Inroduction to Cognitive Sience

Mária Bednáriková

Edition Cognitive Studies
fftu

Introduction to Cognitive Science

Mária Bednáriková

Edition Cognitive Studies

Peer reviewers

Prof. PhDr. Silvia Gáliková, CSc.,
Doc. Mgr. et Mgr. Andrej Démuth, Ph.D.

The publication of this textbook is part of the project *Innovative Forms of Education in Transforming University Education* (code 26110230028) — preparation of a study program Cognitive Studies, which was supported by the European Union via its European Social Fund and by the Slovak Ministry of Education within the Operating Program Education. The text was prepared in the Centre of Cognitive Studies at the Department of Philosophy, Faculty of Philosophy in Trnava.

fftu

ISBN 978-83-7490-613-5

Contents

Terminological Dictionary

Cognitive Sciences — Interdisciplinary activity dealing with thinking and intelligence and incorporating philosophy, psychology, artificial intelligence, neuroscience, linguistics and anthropology. Most frequently, cognitive sciences explains thinking as a computational process that takes place in mental representations. They are have a neurobiological character. The main implementation area of the CS is in the formation of empirically testable hypotheses that explain the structural and procedural aspects of human cognition.

Interdisciplinary — Interdisciplinary analysis draws on the knowledge of several disciplines, each of which provides a different perspective on the issues under consideration. It requires the integration of knowledge, concepts, instruments and methods of various disciplines, and the final research explanation is more comprehensive and more consistent than the sum of explanations of individual scientific disciplines.

Cognition — the sum of all mental structures and processes of human conduct and cognition (from perception and behavior to speech and thinking), mental knowledge structures.

Intelligence — the ability to process information. Internally segmented, as well as global capacity to act purposefully, to think wisely and to effectively cope with environment. The ability to consciously focus own thinking to new requirements.

Modeling — one of the most widespread methods of cognitive sciences. Models are used as the analogy of mental operations. They are computer models that simulate human performance. A scientific model is required to meet the following three criteria: 1. to map a certain property of the modeled object, 2. to reduce number of different object properties to a set of relevant features, 3. model must be compiled pragmatically, with respect to a certain purpose.

Representation — is characterized by the following characteristics: a) is performed by its representing carrier b) has its content; represents one or more objects, c) exists within established representative relations, d) may be interpreted by someone. The mental representations within CS have the characteristics of computational structures. If the mind / brain have the nature of conventional computer, the bearer of mental representations is structured data. If the mind / brain are connectionist computer, the bearers of mental representations are activation states of connectionist nodes or set of nodes.

Algorithm — An algorithm is a definitively determined set of rules for the implementation of information processing procedures. The result is the transformation of one state of a device (machine, computer) to another state. This final set of operations is formulated in the form of symbolic code. The code is implemented into the device on the basis of its formal sequences and due to its syntactic characteristics. These information processing rules are recursive and therefore may be subsequently applied in an unlimited stream on them.

Introduction

Cognitive sciences are currently one of the most progressively developing scientific currents. Yet, their status of multi–, inter–, or transdiciplinary character is quite unclear. It is not possible to unambiguously determine whether it is a new independent scientific discipline, or rather a set of various scientific disciplines, which are united by a common effort to explain the phenomenon of cognition. The structure of the text of the introduction to cognitive sciences is primarily conditioned by the author's approach to this problem.

There are two basic alternatives explaining the nature of cognitive sciences. They are determined by a recognized measure of mutual penetration of disciplines that examine cognitive processes. If cognitive sciences are understood as a set of more or less cooperative and complementary cognitive theories, which do not go beyond their constituent disciplines, the introduction to cognitive sciences shall be established as a diverse mosaic of explaining cognitive processes. Each chapter in this introduction represents an independent scientific discipline that pursues the problems of cognition by the medium of specific methodological approaches and terminology definitions. Therefore, it gradually explains the understanding and explanation of cognitive processes in philosophy, cognitive psychology, cognitive neuroscience, cognitive anthropology, cognitive linguistics, computer science (the science of artificial intelligence) and evolutionary biology.

Another alternative is to identify and describe a common problem, conceptual and methodological framework of cognitive sciences. It is important to specify its unified context — the reliance on empirical data and empirically testable hypotheses, the use of reductive method of explanation, the recognition of causal role of mental states and the introduction of basic paradigms explaining cognitive processes (computational–representational and connectionist). A common framework of cognitive sciences is also generated by a set of quantitative (e.g.: measurement, experiment, mathematical modeling) and qualitative (e.g.: observation, analysis of case studies, analysis of lesions) methodologies, which are utilized to explore and explain the cognitive processes.

Precisely this method of conceptualizing cognitive science has been chosen in the following text.

1. The Definition of Cognitive Sciences

Keywords: *cognitive sciences, cognition, paradigms, history*

1.1 Cognitive Sciences

Cognitive sciences are an interdisciplinary activity dealing with thinking and intelligence and incorporating philosophy, psychology, computer science, artificial intelligence, neuroscience, linguistics, anthropology and evolutionary biology. Most frequently, cognitive sciences explain thinking as a computational process that takes place in mental representations. They are of neurobiological nature. The main implementation area of the CS is in the forming of empirically testable hypotheses that explain the structural and procedural aspects of human cognition. Cognition is understood as the sum of all mental structures and processes of human conduct and cognition (from perception and behavior to speech and thinking), mental knowledge structures. Intelligence is explained as the ability to process information. It is an internally segmented, as well as global capacity to act purposefully, to think wisely and to effectively cope with environment. It is the ability to consciously focus own thinking to new requirements. Intelligent information systems are able to acquire and process information from the environment in order to implement adaptive actions that increase the ability of the organism to survive and reproduce. The aspects of cognition are environmental perception, learning, reasoning, planning, decision making, problem solving and communication (Wilson, Keil, 1999).

Cognitive sciences currently represent internationally established research field of cognitive processes. In this research, it is possible to distinguish two competing paradigms: Computational — representational (which is from the point of view of the CS development more original) and connectionist (also called for its similarity to the neuronal system of living organisms as paradigm of artificial neural networks). Within these paradigms, the human cognition is construed as based on the biological, social and cultural foundations. Cognitive systems may act as biological systems, machines (artificial intelligence) or any combination thereof, which interact with an external and dynamically developing environment. Physical realizations of cognitive operations are neurochemical processes taking place in the brain of animals examined. Cognitive sciences research is, however, carried out in parallel at the level of functional analysis of cognition. The results of this research are applied in the field of medicine and therapy, education, design, software programs, commercials, etc. (Smelser, Baltes, 2001).

1.2 The History of Cognitive Sciences

An important step towards the paradigm of cognitive science was the work of A. Turing "Calculating Machines and Intelligence" (1950). In this paper, he attempts to explain thinking as a computational process, which is governed by strict rules. The cognitive process thus loses its metaphysical vagueness and becomes accessible to empirical explanation. The fundamental task for Turing is the determination of the formal model (cognitive calculus), which would adequately simulate thought processes.

The article by Kenneth Craik "The nature of explanation" (1943) has been an important contribution, as well. Craik was researching the possibilities of the connection of mental operations and mechanical procedures. He adopted the term of the internal model, which has become one of the key terms of cognitive sciences. Craik described the thinking process in three steps: 1. External

phenomena and processes are transformed into representations that take the form of words, numbers and symbols 2.In the process of thinking, representations are operationalized and transformed by precisely controlled method. 3. Transformed representations result in external outputs (behavior or decision making). The essential is the argument regarding the development of internal cognitive models that allow humans to anticipate the future and act sensibly.

The11th September 1956 is regarded as the date of establishment of cognitive science when The Symposium on information theory took place on the ground of the Michigan Institute of Technology (MIT). A number of key thinkers engaged in cognitive processes in the context of computational paradigms met on this occasion here. Noam Chomsky presented his lecture "Three models of language" (field of theoretical linguistics), Herbert Simon and Allen Newell presented their lecture "Machine Theory Logic" (field of artificial intelligence) and George Miller presented his lecture "Magical number seven plus or minus two" (field of experimental psychology). The common feature of these lectures was the tendency to operationalize various aspects of cognition. In the case of Chomsky's contribution, it was the demonstration of the algorithmic character of natural language grammar, Simon and Newell presented the mechanical logical reasoning and Miller pointed at the relation between the short–term memory and formal algorithmic system.

Cognitive sciences have been constituted here as a multidisciplinary examination of cognitive processes. In the 70s, the aforementioned disciplines were supplemented by philosophy, anthropology and evolutionary biology. From this time, an important role belonged to cognitive neuroscience, which has rapidly developed especially with the onset of new imaging techniques of brain examination (PET, MRI and fMRI). Over time, the emerging scientific discipline has been increasingly institutionalized: few years since the constituent conference (1956) the Cognitive Sciences Centre at Harvard has been founded. It was focused mainly at the study of language and mind. It was led by Jerom Bruner and G. Miller (together with N. Chomsky). In 1979, the Massachusetts Cognitive Science Society was established. Its main activity is the organization of annual conferences (the first one was held in 1979 in La Jolla, California) and publication of the journal Cognitive Science. The society currently has about 1,500 members from different countries.

In the 50s of the twentieth century, as mentioned earlier, there was a significant tendency to set apart cognitive processes from their biological constitution. The effort to understand and explain the cognitive processes did not imply the analysis of their neurobiological substrate. The thinking started to be explained as a system of applications of inference rules (in the form of "if — then") on the set of complex symbols whose structure corresponded to the structure of sentences in natural language. This explication method of thinking was applied to the use of language, making judgments and decision–making processes. The formal similarity with cognitive functions has been particularly important here and this computational model had the characteristics of an abstract mathematical model. The fundamentals of this concept have been laid down in the middle of the 19th century by British mathematician George Boole. In his1854book "The Laws of Thought", he tried to prove that the formal mathematical operations performed on sets correspond to logical operations (expressed by logical expressions "and", "or" and "not") applied to the premises. He introduced the mathematical method of expressing logical rules, which contributed significantly to the development of subsequent computational paradigm. His work was followed mainly by A. Turing who developed the so–called Turing machine, Norbert Weiner who was the founder of cybernetics and by Claude Shannon who formulated the concept of information theory (s. Slavkov 2013). In the 50s of the last century, Newell and Simon have developed the first functioning program for reasoning entitled "Logic Theorist", which was later revised to a wider applicable program "General Program Solver". At the same time, Marvin Minsky and John McCarthy of the MIT established the new field of studying cognition, which has been named "artificial intelligence". They focused their attention at, for example, automatic translations into different languages or the development of programs for playing chess (Bechtel 1999).

