but the entire network, i.e. connectome. This increasingly advanced research also affects studies of concepts. As Włodzisław Duch shows, concepts are fluid, defined by dynamic attractor states oscillating around the distribution of neural activity. His paper allows us to understand mental processes involving concepts by referring to neurodynamics of our brain, and it is illustrated by a geometrical model of mind having an explanatory power. In this multidimensional perspective, the geometrical model combines the symbolic level (important for the computational approach to semantics) with the physical (neuronal) level of implementation. Duch points to Roger Shepard’s pioneering research in the 1950s. on the formulation of psychological laws in appropriate spaces, and even much earlier to Kurt Levin’s ideas in the late 1930s. However, as he emphasizes, there is a difference between the application of geometrical models in cognitive science and in psychology or in linguistics. In today’s advanced research, cognitive scientists with a specific semantic orientation (such as e.g. Gärdenfors 2000; 2014) or with a more linguistic approach (e.g. Lakoff and Johnson 1980; Fauconnier 1985; Fauconnier and Turner 1986; 1998) in different ways apply geometrical ideas to their theories in order to understand cognitive processes and to characterize concepts. The use of neuroimaging tools with the record of cognitive processes involving concepts allows the identification of conceptual structures in the brain and the creation of semantic maps. In this way, the path to knowledge of concept formation, i.e., to answering the question about how the brain creates concepts, is open. This is crucial in the research presented by Włodzisław Duch in his paper in this volume.

A different approach to concepts is proposed by André Włodarczyk in his paper “Concepts and categories: A data science approach to semiotics”. The issue of concepts and categories is analyzed within the framework of his innovative project on semiotics. Drawing on the semiotic tradition, he outlines a project in which he reconciles the approach of dyadic (in the sense of Sausurean “signifier(*signifiant*)/signified(*signifié*)” and triadic (Peircean

“sign-concept-object”) semiotics in a specific tetratic theory of sign: {sign, *semion*} object, *noema*. In terms of this theory, *semion* is a formal concept of sign, while the term *noema*, taken from classical Kantian epistemology, is perceived here as the concept in the mind which contributes to representing ordinary objects. The criterion for this distinction between semiotic and noemic units is a double functional aspect of the sign: *per se* (as it is in formal or linguistic semantics) and *per alia* (in ontology). Włodarczyk provides a multi-layered structure for representation of linguistic meanings’ components, showing the operations between their objects in each of the layers. The multi-layered structure of human language allows him to explain basic cognitive processes of knowledge representation, such as conceptualization and categorization along with their units, concepts and categories. He distinguishes five basic layers of semiotic categories: sounds, syllables, words, phrases, and sentences. As he writes in his introduction, signs are represented by categories and concepts which underlie these categories. This project broadens the field of semiotic research by using the tools of modern information technology and the Author shows their usefulness in testing machine translations. Hence, the research requires an application to machine learning and data science tools to modelling linguistic signs, which Włodarczyk initiated in his earlier project entitled “Computer-aided acquisition of semantic knowledge”, run partly in the Centre for Theoretical and Applied Linguistics at Sorbonne and partly in the National Institute of Japanese Language in Tokyo. In cooperation with H  lene Włodarczyk, he develops his project towards the so-called “conceptual semiotics” treated as a theoretical basis for empirically-driven conceptual linguistics programme. This goal shows that Włodarczyk’s approach is not tailored to sole theoretical insights, but also refers to experiments in neurolinguistics on activating our neural network in linguistic processes. Interestingly, his research is based on the hypothesis that there is a common mental code for the human language, regardless of the cultural and environmental differences in which ethnic languages were formed. Therefore, Włodarczyk’s conclusion points to the existence of presemiotic stages of communicative ability within our brain.

The next paper, “Reasoning with expectations about causal relations” by Peter Gärdenfors, one of the most renowned founders of geometrical modelling in cognitive science, answers the question: “How do our expectations about causal relations influence our reasoning?”. Unlike in the classical logic take, it is argued that instead of following logical rules, the practical reasoning of the agent who has various expectations requires another kind of logic. Interest is directed here towards non-monotonic logic. According

to today's naturalistic approaches, the logical relation of inference is replaced by the causal relation between action and its results. Gärdenfors uses his two-vector model that he elaborated together with Maximo Warglien (2012), in which an action is described as a pattern of forces that drive events, and events are illustrated as interactions between a force vector and a result vector whose variables belong to different domains respectively. The text is illustrated with numerous examples and drawings of vectors' distribution. In more complex actions, e.g. on the social nature, it allows for more vectors with different types of variables. The option of consideration changes from the theoretical analysis in terms of propositional structures to a model one in terms of geometry. Reasoning about causal relations is based on the geometric and topological properties of causes and effects modelled in conceptual spaces. The Author employs the framework of conceptual spaces because according to his view, action spaces can be analyzed in the same way, and this means that they are also treated as a collection of quality dimensions. In conclusion, he emphasizes the central role of mental simulations in our reasoning with expectations, and by citing the argument for planning actions in the animal world, he advocates for the primacy of mental simulations over pure logical reasonings.