In the 80s of the twentieth century, Geoffrey Hinton, David Rumelhart and James McClelland constituted a new cognitive paradigm in their work. So–called artificial neural networks are formed on the principle of the neural network structural proportionality as a substrate of thought processes. These are analogous models that take the form of neuronal structures of the brain. The information in them is processed in parallel and distributive, not sequentially as in the case computational mechanisms.

1.3 Recommended Literature

BECHTEL, W., ABRAHAMSEN, A., GRAHAM, G.: (1999). The Life of Cognitive Science. In: BECHTEL, W. & GRAHAM, G. (Eds.): A *Companion to Cognitive Science.* Blackwell, Malden, MA and Oxford: 1999, pp. 1 — 104.

WILSON, R. A. — KEIL, F. C. (ed.). 1999. *The MIT Encyclopedia of the Cognitive Sciences.* Cambridge, Mass.: The MIT Press, pp. 15 — 36.

SMELSER, N., J., BALTES, P., B.(ed.): *International Encyclopedia of the Social & Behavioral Sciences.* Amsterdam: Elsevier 2002, pp. 2154 — 2158.

GOLDMAN, A., I. (ed.): *Readings in Philosophy And Cognitive Science. London:* The MIT Press 1993, pp. 24 — 52.

2. Basic Characteristics of Cognitive Sciences

Keywords: *science, scientific method, interdisciplinarity, multidisciplinarity, transdisciplinarity*

2.1 The main features of scientific cognition

One of the constitutive characteristics of cognitive sciences is their fixture in the scientific rationality and methodology. The main features of science as a cognitive system include:

- scientific method — an empirical process of discovery and demonstration indispensable to scientific investigation. It predominantly includes observation of phenomena, formulation of hypotheses about the observed phenomenon, a set of experiments to confirm or disprove the hypothesis and formulation of conclusions that confirm, falsify or modify hypothesis. Scientists use the scientific method to search for the cause and effect relationships in nature. They proceed according to the principle of observation — prediction — testing — generalization.
- structure — precisely defined internal links and construction
- language — exact verbal system
- critical thinking — scientific knowledge is subject to constant process of falsification; the formulation of conclusions in the form of laws, which have (in the strict criteria of validity) general application.

Theoretical scientific knowledge is:

- general
- systematic
- explanatory
- predictive
- critical
- objective (fulfills the condition of detection and inter–subjective verifiability)
- exact
- undergoing evolution

Scientific rationality is therefore characterized by its generalized approach, which is not based on individual subjective survival, but inter–subjective repeatable experience. This is a fundamental basis of empirical data, which are further reviewed and explained by accurately defined exact method (frequently utilizing mathematical descriptions). Another feature of scientific rationality is an effort to create a systemic unity. In this sense, one of the first scientists is Aristotle, who developed a classification of knowledge and division of science into theoretical, practical and formal. The scientific explanation has a theoretical–explanatory character. The essence of science is not to describe phenomena, but to explain and therefore substantiate it. Scientific thinking may be described as a thought process that is applied in science and involves cognitive processes of theoretical generalization, experiments preparation, hypotheses testing, data interpretation and scientific discovery. Scientific thinking is constituted on the basis of inductive or deductive operations, on the principles of analogy, abstraction, idealization. It is based on the principle of deterministic world order, the principle of causality. Causality is the relationship between two time simultaneous or successive events, when the first event (the cause) causes a second event (the effect). In the case of a causal relationship, the following applies — if there is one phenomenon, then it produces, brings about or determines the second phenomenon. If a certain phenomenon occurs, the second must (necessarily) occur as well.

Scientific explanation is a certain set of statements, which explain the existence or presence of objects, events or state of affairs.

The most common forms of explanation include causal explanation, deductive — nomological explanation, which means the inclusion of explanandum (the object of explaining) in the general argument, from which it can be derived by a deductive argument (e.g.: "All gases expand when heated." This gas is heated, this gas expands.), and statistical explanation, which means the inclusion of explanandum in the general argument, which is formulated on the principle of induction (e.g.: "Most people who smoke tobacco develop cancer." This person smokes tobacco, this person shall develop cancer.)

A scientific method is generally described by several basic steps:

— Observation and description of a phenomenon or group of phenomena
— Formulation of hypotheses, which explains the found and observed phenomenon on the basis of the principle of causality.
— Validity of hypothesis is tested in a variety of ways, at which the measure of predictive power of the formulated hypothesis is important. Experimental tests are created (especially in the case of natural science) to either confirm a hypothesis (collaboration) or to disprove (falsify) it on the basis of predictions of hypotheses.
— In the last step, repeatedly confirmed hypothesis is introduced into the system of other confirmed assumptions and general laws of scientific theories. A scientific theory is an explanation of a set of related observations or events based on a hypothesis confirmed and repeatedly verified by independent groups of researchers.

This model of scientific research is mainly based on the principle of inductive inference. Induction is the process of deriving general principles from individual facts and cases. It is a line of reasoning that proceeds from empirical premises to empirical findings and conclusions are not directly deductively derivable from these premises. Inductive arguments are therefore a type of extending argument, in which, by the principle of probability, it is possible to derive

more than its premises contain. Premises are the basis of conclusion, but the conclusion does not necessarily follow from them.

2.2 The Problem of Multidisciplinarity, Interdisciplinarity and Transdisciplinarity

The term multidisciplinarity refers to the phenomenon of the accumulation of knowledge from various disciplines, while the objects of their research do not overlap each other and the resulting output of a multidisciplinary research has only additive and not integrative nature. Multidisciplinary only ascertains the multiplicity of disciplines that participate in the study the same subject, while it does not question the nature and quality of relations between them. Specific prospects of scientific disciplines are postulated as complementary, they boundaries are preserved. This approach is a characterized by the cumulativeness and additivity of knowledge within the process of collaborating scientists from different disciplines. Methodological procedures and terminology definitions within the participating disciplines remain clearly distinct, frequently even disjoint. The resulting knowledge is the sum of the individual branches of knowledge. In The Oxford Handbook of Interdisciplinarity (Frodeman (ed.), 2010) multidisciplinary learning is characterized as a juxtapositional, sequential and coordinated.

For example, the process of establishing a single European Union may be explained by sociological, economic, political science or historical explanation. Cognitive processes in living organisms have been the subject of research of various scientific disciplines (e.g.: philosophy, psychology, linguistics and neuroscience) even before the emergence of cognitive science, but this cognition was only of multidisciplinary nature. Indeed, there was no unifying conceptual and methodological framework (common paradigm) for creating theories of cognition.

An interdisciplinary approach is a synthesis of two or more disciplines that result in establishment of a new scientific discourse, while the knowledge that results from it has an integrative character. For example, Galileo's method of applying mathematics to scientific explanation amounted to the establishment of a new interdisciplinary platform for the scientific objectivity and exactness. Another example would be the implementation of various mathematical models into the explanation of social and economic sciences (game theory, chaos theory, etc.) or the application of knowledge of nuclear physics in the medical diagnostics. An interdisciplinary approach often results in a new scientific discipline (e.g.: the case of cognitive science, biochemistry, biotechnology, ecophilosophy, etc.). While in the case of multidisciplinary research a person works as with the different explanatory and conceptual frameworks; in the case of an interdisciplinary approach a person moves on their borders, while the boundaries of these different frameworks dissolve, they are not clearly definable. The result is an integration and synthesis of previously separated scientific currents, including the unification of methodologies. Multidisciplinary approach is characterized by an external coherence (motivated by the external environment in favor of greater complexity of knowledge); interdisciplinarity is associated with an internal coherence (motivated by the internal common goal of representing a deeper level of analysis and detection of new efficient causes of studied phenomena). The result of interdisciplinary approach is a more than just the sum of its parts.

Transdisciplinary approach allows the creation of holistic schemes that prioritize explanation in the terms of complex systems prior to their individual parts. Scientists collaborate on joint research using the same epistemological, conceptual and methodological framework. Transdisciplinarity is a seamless transition through various scientific disciplines in order to achieve an integrated, assimilated or unified explanation of the phenomenon. An example of such an approach may be various philosophical theories (e.g.: structuralism, discourse theory).

In order to illustrate analyzed approaches graphically, multidisciplinary would be represented as two mutually disjoint circles, interdisciplinarity as two partially overlapping circles and transdisciplinarity as the third circle that unites two partially overlapping circles.

P. Thagard (Frodeman (ed.), 2010, p. 236) describes the relationships between the various disciplines of cognitive sciences in the form of hexagons, in which all vertices are connected to each other. Individual links do not represent the same level of interdisciplinarity: strong ties are mainly between philosophy, psychology and linguistics, also between psychology, artificial intelligence, neuroscience, and anthropology (applies to other sequences as well). Weak type of interdisciplinarity is between philosophy, anthropology, artificial intelligence and neuroscience. At present, however, the link between philosophy on the one hand and artificial intelligence and neuroscience on the other hand is becoming more dominant.

According to the interpretation of the level of interconnection of cognitive science disciplines (philosophy, psychology, linguistics, artificial intelligence, neuroscience, and anthropology), it is necessary to distinguish between denominations "cognitive studies", "cognitive sciences" and "cognitive science". Degree of interdisciplinary link is lowest in the case of cognitive studies (interdisciplinarity is a based primarily on the existence of common problems) and highest in the case of cognitive science (sometimes overlapping with the transdisciplinarity).

2.3 Recommended Literature

HOLYOAKK, J., MORRISONR, G. (eds.): *The Cambridge Handbook of Thinking and Reasoning*. New York: Cambridge University Press 2005, pp. 705–725.

FRODEMAN, R.: *The Oxford Handbook of Interdisciplinarity.* Oxford: Oxford University Press 2010, pp. 234–245.

CARNAP, R.: Filozofia a logická syntax. In: *Antológia z diel filozofov IX. Logický empirizmus a filozofia prírodných vied.* Bratislava: Vydavateľstvo politickej literatúry 1968, pp. 265–277.

RUSSELL, B.: Our Knowledge of the External World As A Field for Scientific Method. In: *Philosophy.* Chicago and London: The Open Court Publishing Company 1915.

3. Cognitive Turnover and its Characteristics

Keywords: behavioral approaches, introspective approaches, modularity, genetic epistemology

3.1 Cognitive Turnover

In the time of the formation of cognitive sciences (beginning of the second half of the 20th century), the behavioral interpretation of cognitive processes prevailed in psychology. This approach limited its attention only to inputs (stimuli) and outputs (responses) of the body, while the whole process of the internal processing of information was kept aside. Mental states and processes in this interpretation are referred to as directly and scientifically unobservable and therefore unknowable. They have become a "black box" phenomenon. By pointing out the inability of language to explain the relationships of stimuli and responses, N. Chomsky has been prompted to a paradigm change in the explanation of cognitive abilities. This turnover is termed as "cognitive revolution" and is characterized by several features:

1. It recognizes the real existence of mental states and processes.
2. The result of this postulate is not the dualistic version of the relationship of mind and body. The possibility of solving the eternal philosophical problem of coexistence of mental and physical man is in the understanding of a man as a certain system for processing information, which resembles a computing device. It is possible to distinguish following two levels — software and

hardware. The software level is based on a certain type of code, on a sequence of information with a computational character. It is therefore an algorithm. The hardware level is the material base, which implements an algorithm — a set of rules to perform certain operations. The problem of the relationship of mental and physical in the cognitive research is conceptualized on the basis of the above computer metaphors.
3. In the context of the works of A. Turing dealing with computational mechanisms, cognitive processes are understood as internal algorithms that operate with mental representations. Intelligent behavior is explained by specific manipulations of perfectly structured symbols. Mental states are thus seen as information states. Information processing algorithm represents a set of well–defined operations with a set of mental representations. This method of explaining cognitive processes is called representational — computational.
4. The decisive criterion for assessing the adequacy of the cognitive science theory is the criterion of psychological plausibility. Theory must explain the observable properties of the cognitive system; it must correspond to psychological reality. Equally important is the area of neurophysiological findings. A hypothesis in cognitive research must therefore be potentially empirically falsified by observable psychological and neurophysiological facts.

Cognitive turnover or cognitive revolution was therefore a transition from the description of cognitive abilities to their explanation. Chomsky's theory of generative grammar meant a transition from the system description of language to the cognitive science explaining that meets all of the above features (Chomsky, 1986). Mental states are explained on the basis of their functional organization as the cause of certain effects.

3.2 Causal Role of Mental Status in the Philosophical Analysis of David M. Armstrong

Armstrong developed the method of causal analysis of mental concepts. It is a special type of mental concept analysis. The author defines these as certain reasons, as something that produces a certain effect. A classic example of this concept is the concept of poison. A poison is always specified by a certain sum of its effects. Generally these effects include death, or damage to the body, but it would be an over–generalization to attribute only lethal effects to a poison. However, for the detection of a poison, it is essential to examine the consequences of its effects, and in this way to work towards the identification of a poison. Therefore, a poison is defined as something that causes, for example, heart palpitations, blurred vision, after–taste in the mouth, etc. Armstrong seeks a similar method to define mental states. As the effects of such conditions, he indicates a certain mode of behavior of a person who is in the examined mental state. For example, if a person screams, this is due to the mental state, namely fear or anger. As the cause of this condition, it is possible, for example, to determine the presence of a violent person or the destruction of some valued thing. Therefore, Armstrong sees the primary cause of mental states in the objects and events situated in the environment, with which a person comes into contact. It is a simple scheme of the cause and effect, due which it is possible meaningfully grasp previously vague concepts of different mental states. The area of human experience in here becomes only a kind of "transfer station" from the effect to the cause, while — and this is important — both are purely material terms (in terms of the concepts that are used by physical sciences). The following results from the aforementioned: if the cause of a purely mental concept is material (the impact of an event, object, environment) and the effect takes place within the purview of the material world (a certain form of behavior, actions, activities), why would something that stands in the background (or rather, inside) should be something immaterial?

Here, again, we would get into similar problems as Descartes faced in his concept of two types of substances — material and immaterial. Therefore, within the presented scheme of the cause and effect, the claim that mental states are ongoing neuronal processes in the brain does not sound as contradictory at all. The whole sphere of conscious experience is a part of a causally ordered material world, which does not acquire any specific immaterial properties, even in the case of a human brain. If it is possible to describe the input and output in the terms of physical science, why should the term "happiness" include any non–physical aspects?

In the case of concepts, the effect of which is an extremely diverse range of behavior and actions, it is necessary to apply more sophisticated and comprehensive causal analysis. On such notion is the concept of introspective awareness and mental imagination. "To have the mental imagery is a type of mental state, which cannot be explained *directly* by causal concepts, but only by the conformation to the corresponding sensations, which *can* be explained in the terms of their causal roles." (Armstrong 1991, p. 84) Therefore, if this method is being fallowed in causal analysis of mental status introspective awareness, this state may be likened to the "perception" of own mental states. Causal analysis of the mental state of "perception" is already, according to Armstrong, easier, so consequently it is possible to explain this concept within the specification of its causal role.

The objective of causal analysis of mental states is to conclusively demonstrate that the theory of neurochemical nature of mental states may not be contradictory. The basic effort here is to demonstrate the possibility of defining the concepts of mental states on the basis of their causal role, and then the possibility of physical explanations would not sound problematic at all. "I admit that my analysis of mental concepts was acquired, because it allowed such identification, but in the formulation of theories, a similar approach is normal and absolutely legitimate." (Armstrong 1991, p. 80)

The author seeks to highlight the possibility of the existence of another type of narrative theory, which, in the accordance with the principle of Occam's razor, incorporates mental states into purely physical image of the world and identifies them with brain conditions. The subjective nature of experience is given a certain type of causal role, certain ways of human behavior, of which it is a cause. The mind acts like an array of causes. Every mental state is characterized as functional, while this function is specified by its causative effect on the behavior of organism. The center of the causal action is the central nervous system, therefore no philosophical problem of the mind — body relationship exists; similarly, there does is not a problem of the relation between bus and it's motor. The only peculiarity of brain matter is its unique and extremely complex grouping. Perception of colors, sounds, feelings, joy, anxiety, art and poetry does not mean constitution of some unknown objects "sui generis". It is only a different way of perception. "The difference lays not in what is identified, but how it is identified." (Van Gulick 1995, p. 30)

3.3 Chalmers' Concept of Naturalistic Dualism

In his concept of naturalistic dualism, Chalmers comes from the assumption of irreducibility of experience to neurobiological processes. He postulates the existence of two domains — physical and mental. These are arranged hierarchically in a specific way. The conscious experience emerges namely from physical processes. There are two types of laws — those that apply to the material world and those that determine the process of experience formation as an independent fundament from the substrate material. But how to define the mental sphere? Is it necessary to proceed in the same way as physics does in the postulation of matter? In order for material and experience to be equivalent fundamentals, it is necessary a precise language is required, which shall be used to discuss the experience and the methods, by which the experience shall be reviewed. Again we come to the problem, which Thomas Nagel saw in the impossibility of articulating an experience as a subjective quality using the objectivist methods of natural sciences, which works mainly by the principle of the quantification of phenomena.

Chalmers, however, does not intend to postulate dualism in the terms of two completely different substances. The theory explaining the emergence mechanism of experience of physical processes must contain a framework of a physical theory. In fact, an experience is not separable from neurobiological principles occurring in human brains. Similarly, it is not a kind of epiphenomenal phenomenon, emerging as a result of these random processes. An experience is deliberately "produced" by a system of neuronal maps. Similarly, as some structures in the human brain, which humans have "shared" with other animals, have their roots in millions of years of evolutionary development, an experience has its root in the physical brain substrate (here arises an interesting question concerning the possibility of experience gradually gaining independence from the substrate due to many centuries of continued evolution). But how may we consider the mass, electric charge and space–time, on the one hand, and experience, on the other hand, as irreducible fundamentals, if there is only one method of their evidence, which has the same form for the description of physical laws, as well as for the explanation of phenomenal qualities of experiencing subject? In that case, there must be some common properties in these fundamentals, by which it is possible to satisfactorily explain them within a single system.

Therefore, there is no dualism in the classic sense of the word in Chalmers' concept. The central goal of non–reductive theory is the identification of physiological processes, from which an experience arises and the description of the emergence mechanism. "Non–reductive theory must contain several *psychophysical principles* that combine the characteristics of physical processes with those of experience. Ultimately, these principles should indicate what types of physical systems are associated with experience ... what kind of physical properties is necessary for the emergence of experience and what kind of experience may be expected in a given physical system."(Chalmers 1995, p. 212).

3.4 Recommended Literature

ARMSTRONG, D., M..: *The Causal Theory of Mind*. In: Rosenthal, D. (ed.): The Nature of Mind. Oxford: Oxford University Press 1991.

CHALMERS, D. J.: Moving Forward on the Problem of Consciousness. In: SHEAR, J. (ed.): *Explaining Consciousness — The „Hard Problem*". London: The MIT Press 1996, pp.200–219.

VAN GULICK, R.: What Would Count as Explaining Consciousness? In: Metzinger, T. (ed.): *Conscious Experience*. Schöningh: Imprint Academic 1995, pp.61–79.

THAGARD, P.: Úvod do kognitivní vědy. Mysl a myšlení. Praha: Portál 2001, pp. 7–38.