The last two papers focus on the role of cognitive aspects of science. In his contribution devoted to "Cognitive artifacts and their virtues in scientific practice", Marcin Miłkowski argues in favour of developing "cognitive metascience" as a novel approach in the study of scientific knowledge. It is argued that the phenomenon of science is constituted by scientific representations labelled "cognitive artifacts". In line with this theoretical point of departure, a wide taxonomy of cognitive artifacts that allows to interpret scientific phenomena in terms of outcomes of cognitive processes has been propounded. As this taxonomy is built upon the functional relationship between the use of a given artifact and the general goal of inquiry, it allows us to justify normative claims about virtues and vices of various cognitive artifacts. The proposed systematic take on cognitive artifacts opens a promising perspective for studying their functionality by employing language technology toolset for studying scientific communication, and specifically for exploring linguistic manifestations of specific features of certain cognitive artifacts, as described by the scientists themselves. To this end, Miłkowski offers a case study that shows how his conceptualization of typical cognitive artifacts allows for identifying their linguistic markers. That opens perspectives for a new research strand that could, among other tasks, allow for grasping (on a linguistic sur-

face) differences between various systems of cognitive artifacts as present in different approaches to science and, treating language processing tools as key devices applicable in developing digital, cognition-driven philosophy of science.

In line with exploring the cognitive aspects of science, Paweł Kawalec and Anna Kawalec in their contribution titled “Knowledge routines, threads and network dynamics” delve into the topic of knowledge generation that is claimed to be basically overlooked in the contemporary discussions in epistemology and philosophy of science devoted to the issues of knowledge. The Authors offer an original account of *investigations* defined as the kind of inquiries aimed at augmenting knowledge which result in contributing to the common knowledge of a community. The proposed alternative to the standard epistemological take of knowledge as a mental state is a proposed system of interrelated notions amongst which the key concepts are those of *routine* (understood as a complex, coordinated and structured set of research activities) and *knowledge thread* (conceived as a common symbolic representation form). The dynamics of threads is shown e.g. by discussing the case of the recent discovery of microRNAs in molecular biology. The notion of routine, along with Kazimierz Twardowski’s discussion of science as a process and science as a product, is employed to propose the model of knowledge in which knowledge as a product constitutes a manifestation of not a sole individual mental state, but the complex result of the whole *routine* constituted by such particular outcomes as publications, skills, tacit knowledge, laboratory notes, data sets or modified equipment design.

The present collection, by combining (i) the geometrical take on cognitive processes, (ii) the semiotic model of cognition, (iii) the discussion of the most recent applications of conceptual spaces in the study of a variety of cognitive phenomena, and (iv) the cognitive view on science that emphasizes the *cognitive metascience* approach based on the idea of cognitive artifacts, and the *knowledge generation* take emphasizing the role of investigations, illustrates the wide range of research performed within the contemporary study of knowledge representation methods and models.

Acknowledgements

The contributions to the present issue have also required a wide Panel of Experts whose help has turned out to be invaluable for developing this volume. We owe special thanks and sincere gratitude to the following scholars for their insightful reviews: William Croft (The University of New Mexico), Hajo Greif (Warsaw University of Technology), Jesper Kallestrup (Uni-

versity of Aberdeen), Piotr Konderak (Marie Curie-Skłodowska University, Lublin), Robert Kublikowski (John Paul II Catholic University of Lublin), Sabine Ploux (French National Centre for Scientific Research), Gerhard Preyer (Goethe-Universität Frankfurt am Main), Giuseppe Primiero (University of Milan), Bartłomiej Skowron (Warsaw University of Technology), Michał Stelmach (Warsaw University of Technology), and Antonio Vassallo (Warsaw University of Technology).