4. Reductive Method in Cognitive Sciences

Keywords: *unification, reduction, reductive explanation, elimination*

4.1 Reductive Method

The scientific examination of cognitive processes is characterized by its interdisciplinary nature. The essence of interdisciplinary approach is in the utilization of reductive method that allows reconceptualization of explanatory diverse frameworks aimed at the development of new methods of explaining the investigated phenomenon and the development of a unified set of scientific methods. Roots of reductive methods can be found in seventeenth–century mechanistic science, which provided one of the fundamental requirements of scientific explanation. Objects that are observed in the natural world must be explained by the particles they are composed of. This postulate explains that larger entities are adequately explained by reducing to the particles they are composed of. The explanation concerns the behavior of the particles and the relationships among them. This interpretation of scientific explanation is called reductionism.

Reductive explanations are based on the assumption of the natural hierarchy of the observed phenomena, which is reflected in the organization of scientific knowledge. Therefore, it is possible to distinguish many scientific disciplines that are hierarchically well organized — from psychological and social sciences to particle physics. Each of these "degrees" of scientific explanation has its own vocabulary, a set of explanatory principles and methods of examination, which together constitute a kind of separate ontology in the given field. Some scientists are considering the possibility of creating so–called theory of everything that would work with a minimum of explanatory principles (fundamental laws) and explained the maximum of observable phenomena. In the 14th century, W. Ockham formulated the principle of reductive explanation, which is known as "Occam's razor". According to this principle of economical explanation, entities should not multiply, unless it is necessary (entia non sunt multiplicanda sine necessitate).

In principle, the reductive explanation is based on the determination of a certain type of relationship between various entities. In the context of reductive explaining, it is possible to distinguish two main problems in the definition of the following relationship: (1) between which types of entities can be reductive relationship indicated, (2) what is the nature of the reductive relationship.

The reductive explanation may either involve an event, phenomena, properties, objects (ontological reduction), or theories, concepts, models, diagrams (epistemological reduction). In addition to this breakdown, the different levels of scientific reduction may be distinguished: (1) reductions within one level (including intertheoretic single–level reductions), (2) abstract inter–level reductions (explanation of the properties of higher levels by the characteristics of the lower level), (3) spatial inter–level or strong reductions (scientific explanation is focused at the description of the elementary physical particles behavior).

J. Searle (2007) distinguishes between several types of reducers: a) reduction ontological — it is a strong type of reduction (for example, the definition of water as H_2O molecules), b) the ontological reduction properties — certain property of the object is explained within the properties of the lower level (e.g.: when the property "to have the same temperature" is defined as the property "to have the same average kinetic energy"), c) theoretical reduction — it is

a single level reduction between different scientific theories (e.g.: the inclusion of Newton's laws of motion under the general theory of relativity), d) definition reduction — it concerns possibilities to reduce definitions consisting of words and phrases that refer to the same object, e) causal reduction — causal effects of a reducing entity have a greater explanatory power than causal action of a reduced entity.

4.2 The Problem of Unification of Scientific Knowledge

Many scientists consider the basic tendency of science as a way to create a single theoretical system that would systematize all available knowledge. This approach should lead to establishment of a single (unified) science. The process of unification is problematic. Opinions regarding the way to achieve unification vary. In principle, it is possible to distinguish two ways of unification: (1) typical and on the basis of similarity (typical unification, TU); (2) based on functional communication and coordination (conjunctive unification, CU). In the first case, the unification is based on proving common properties, similarities. In the second case, the unification is understood as a demonstration of a link and functional conditioning between various entities.

There are different degrees of similarity and different degrees of connectivity. A weak type of conjunctive unification is a union of groups of objects that are associated by spatial distribution (e.g.: the foundation of villages, towns, counties, states, etc.; the establishment of geographic locations) or temporal parallelism (e.g.: devising a historical period). A strong type of CU is the explanation of various events as causally conditioned, or organized into broader integrated functional systems. Between these two boundary types of CU, there are many intermediate degrees, when between two disparate phenomena, which were considered unrelated to each other, there are gradually emerging contexts and functional conditionings. In the case of a typical unification, it is the demonstration that apparently different entities or characteristics may be merged under one general type. The strongest type of TU is the reductive identification, where the studied phenomenon is explained on the basis of identification with another phenomenon with an explanatory stronger theory, it is thereby essentially eliminated. An example is the Maxwell's theory of electromagnetism that explains the light by identifying it with electromagnetic radiation. Conversely, a weak type of TU is the demonstration that different objects are part of a broader category of objects that have certain characteristics in common. Even weaker way of the unification based on the type of similarity is the demonstration that different objects are members of a wider group, but not based on a set of similar properties, but because each member is coupled with a centralized prototype on the basis of some similarity (e.g.: a species of fish, in which the individual families are grouped by minimum quantity of common characteristics to the prototype). Typical unification may be determined based on internal or external similarities. For example, the members of the "vertebrate" group are affiliated to one group based on a common internal features (they have a backbone). Conversely, the "gene" group members are united by a common external characteristic, which is the causing of certain effects within developing organisms, while the similarities in the internal structure are secondary. Functional characteristics, by which the objects are combined into a single group, may be realized in different ways, within different internal organizations.

The other means of unification of natural phenomena is their unification on the basis of characteristics, which they lack, while in other properties they may differ. For example, the identification of different types of mental illness is based on the method of classification (e.g.: a condition called "prosopagnosia" is characterized by the inability of subjects who suffer from this disease to recognize their own face). In the case of intertheoretic reductions, which are very effective in the scientific explanation, typical, as well as conjunctive unifications are being applied. On the basis of functional

cooperation it is possible to integrate disparate phenomena into a single explanatory framework (CU), but this process frequently assumes the identification of similarities between phenomena at a lower level (TU).

In addition to unification that relates to the researched subjects, it is possible to set apart the unification at the level of examination (so–called epistemological unification) and at the level of method and objective scientific explanation (so–called normative unification).

The problem of scientific explanation unification is rather difficult and complex, but also the possibility to describe the behavior of a vast amount of observed phenomena on the basis of a limited number of explanatory principles is one of the sources of rapid expansion and efficiency of scientific knowledge.

4.3 Intertheoretic Reductions in Cognitive Sciences

One of the central problems in contemporary cognitive science is the problem of identifying the conditions of possibility for the intertheoretic reduction (the reduction of one theory to another theory). Paul Churchland formulates the problem of intertheoretic reduction as follows: "The intertheoretic reduction is in fact rather a relationship between two different conceptual frameworks that are describing the phenomenon than a relationship between two different aspects of this phenomenon. The purpose of a reduction is to ultimately demonstrate that, what we considered as two spheres is in fact one sphere, although described in two (or more) different vocabularies." (Churchland 1998, p. 67). This argument may be illustrated by examples of the development of certain scientific theories. One of the earliest is the example of intertheoretic reduction of Kepler's laws of planetary motion to Newton's three laws of motion. Newton's theory in fact proved to be more widespread and systematic and therefore more effective. It explained a wider range of possible movements and was based on a set of clearly defined units, such as force, acceleration, inertia and gravity. “God or the supernatural character of the heavens was lost forever. Sub lunar and lunar sphere were thus united into a single realm, where the same types of objects were managed by the same set of laws.” (Ibid.) Another model case of intertheoretic reduction is a theory of heat as average molecular energy or identification of sound with pressure waves spreading in atmosphere. All three spheres of movement — lunar, sub lunar and microscopic — were combined into a single theory of motion. The most famous reduction in the history of modern science is the reduction of Newton’s laws of motion to Einstein’s special theory of relativity.

On the basis of these cases, it is possible to determine the conditions for the possibility of intertheoretic reduction. The reducing theory must be sufficiently systematic, so that predictive or explanatory losses were avoided by the replacement of the old theory with a new one. Therefore, the reducing theory must include everything that proved to be valid in the reduced theory. This does not mean that the new theory is completely isomorphic to the old, as in many important aspects the reduced theory may be falsified. The old theory may not only be reduced, but even eliminated, if it turns out to be entirely unfounded. The fundamental objective of the reduction is to introduce as few as possible explanatory principles, by which it is possible to explain most of the observed phenomena (the principle of Occam’s razor).

However, a necessary condition for the application of the unifying approach is, as it has been emphasized, the singular nature of the investigated phenomena, therefore the possibility to explain these phenomena by the same laws, the same language and the same methodology. Today, when identifying a gene with a portion of the DNA molecule, it is a result of the application of the reduction between two theories of heredity — the biological and chemical — in practice.

4.4 Recommended Literature

JONES, T.: Unification. In: Psillos, S., Curd, M.(ed.): *The Routledge Companion to Philosophy of Science*. New York: Routledge 2008.

SARKAR, S.: *Genetics and Reductionism*. Cambridge University Press, New York 1998.

CHURCHLAND, P. M., CHURCHLAND, P. S.: *On The Contrary. Critical Essays*. London: The MIT Press 1998.

SEARLE, J.: *Myseľ, jazyk, spoločnosť*. Bratislava: Kalligram 2007.

5. Neuroscientific Theories of Cognitive Processes

Keywords: *theory of consciousness, organism, neural maps, mental images, dispositional representations*

5.1. Non–eliminativist Neuroscientific Theories of Consciousness

In an effort to clarify possibilities and impulses brought to present philosophical conceptualising by cognitive and scientific theories on mind and consciousness, we will focus on the analysis of Antonio Damasio's concept. His theory of consciousness could briefly be described as a theory on the process of constant monitoring of the state of an organism in relation to internal and external environment. Essential effort is to examine consciousness as a phenomenon of natural world, while the condition of maintaining the complexity of this phenomenon is crucial in all its demonstrations and functions. "It is correct from my viewpoint that it is soul and spirit with all their dignity and human dimension that is a complex and unique state of an organism. Our essential responsibility as of human beings might be to remind our complexity, fragility and uniqueness to ourselves as well as to the others every day of our lives." (Damasio 2000, p. 216). The key Damasio's effort is to search for natural explanation of the phenomenon of consciousness. In doing so, the basis is understanding of consciousness as a state of an organism as very complex, given by a set of relationships of the organism to external and internal conditions. Emotions, reason and human brain create an inseparable unity, a new and unique substance, in searching of which he is inspired by Baruch Spinoza. He divides relationships between emotionality, rationality and human body into relationships of seemingly contradictory pairs: thinking and deciding — emotional experience, biological regulations — feeling, neural representations — mental content and into a broader relationship mind — body. It is important to look for connections between these phenomena. The relationship between mind and body is analysed according to a clear concept: "...the mind exists in an integrated organism and for it" (Damasio 2000, p. 11). This theory is based on several theses:

1. Organism is understood as an inseparable unit integrated by means of mutually reacting biochemical and neural regulatory circuits.
2. Organism acts as a whole also in relation to external environment (i.e. interactions with the environment are not only carried out on the basis of the relation to brain).
3. Mental processes can only be fully understood in the context of mutual interaction of an organism and its environment, while also those aspects of reality which are a product of the activities of such organism need to be considered.

Problematic complexity of the analysed relationships is obvious. The key function of consciousness is mapping of the state of an organism. Consciousness is in constant and close contact with body. Principal for the existence of consciousness is a smooth flow of bodily representations. This information on the state of an organism is the basis for our feelings and our self–awareness, and their absence can cause total interruption of the creation of external world representations. The consciousness process in this concept is thus a constant scanning of all processes taking place in the human body, also enabling the process of the creation of mental images of the environment as a complicated emerging of information from sense organs and information and state of an organism. Brain has to process a huge amount of information and create effective decisions in split seconds. Consciousness developed as an effective tool of a complex decision–making process. It works on the basis of mental images (thoughts, imaginations, ideas,...). Also working of an organism in time, i.e. planning, foreseeing and expecting requires images. These are a result of a persistent process of mapping, simultaneously taking place in different parts of brain. Mental images are space–time organised dynamic neural maps depicting activities taking place at various places of an organism.

There are two types of mental images according to which internal organ stimulates their creation. They can result from messages about the condition of internal organs like heart, intestine or muscles, which are sensitive to changes of chemical parameters of internal environment. The second type of images are those whose creation is initiated by so called special sensory probes like retina or cochlea in the inner ear. Changes of light and sonic waves are important in case of these images. The brain maps bodily changes resulting from the changes at the level of chemical phenomena (received through the bloodstream) and electrical phenomena (coming through neural pathways) as well as macroscopic events. The whole set of changes taking place in an organism in a moment is "written" in a particular neural representation produced by different brain structures (actively forming the final form of this map). Eventually, the given state of the organism is generated in the form of special mental images. They represent the state, activities and structure of the organism as a whole in a certain time period, while a certain type of mental images also represents a relationship of this integrated organism to the whole of the external world (physical, social and cultural, etc.).

Such defined mental images are considered by Damasio to be the founding "building stones" of the stream of consciousness. It seems that the form of images (thoughts, imaginations) as space–time arranged neural activities mapping bodily changes is the most effective way of the coordination of a huge "mass" of our organisms and all changes taking place in them in milliseconds. "What finishes

as a functional map in sensory brain regions and what appears in the form of a thought in the consciousness corresponds to a bodily structure in a certain state in a group of relations." (Damasio 2004, p. 227). Our feelings and emotions play an essential or even the key role in this systematic mapping.

Damasio understands emotions and feelings as basic aspects of biological regulation which is a function of evolutionally older subcortical brain structures. Emotions are divided into primary and secondary. Primary emotions are inherent and predominantly depend on the limbic system. Amygdale and gyrus cinguli, a belt–like structure, also play an important role. The mechanism of secondary emotions has evolved in the course of evolution on the basis of the system of genetically determined emotional conditions. The reason for their creation was an increase in adaptability in the interest of survival. Secondary emotions occur upon realising one's emotional conditions and creating of systematic connections between objects and events on one hand, and primary emotional conditions on the other one. Their occurrence is conditioned by working of the frontal parts of frontal lobes and somatosensory cortical areas. The whole process starts by a mental image reflecting a particular situation. Neural basis of this image are topographically arranged representations created in visual, auditory and other cortical areas, cooperating with dispositional representations contained in association cortical areas. Those disposition representations containing information from our different experience regarding previous emotional answers follow the created image. Rather acquired disposition representations (which however can only work in a close cooperation with inherent emotional answers) are thus engaged here. Thus processed information gives a signal to the neural gearing of primary emotions — amygdale and cingulate cortex. A set of different activities (change of viscera condition, activation of neural transmitters in the brainstem and subsequent change in cognition processes, etc.) is initiated. The set of all these changes creates so called *emotional and bodily condition*.

Emotional experiencing has a dominant share in the creation of disposition representations, which are unsuitable for the creation of so called autobiographic me. Damasio divides consciousness into core consciousness and extended consciousness. This extended consciousness is what we mean in relation to the uniqueness of the human. It gives us a possibility to understand things and events which we immediately perceive in a broader time and personal frameworks. The condition of things does not only exist here and now but thanks to the extended consciousness, it also has its duration in the past and a probable status in the future. This most complicated form of consciousness gives us a unique possibility to "get off" the world and adopt a sort of "non–position". The centre of this extended consciousness is the already mentioned autobiographic me.

A fundamental condition of functioning of the autobiographic me is a constant stream of reactivation of memories closely related to our personal past, particularly emotionally coloured memories. Those are gathered in the autobiographic memory. No concept of personal, unique me can develop without it. The concept of me as a central image of the extended consciousness undergoes certain phases. At first, it exists in an unconscious form as a proto–self, which is a set of non–reflected representations of various immediate conditions of an organism at its various levels. Realisation of a latent possibility of proto–me in the core consciousness distinguishes so called core self. A relationship of perceived conditions to the whole individual organism occurs in its framework. However, this relationship is only temporary and is only taking place here and now in a short time framework. The result is the existence of a simple "sense of self knowing". Only the constitution of the autobiographic memory as a system of *organised* memories of events and objects from the past life of a unique organism enables the creation of the autobiographic me as a basic reference system of our conscious existence. It is a certain abstract of our identity.

5.2 Eliminativist Neuroscientific Theories of Consciousness

The eliminativist theory is based on the brain examination results obtained using several basic methods. Computed tomography (known as CT) enables the examination of brain tissue density by means of X rays absorption measurement, evaluated by a computer programme. Brain regions with various density can thus be detected and shown in actual spatial relationships. It is possible by means of this method to identify different brain injuries, tumour diseases, brain volume increase and other disease processes. It is possible to follow the flow and volume of blood in the brain and brain metabolism (so called emission CT) upon contrast medium administration into the brain bloodstream.

Another way of brain examination is nuclear magnetic resonance, based on using magnetic qualities of hydrogen nucleus in human body tissue. Distinction between grey and white brain matters and a better demonstration of some brain structures (e.g. thalamus or basal ganglia) can thus be secured.

A well–known and already quite long used method is electroencephalography (EEG). It focuses on identifying of brain activity through the measurement of a difference in electric potential between two electrodes placed on the head surface (it is among non–invasive methods). Electric current generated upon the brain activity is recorded as a curve and multiple enlarged. EEG curve of a healthy person has a typical behaviour.

Based on data collected by means of these methods, concepts on human consciousness are created, having a scientific theory nature. They are formulated as testable hypotheses. An important information source of these concepts is also data collection from various cases of brain lesions. All collected data serves to verify or rather falsify the existing theories.

Eliminativist neuroscientists ask the following: "Can we understand in neurobiological terms, what it is like for an organism to be conscious?" (Churchland 1991, p. 277). Because the concept of so called popular psychology or "common sense conceptions" represents a misleading and implausible theory for these philosophers, they do not propose its reduction but complete elimination for the benefit of neurobiological theory on brain functioning. They doubt the possibility of finding a common explanatory framework of psychological and neurobiological theories, and they therefore refuse to adopt the reduction method. "... everything we know about biology, evolution, neuroscience, physics and chemistry suggests that substantial dualism cannot be true and that mental conditions are the conditions of brain. In relation to it, materialistic effort is looking for a neurobiological substrate of consciousness." (Churchlandová 1991, p. 279). The whole problem of the consciousness phenomenon is solved by means of finding a complex neural configuration. Eliminativists hope that the case of consciousness will follow the case of genetic information transfer. The idea that a great amount of information, from the eyes colour through temperament and talent to dispositions to precisely determinable diseases, is transferred on generations thanks to quite simple chemical substances in precisely arranged structure seemed absurd to many. The whole issue got under a different light after gene structure description and human genome decoding. The function of non–material revival principle was taken over by chemically defined deoxyribonucleic acid spiral. Eliminativism supporters hope for a similar development in the research on consciousness.

It is probable that the mind is not a uniform phenomenon, the only neural configuration. It is therefore necessary to divide the ambiguity of consciousness and detect those aspects explainable within neuroscience. We should free ourselves from the common division and categorisation of consciousness adopted in the theory of popular psychology. Such categorisation is only based on external similarity of phenomena.

Identification of basic research strategies, clear problem formulation and its examination methods are crucial for eliminativists to create a physicalist theory. We have to specify which aspect of consciousness will be understood as determining for stating the "be conscious" state. "If there is a relevant consciousness area with sufficient supporting infrastructure and surrounding theory enabling experimental discovering, then it is the sleeping — dream — awake cycle." (Churchlandová 1991, 290). These states include several significant differences making their determination easier. In order to distinguish between them, some medical tools are also used, measuring electric brain activity (electroencephalogram), heart activity (electromyogram), and eyes activity (electrooculogram). Differences in these activities generate the sleeping — dream — awake cycle and are predominantly detectable in introspective acts of phenomenal experience. Consciousness is completely absent during so called sound sleep phases. Neither any introspective processes nor phenomenal experience is carried out here. In the dreaming phase, awareness of external stimuli is absent, however we perceive internally initiated images which we can often remember and report in the awoken state. The awoken state phase represents a constant state of realising, accepting and processing of information on external as well as internal environments of an organism. Brain ensures a complex sensorimotor activities. The neurobiological theory on consciousness can thus examine the complex and diversified phenomenon of consciousness in only certain aspects. These aspects are selectively specified on the grounds of their greater or smaller connection to conscious states as well as on the grounds of availability of methods and their detection and monitoring. Some scientists denote the cycles of sleeping, dreaming and awoken state as significant consciousness aspects, while it is important for the others to monitor our experiencing of emotions and feelings, as according to them, they are the basis of understanding and explaining of conscious states. However, a question arises in relation to eliminativist concepts whether it is possible to build on a clearly neurobiological theory on consciousness with regard to present state of human brain knowledge. Also Churchland postulates the need of a more broadly framed theory: "Neurobiology needs a theory on the processes taking place above the level of a single cell." (Churchland 1991, 278).