REFERENCES

- Ataria, Y. (2000). *Consciousness in Flesh*. New York: Palgrave Macmillan.
- Bartsch, R. (1998). *Dynamic Conceptual Semantics. A Logico-Philosophical Investigation into Concept Formation and Understanding*. Stanford: Stanford Center for Studies of Language and Information – CSLI Publications.
- Beer, R. (1997). “The dynamics of adaptive behaviour: A research program”. *Robotics and Autonomous Systems*, 20, 257–289.
- Bratman, M.E. (1987). *Intention, Plans, and Practical Reason*. Cambridge Mass.: Harvard University Press.
- Chemero, A. (2009). *Radical Embodied Cognitive Science*. Cambridge Mass.: The MIT Press.
- Churchland, P.S. (1989). *Neurophilosophy. Towards a Unified Science of the Mind/Brain*. Cambridge Mass.: The MIT Press.
- Churchland, P.S. and Sejnowski, T. (1992). *Computational Brain*. Cambridge Mass.: The MIT Press.
- De Preester, H. (2002). “Naturalizing husserlian phenomenology: an introduction”. *Psychoanalytical Perspectives*, 20, 633–647.
- Duch, W. (1997). “Platonic model of mind as an approximation to neurodynamics”. In: Amari, S.I. and Kasabov, N. (eds.), *Brain-Like Computing and Intelligent Information Systems*. Singapore: Springer, 491–512.
- Fauconnier, G. (1985). *Mental Spaces: Aspects of Meaning Construction in Natural Language*. Cambridge Mass./London: The MIT Press/Bradford.
- Fauconnier, G. and Turner M. (1996). “Blending as a conceptual process of grammar”. In: Goldberg, A. (ed.), *Conceptual Structure. Discourse and Language*. Stanford: Centre for the Study of Language and Information – CSLI Publications, 113–130.
- Fauconnier, G. and Turner. M. (1998). “Conceptual integration networks”. *Cognitive Science*, 22(2), 133–187.
- Fodor, J. (1983). *The Modularity of Mind*. Cambridge Mass./London: The MIT Press/Breadford.
- Fodor, J. (1987). *Psychosemantics. The Problem of Meaning in Psychology of Mind*. Cambridge Mass.: The MIT Press.

- Fodor, J. and Lepore, E. (1992). *Holism. A Shopper's Guide*. Oxford: B. Blackwell.
- Gallagher, S. (2012). "Taking stock of phenomenology futures". *The Southern Journal of Philosophy*, 50(2), 304–318.
- Gärdenfors, P. (2000). *Conceptual Spaces. The Geometry of Thought*. Cambridge Mass.: The MIT Press.
- Gärdenfors, P. (2014). *The Geometry of Meaning: Semantic Based on Conceptual Spaces*. Cambridge Mass.: The MIT Press.
- Gärdenfors, P. and Warglien, M. (2012). "Using conceptual spaces to model actions and events". *Journal of Semantics*, 29, 487–519.
- Gibson, J. (1979). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.
- Hampton, J. (1999). "Concepts". In: Wilson, R.A. and Keil, F. (eds.), *The MIT Encyclopaediae of Cognitive Science*. Cambridge Mass./London: The MIT Press/Bredford.
- Kühle, L. (2017). "William James and the embodied mind". *Contemporary Pragmatism*, 14(1), 51–75.
- Lakoff, G. and Johnson, M. (1999). *Philosophy in Flesh: The Embodied Mind and Its Challenge to Western Thought*. Chicago: University of Chicago Press.
- Lewin, K. (1938). *The Conceptual Represetation and the Measurement of Psychological Forces*. Durham NC: Duke University Press.
- Margolis, E. and Laurence, S. (eds.) (1997). *Concepts. Core Readings*. Cambridge Mass.: The MIT Press.
- Margolis, E. and Laurence, S. (eds.), (2019). *The Conceptual Mind, New Direction in the Study of Concepts*. Cambridge Mass.: The MIT Press.
- Newell, A. and Simon, H. (1976). "Computer science as inquiry. Symbols and search". In: Haugeland, J. (ed.), *Mind Design*. Cambridge Mass.: The MIT Press, 35–66.
- Peacocke, Ch. (1992). *A Study of Concepts*. Cambridge Mass.: The MIT Press.
- Peacocke, Ch. (2004). "Concepts, knowledge, reference and structure". *Mind and Language*, 19(1), 85–98.
- Petitot, J. (2014). "Landmarks for neurogeometry". In: Citti, G. and Sarti, A. (eds.), *Neuromathematics of Vision*, Berlin–Heidelberg, Springer, 1–85.
- Shepard, R.N (1957). "Stimulus and response generalisation: A stochastic model relating generalization to distance in psychological space. *Psychometrics*, 22, 325–345.
- van Gelder, T. (1995). "What might cognition be, if not computation?". *The Journal of Philosophy*, 92(7), 345–389.
- van Gelder, T. (1998). "The dynamic hypothesis in cognitive science". *Behavior and Brain Sciences*, 21, 615–665.
- van Gelder, T. And Port, R.F. (1995). "It's about time. An overview of the dynamic approach to cognition." In: van Gelder, T. and Port, R.F. (eds.), *Mind and Motion*, Cambridge Mass.: The MIT Press, 1–43.

- Varela, F., Rosch, E. and Thomson, E. (1992). *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge Mass.: The MIT Press. (Revised Edition 2017).
- Zahavi, D. (2004). “Phenomenology and the project of naturalization”. *Phenomenology and the Cognitive Sciences*, 3, 331–347.
- Zalta, E. N. (2001). “Models of presentation and fregean senses”. *Philosophical Perspectives*, 11, 335–360.