5.3 Recommended Literature

DAMASIO, A.: *Descartův omyl*. Praha: Mladá fronta 2000.
CHURCHLAND, P. S.: Eliminative Materialism and the Propositional Attitudes. In: ROSENTHAL, D. M. (ed.): *The Nature of Mind*. Oxford: Oxford University Press 1991.
DAMASIO, A.: *Hledání Spinozy. Radost, strast a citový mozek*. Praha: Dybbuk 2004.
PETRŮ, M.: *Fyziologie mysli*. Úvod do kognitivní vědy. Praha: Triton 2007.

6. Models and Analogies in Cognitive Sciences

Keywords: *model, representation, types of models, analogy, metaphor*

6.2 Models and Their Types

The theoretical model is a structured set of theoretical assumptions about a target object X, representing the basis of examining the object X. The selection of theoretical assumptions is determined by essential similarities (analogies) between the target object X and other known object Y. The scientific model mostly has a character of quantitative mathematical model. The main model function is to represent the object being cognized. Many questions arise in relation to this function: How are the models created and what are their constitutive elements? In what way can a model relate to reality and represent it? To what extent can idealisation influence its representing function? In what sense is a model a new source of knowledge?

The scientific model cannot be understood as a precise replication of its object but as an idealised and abstract representation. The model selectively reflects only several qualities of the displayed object. For example an architectural model of a building almost exclusively displays spatial dispositions, while the object's infrastructure is not dealt with. The main feature of different types of models is their representing function, determined by cognitive processes of idealisation and abstraction (Part 4).

Representing function of a model is a result of its three partial functions (Kuhne, 2005):

— the mapping function, mediating the relationship between a model and its original
— reductive function, based on which a model only reflects relevant qualities of an object
— pragmatic function, securing model's practical efficiency

A model cannot simply be a copy of an object, as it would thus resign to its reductive function. Similarly, it is not only a description, as it is formulated with regard to a certain purpose. If we for example created a model of a very complex system which would be equally complex, it would lose the meaning. A complex system model has to primarily be a simplification.

Psychologist K. Craik introduced the term mental model. He understood it as a psychological representation of actual or hypothetical situations, having a form of a reduced scale of reality whose objective is to support and stimulate cognitive processes applied in explaining of phenomena (Craik 1943). Mental model is constructed in the working memory as a result of the process of perception, thinking or imagining. Its structure, which should correspond to structure of the object it represents, is especially important. P. Johnson–Laird postulates the difference between a mental model and other mental representation, having a form of a propositional representation. In stating: "The triangle is on the right of the circle", attention in case of propositional representation is drawn to the syntactic structure of such statement (the position of predicate, subject and object). Propositional representation has a syntactic structure and is the basis of the language of thought. On the contrary, the mental model represents a spatial structure, which is isomorphic, with current spatial disposition between two objects. The model "excerpts" from reality what is common for all cases when the triangle is on the right of the circle. The size of objects, their mutual distance and position can secondarily complement each other, thus specifying the model (Johnson–Laird 1999). Model construction on the basis of propositional representations is a part of the cognitive process of understanding. We can create analogies and discover relations on the grounds of this process. The mental model as a result of perception and search for analogies represents the basis of major cognitive activities (e.g. argumentation). Creation of models from models themselves is the basis of metarepresentation, which is a critical condition of consciousness existence.

Several types of models are used in scientific research:

— iconic or scale models — represent objects as idealised and abstract structures (e.g. DNA molecule model)
— analogical models — represent objects on the basis of analogy based on the relationship of similarity between model qualities and qualities of its object
— mathematical or abstract models — represent their target objects by means of a formal language of mathematics

Differences between various types of models thus lie in various ways of fulfilment of the representation function (Portides 2008).

Mental models represent entities and persons, phenomena and events and other various complex systems. An advantage of the mental model is a possibility to simulate different variants and alternatives, evaluate the best of them, create strategies for the future and apply cognition from the past events in doing so.

According to Johnson–Laird (1999), we can distinguish between the mental model and linguistic structures, semantic networks or other types of mental representations according to the principle of iconicity. The mental model has a structure corresponding to the structure of represented object (at the level of qualities as well as relationships). For example in case of visual images, it concerns three–dimensional mental models, structurally analogical with perceived objects.

6.3 Analogies

Greek origin of the word analogy indicates its primary meaning — proportion. Proportionality for example concerns numerical relations — relation 2 to 4 is proportional to relation 4 to 8. The analogy points out the similarity of relations within various domains. The basic scheme of analogy is: A is in relation to B like C is in relation to D. Two situations are analogical if they have a common pattern of relations between their constituents in spite of the fact that constitutive elements themselves differ in different situations. For example electrons are in relation to nucleus like planets are in relation to the Sun. Analogical thinking uses the existence of proportional relations between basic and target systems, and on this basis, it derives probable new qualities of the target system. Analogy is therefore a form of inductive reasoning. It is based on the asymmetry between an original cognition and a new cognition. It can result from either formal or material similarity. Formal analogy reflects the structural proportionality, while it does not require (contrary to the material one) identity or similarity of attributes of elements being compared. Orbital motion of electrons and planets, caused by gravity forces, can be an example of the formal analogy. However, the character of these forces is different (it is electromagnetic force in case of electrons, and gravitation force in case of planets.). We therefore consider the similarity of phenomena in this case, not their identity (material analogy). M. Hesse distinguishes three types of material analogies: positive analogies (identifying common qualities of two different systems), negative analogies (identifying qualities differentiating one system from another) and neutral analogies (identifying qualities about which we do not know yet whether they will represent positive or negative analogies, however it is assumed that they will be one of these cases). An example of neutral analogy is the statement: Y can play a heuristic role in revealing other qualities of X (Hesse 1967).

Analogy can be broadly applied within construction of models, as it helps their explanatory function. Explanation is in a certain sense a transformation from something unknown to something known. Analogies enable elucidation of new knowledge by means of their comparison to something already known. They are also applied in introduction of new terms, emphasizing similarities with already existing terms, relations are created between "old" and new terms, indicating their position in a valid system. P. Thagard (2001, s.99) determines four phases of analogical derivation: 1. identification of the need to solve a target problem (analogue), 2. search of a similar problem and its solution in the memory, which can be used as a source of analogical reasoning, 3. comparison of source and target analogues, and creation of a connection between them (identification of differences as well as common features), 4. source problem modification so that it can be used in solving the target problem. "Understanding of analogical derivation requires the specification of procedures for recollection (recalling from the memory), comparison (mutual mapping of source and target analogue) and adaptation." (ibidem). Searching for analogues is directed by three restrictions: similarity, structure and purpose.

The model can be based on analogy but it is not exhaustively defined by it. The criterion in model evaluation is not an extent of its analogical character in relation to represented object but the fact whether the model enables us to grasp the examined object in a certain way and thus interpret the collected data.

6.4 Models and Metaphors

The key function of metaphor is to shift the meaning of an expression from the "familiar" application area to a target area. Some scientific models can be analysed in relation to their metaphorical function, as they include the transfer of notions from a known to an unknown area (e.g. in case of artificial neural networks). Metaphorical model appears to be very effective, particularly in drafting new theories and implementation of new entities, when we do not dispose of any "customary" terminology we could use. Metaphorical expressions are applied in case if two referenced areas are understood as certain structural analogies. For example a significant progress in explaining human cognitive abilities within the cognitive and scientific research was the introduction of so called computer metaphor. Human brain and human mind are explained on the grounds of similarity of the relationship between hardware and software operating in computer mechanisms. The introduction of this metaphor enables prevention of the problem of two mutually independent substances — body and soul, discussed in the long term.

7.5 Recommended Literature

KUHNE, T.: *What is Model?* Available on: http://drops.dagstuhl.de/opus/volltexte/2005/23

CRAIK, K.. The Nature of Explanation. Cambridge: Cambridge University Press 1943.

JOHNSON–LAIRD, N., P.: Mental models. In : Wilson, R., A. and KEIL, C., F. (ed.): *The MIT Encyclopedia of the Cognitive Sciences*, The MIT Press, Cambridge 1999.

PORTIDES, D.: Models. In: Psillos, S., Curd, M.(ed.): *THE ROUTLEDGE COMPANION TO PHILOSOPHY OF SCIENCE.* Routledge, New York 2008.

HESSE, M.: Models and Analogy in Science. In: Edwards, P. (ed.):*The Encyclopedia of Philosophy*, New York: Macmillan 1967.

7. The Basic Paradigms of Cognitive Sciences

Keywords: *computation and representation paradigm, computation, representation, connectionist models, artificial neural network*

7.1 Computation and Representation Paradigm

The basis of the computation and representation theory of cognitive processes is: 1. Explanation of mental states as representing states. The implementation of mental states is states of brain, understood as representing the states of other systems, e.g. external world or internal environment of an organism. 2. Transitions between states are explained as computation operations of representations.

In formulating the computation theory, psycholinguist J. Fodor has a basis in the classic model of Turing algorithm (Turing, 1950). Algorithm is a final determined group of rules to carry out information processing procedures. The result is a transformation of a state of a device (machine, computer) into another state. This final group of operations is formulated in the form of a symbolic code. The code is implemented in the device on the basis of its formal succession thanks to its syntactic characteristics. These rules of information processing are recursive, i.e. they can subsequently be applied to themselves in an unrestricted series.

According to Fodor, cognitive processes are computation processes. They represent causal operations with mental representations, creating a "programme" — language of thinking, i.e. a structured syntactic chain of mental representations by means of their syntactic structure. Semantic content is coded in symbol sequences of this algorithm. Thus coded information fulfil the characteristics of intentionality — they represent events and phenomena of the external environment. Device in which this "programme" is implemented is human brain. The algorithm advances in a consecutive set of operations, which need to be carried out in a particular order. Another task will not be initiated unless the previous has been completed. Classic algorithm, which was also a basis for Fodor, thus processes information in series (operation after operation). Connectionist models of cognitive processes, on the contrary, are based on the interaction between nodes with parallel processing.

Computation operations are a principle of an abstract device known as Turing machine. It is based on sequential conditions and rules, determining changes of these states. Each precisely defined function can thus be carried out by this machine in a succession of steps, observing one simple, syntactically structured rule: "if condition S gets input V step Q will be carried out". Turing machine comprises a control unit, tape and read and write heads. The control unit is at each time defined by a certain condition, which changes in a precisely established way on the basis of information coming from the read and write heads. The tape in this abstract automatic machine is an infinite, linearly arranged sequence of units, which are bearers of symbols from a finite symbol set. They constitute an input alphabet, coding the computing algorithm of Turing machine (TM). TS head always reads one unit on the tape over which it is positioned at the given moment. Besides reading, the unit can also be rewritten or shifted by one unit to the right or left. TS is thus able to carry out a particular function (to shift from an initial condition p to a desired condition q) on the grounds of precisely determined sequence of steps of working with symbols introduced in advance. The basis of TS is an algorithm, which is a specific guide in tasks solving. Algorithm is a finitely determined set of rules to carry out procedures of information processing. The result is

a transformation of one condition of a device (machine, computer) to another condition. This final set of operations is formulated in the form of a symbolic code. The code is implemented in the device on the basis of its formal sequence through its syntactic characteristics. It has several definitional qualities: a) it is finite (it comprises a finite number of instructions, while each of them is carried out in a finite time), b)it is related to its discreteness (it comprises discrete, separable units — instructions), c) it is sequential (another operation can only follow the completion of a previous one), d) it is determined (operations sequence is precisely specified), e) it has a mass character (e.g. addition algorithm is applied to any number pairs) f) it is resultative (it reaches a final condition in a finite time). The attribute "computation" is thus related to the characteristics of a special type of cognitive architecture — serial algorithmic systems working with relatively fixed, explicit and discrete representations. Neurobiological data also indicates a resemblance of brain and TS, as the neural level also concerns processes of information processing on the basis of the mechanism "input — processing procedure — output" (Wilson, Keith, 2001). Brain is really equivalent to the Turing machine in such formal understanding.

7.2 Connectionist Models

Connectionist models of cognitive functions appeared in the 1950s — 1960s. The hardware component of these models are networks comprising a great number of densely mutually interconnected units — nodes, corresponding to notions or qualities. It is so called Parallel Distributed Processing of information. The thinking process is modelled by parallel processing of a sub–symbolic information. Connectionist models, also called artificial neural networks, are more similar to the constitution of our neural system than the computation and representation models. The difference between hardware and software, or neural and mental levels, is not as significant as in case of symbolic models, as the programme is directly related to the network physical constitution, in which it is implemented. Units of the connectionist model are analogical to biological neurons and communicate through weight connections. Those are analogical to synaptic neural connections. Unit connection points have certain weigh coefficients, determining the connection intensity. The coefficients can have negative or positive values. The connection is inhibitive in the first case, while it is exhibitive in the latter. Neural network operation is dependent on its architecture and weight coefficients of nodes. The basic difference between symbolic and connectionist paradigms is in their approach to cognitive functions interpretation. Connectionist models are characterised by their bottom–up approach. Artificial neural network units do not have a representing function. Each neuron has an internal potential, based on which it subsequently produces a particular output. Neurons communicate with each other on the sub–symbolic level, which has a numeric character (outputs are impulses with different frequencies). An idea or a notion in the connectionist network have a form of a complex picture of nodes activities, representing a distributed representation.

Neural network architecture determines its potential. There are two basic types of connectionist networks: feed–forward and recurrent. Information in a feed–forward network passes in only one direction from the input to the output. Recurrent neural networks also comprise feedback from the layer of so called hidden neurons. This network layer produces outputs which recur at the previous level as contextual inputs for further computational operations. Contextual inputs can serve as a memory. Recurrent networks thus become suitable for modelling of space–time tasks (e.g. in case of generating sentences in a language). Neural networks can have several layers, while the number of hidden neurons determines the model complexity.

The learning process in case of computation and representation models is only explainable by an external intervention. On the contrary, connectionist models can also successfully simulate the ability to learn on the basis of changes of nodes weights. These changes are carried out by implementing a learning algorithm, causing weight changes with regard to required output. A typical example of connectionist network learning is a model of neural network for the creation of past tenses of English verbs designed by Rumelhart and McClelland. The learning process in case of computation and representation models is only explainable by an external intervention. On the contrary, connectionist models can also successfully simulate the ability to learn on the basis of changes of nodes weights. These changes are carried out by implementing a learning algorithm, causing weight changes with regard to required output. A typical example of connectionist network learning is a model of neural network for the creation of past tenses of English verbs designed by Rumelhart and McClelland.

7.3 Recommended Literature

TURING, A., M.: Computing machinery and intelligence. *Mind*, 59, 1950, pp. 433–460.

PINKER, S., PRINCE, A.: On language and connectionism: Analysis of a parallel distributed processing model of language acquisition. In: *Cognition, 28*, 1988, pp. 73–193.

NORRIS, D.: A connectionist model of continuous speech recognition. In: *Cognition, 52*, 1994, pp. 189–234.

CARRUTHERS, P.: *Language, Thought and Consciousness. An Essay in Philosophical Psychology*. Cambridge: Cambridge University Press 1996.

8. The Issue of Language in Cognitive Sciences

Keywords: *linguistics, language, system, linguistic methods*

8.1 Cognitive Linguistics

Cognitive linguistics is one of the disciplines of cognitive sciences, dealing with description and interpretation of mental structures and processes related to language knowledge. It is an integrating scientific discipline, trying to find connections between the structure of mental representations, their processing and neural substrate. It examines possibilities of modelling of the process of acquisition, reception and production of a language, while a fundamental effort is to create a complex theory on the interconnection of structural and procedural aspects of language knowledge.

Cognitive linguistics perceives language as a tool for organizing, processing and delivering of information. Processing and storage of information are the determining characteristic feature of the language ability. Despite the beginnings of cognitive and linguistic research, preferring explanation of syntactic structures of language knowledge (Chomsky's Universal Grammar), present–day linguistics understands the language as primarily semantic, as a bearer of a particular meaning. Language has certain characteristic features: a) it is perspectivist — language is not only a reflection of an objective state of things but it is a constituent of such state (Wittgenstein mentions language as a condition of the possibility of world existence), b) it is dynamic and flexible — it reflects changing environment we live in, therefore new expressions and meanings always appear in the language as reflections of our new experience, c) it is encyclopaedic and non–autonomous — the language also reflects social and cultural context and it is also formed by other cognitive abilities, d) it is conditioned by using and experience (Geeraerts, 2006).

Two opposite approaches to language ability interpretation dominate within cognitive linguistics — modular and holistic. The modular approach characterises the language as an autonomous module, separated from the modules of other cognitive abilities. Chomsky's theory on generative grammar or Fodor's hypothesis of the language of thinking are among examples. Holistic approach refuses the language conceptualisation as an autonomous module and postulates the interpretability of language knowledge only as a part of general conceptualization processes and categorization principles. Language structures and operations are thus an inseparable part of the set of cognitive abilities.

8.2 Methodology of Language Cognitive Research

Methods of the language cognitive research are given by its interdisciplinary character. Besides classic rationalistic processes of inductive and deductive reasoning, many empirical and observation methods are also used within the cognitive linguistics. We have already mentioned the criterion of psychological and neurophysiologic plausibility of cognitive theories and their empirical character. One of the key methods therefore includes the method of experiment, enabling a direct contact with neuropsychological reality. It is a controlled monitoring of the behaviour of persons during the experiment, where the experimenter affects the course of experiment by specific instructions. Particular causal connections are subsequently stated on the grounds of observed change of the behaviour of experiment participants. The experiment thus serves to confirm or disprove formulated hypotheses. We distinguish two basic types of experiments — so called off–line and on–line experiments.

The ability to store provided information in the memory is examined in off–line procedures.

It is for example a method of free or bound reproduction. In case of free reproduction, the task of experimentee is to repeat provided information, while the interval from receiving the information to its reproduction can differ. In case of bound reproduction, experimenter provides the experimentee key terms, which should help a more precise reproduction of provided information. In such reproduction, a significant impact of knowledge from remote memory mostly appears, when experimentees insert information not provided in the original text in their descriptions of the information. The impact of individual experience on perception and processing of the given information is obvious here. However, it is not certain whether activation of knowledge stored in remote memory takes place at receiving, or not sooner than at the reproduction of information. Off–line method is therefore mainly suitable to find out the structural side of language knowledge, while the procedure of their processing can hardly be affected in this way.

In case of on–line methods, the information processing procedure is directly affected, it is therefore mainly suitable to find out the cognition process character. It for example concerns the priming method, examining the impact of knowledge structures stored in remote memory on operations with lexical units. The examinee is at first presented a word with a particular meaning, then another one, so called target word. The task of the examinee is to determine whether the target word has a meaning or it is only a random group of syllables. This procedure leads to finding out that time necessary to determine the meaningfulness of the word is shortened in parallel with whether the first word has a semantic relationship to the target word. Semantically related words are thus activated in remote memory at the same time. Another type of on–line method is measurement of the speech units processing. Relation between

the information processing length and the complexity of cognitive processes in progress is found out in this procedure.

Another group of methods, which is a basis of cognitive and linguistic research, are neuropsychological methods searching for relations between mental and physiologic processes. These methods include computer display methods, which monitor different biochemical brain activities (e.g. glucose processing in specific brain regions), or bloodstream through particular brain parts. Much knowledge on the connection between mental and neural structures is also acquired from the studies of various pathologic clinical cases and dissociations method. In case of dissociations method, dependence or autonomy of particular cognitive capacities is defined for a patient who suffers from a specific neurological disorder. It is for example examined whether the face recognition disorder (prosopagnosia) is related to another memory disorder.

Database for confirmation of linguistic hypotheses is created by sentences in natural language. Further facts necessary to confirm the explanatory power of linguistic theory provides the process of language acquisition. If we follow how children acquire their language competence we reach interesting findings. Children mostly acquire their mother tongue spontaneously, fast and very effectively. A child at the age of four already has a developed language competence, i.e. ability to distinguish between grammatically correct and incorrect sentences (Rybár, 2005). Within these four years, however, the child is confronted with a significantly limited sample of sentences in the language, while it gets in contact with almost exclusively positive examples, as parents correct children particularly in order to use words correctly, but not to create sentences according to grammatical rules (Takáč, 2005). These facts are collectively named as a lack of stimulus or poverty of stimulus. Another important finding is that child is also capable of independent production of sentences they have not heard before. This situation can be compared to a person who wants to learn chess rules (which they have no idea about) exclusively by monitoring of a particular limited number of chess games. Comparison of the amount of data we have at disposal at learning a language to the complexity and complexness of the language system lead Chomsky to the universal grammar hypothesis postulation. Also in case of the acquisition of competence in other cognitive systems (e.g. perceptual), it rather concerns the development of inherent abilities, not acquisition of new knowledge (in line with empiricism). According to this theory, a child is able to acquire a language on the grounds of inherent cognitive structures generating a sort of "conditions of a possibility" of any language competence. The universal grammar reduces the field of all logically possible grammars to the sphere of biologically possible grammars, i.e. those which are natural for us. The process of a language competence acquisition is significantly facilitated by the reduction of possibilities.

8.3 Recommended Literature

GEERAERTS, D. (ed.): *Cognitive Linguistics: Basic Readings.* Berlin, New York: Mouton de Gruyter 2006.

SCHWARZOVÁ, M.: Úvod do kognitivní lingvistiky. Praha: Dauphin 2009.

PINKER, S., BLOOM, P.: Natural Language and Natural Selection. In: *Behavioral and Brain Science*, *13,* 1990, pp. 707 –784.

CARRUTHERS, P.: *Language, Thought and Consciousness. An Essay in Philosophical Psychology*. Cambridge: Cambridge University Press 1996.

9. Philosophical Problems of Cognitive Sciences

Keywords: *philosophy, soul, consciousness, subjectivity, objectivity*

9.1 Philosophical Concepts of Consciousness

In an effort to formulate the theory of consciousness, philosophers encounter an issue which we could term as a problem of dual character of consciousness — material and mental one. The material substrate of consciousness connects with the human brain and whole neuronal system. The neurobiological nature of consciousness is accepted as obvious in majority of philosophical concepts. However, more complicated situation takes place in case of explanation of its mental nature. It is usually connected with the world of subjective experiences philosophically conceptualised as qualia. Consciousness is postulated as a source of entire subjective reality put in opposition to the world of objective scientific description. This results in origin of two mutually exclusive viewpoints on reality — the subjective viewpoint of a so–called first person, i.e. our "self" and the objective viewpoint of a so–called third person that is an uninvolved person.

The philosophical problem of consciousness has been running throughout the whole history of philosophical conceptualisation of the world in various forms as a red thread. At the primary level, the issue of consciousness is explained as a part of our rational soul which is usually grasped on the basis of its thinking capacity (ability). In this conception, the rational soul represents at the same time a substantial characteristic of a human being. It can be stated that ability to think is connected with substance of a human being. It is this ability that gives us a possibility to seemingly step back from the present situation to a "non–place", to go beyond borders of physical "here and now" and adopt a metaphysical stance outside space–time framework. The rational soul is connected with ability to think abstractly. Substance of human being overlaps with a capacity of self–reflection. And in turn, that one is closely connected to a potential of our memory (a relation between capacity of our memory and time passage is excellently elaborated by St. Augustine). Descartes even uses ability of thinking in order to determine awareness of existence. What represents an irrefutable sign that a human life is not only a dream? Certainly, it is his exceptional ability to doubt. We could say that according to Descartes, existence of a human being is connected with a possibility to doubt existence of everything with the exception of existence of doubt itself. Here we can see an effort to grasp substance of human being on the basis of his rational soul brought to the limits, the very edge of radical scepsis. English empiricism brings conceptualisation of another dimension of our mind — the sphere of secondary qualities, subjective experiencing and experiential experience. There emerges a significant philosophical problem very aptly formulated by Berkeley — "to exist is to be perceived". And Hume's doubting upon a natural relation between an action and reaction forces Kant to search and establish possibilities of philosophical reflection of the world anew, again, in a close relation to rational capacities of human being.

The problem of rational soul, thinking thing, mind or consciousness is always present in philosophical explanation of the world. Protagoras' idea on a human being as the measure of all things, of those that are that they are, and of those that are not that they are not does not lose its up–to–dateness also in contemporary philosophy of mind. However, when philosophically examining human mind today, we have to reflect also other, maybe not less important

philosophical problem — the problem of scientific explanation of the world. When the "rational soul" works within what we can call scientific explanation of the world, it achieves surprisingly convincing results and is endowed with exceptional predictive power. This phenomenon is probably for many of us acceptable in connection with explanation of "functioning" of a world of microparticles or world of macroscopic objects, however, in case a field so intimate for a human being and sphere so connected with his substance, such as the "rational soul", "mind" or "consciousness", for many centuries of philosophical thinking on a human being become a centre of interest of scientific explanation, we are suddenly reluctant to accept findings provided by scientific explanation of the world.

Plato introduces a basic distinction between the body and soul already in times of ancient philosophising on a human being. In order to ensure an objective character of cognition, he creates a world of independently existing ideas as patterns of all existing things. A body represents an obstacle for the soul desirous of true cognition, is its prison, a source of its error. When describing the soul having cognitive character in the dialogue Phedon, he says: "But the soul doesn't never reason better than when nothing disturb it, no hearing, no sight, no pain neither some pleasure; in the contrary, the soul isolate totally in itself, getting ride of the body breaking up all contact with it in order to try to understand reality." (Platón 1990, p. 736) The cognitive strategy is obvious: "only through the soul we can observe things about ourselves." (Platón 1990, p.738) So, there exist only two alternatives: either we will try to systematically separate the spiritual sphere from the physical one, or we will never be able to achieve undisputable cognition and live whole our live imprisoned in a sensual illusion. The process of cognition defined in this way implies the following:

1. unequivocal postulation of a basic conflict between the physical and spiritual and introduction of two completely dissimilar worlds — the material and ideal one. 2. internalisation of cognition into the sphere of subjective recalling, 3. postulation of being as

the thing about oneself representing the only valid object of cognition, 4. determination of the only competent subject of cognition — i.e. the spiritual soul completely freed from the body. This world image possesses such a huge explication power that even many of contemporary philosophers (explicitly or implicitly) base their explanation of reality right on this concept. Also Augustine asserts that we can cognise best introspectively through substance. In his 8th book, De trinitate, he writes: "For he knows the love with which he loves, more than the brother whom he loves." (Augustín, 309).

Aristotle comprehends the rational soul similarly in certain aspects: "… that in the soul which is called mind (by mind I mean that-whereby the soul thinks and judges) is, before it thinks, not actually any real thing. For this reason it cannot reasonably be regarded as blended with the body: if so, it would acquire some quality, e.g. warmth or cold, or even have an organ like the sensitive faculty." (Aristoteles 1995, p. 94) Thus, according to Aristotle, the rational soul is of a dual character — active one and therefore non–physical and passive one and therefore physical. Again, we encounter postulation of two worlds — a world of material beings which we cognise by the passive reason and world of abstract beings which we cognise via the active reason. When cognising, the passive rational soul can rely only on physical senses, on the contrary, the active part of rational soul has to be separated from the body in order to be able to cognise abstract objects and to be eternal and immortal. "…for always the active is superior to the passive factor, the originating force to the matter which it forms."(Aristoteles 1995, p. 96) So in spite of the "promisingly" sounding determination of the reason as a pure capacity, finally also Aristotle hypostasis the rational soul as something substantially dissimilar to the body. "…no sentient power exists without a body. But the intellect is separated and the intellect is the human soul. Therefore the human soul, so far as its act of existing is concerned, is separated from the body," writes Thomas Aquinas on Aristotelian dualistic comprehension of the body and soul. (Akvinský 2003, p. 35) Aquinas himself attempts to overcome this dualistic concept. He defines the relation of body and soul primarily as a relation of matter and form within one collective existence. A human being can exist only as a unity of soul and body: "… the soul is said to be the act of a physical organic body, because the soul causes it to be a physical organic body just as light makes something to be lucid."(Akvinský 2003, p. 29) Thus, in Aquinas' conception, the relation of soul and body is not comprehended so hierarchically as in the one of Aristotle where the originating and active rational soul "exceeds" the passive factor. On the contrary, Aquinas sees mutual conditionedness of the soul and body even although he accepts a possibility of existence of the soul outside the body: "Although the soul can exist of itself, it cannot be completely in its species without the body."(Akvinský 2003, p. 29) As if corporeity represented a fundamental part of human soul characteristics equally as soulfulness among characteristics of a human body. The body and soul are parts of human nature. The difference arising between them results only from abstract reasoning within which we separate matter from form. Yet, this difference is not of ontological nature: "…since the intellective soul is the form of man, it does not belong to a different genus from that of the body. But each belongs to the genus "animal" and the species "man", by reduction."(Akvinský 2003, p. 49) We might say that it is this comprehension of Aquinas that represents a suitable philosophical concept for current reductive tendencies in explanation of consciousness.

9.2 The Problem of Objective Explanation of the Subjective

A philosopher, Thomas Nagel, often ponders in his works on a possibility of implementation of the objective method of examining of physical phenomena to a sphere of examination of mental phenomena. His essential belief is that physical interpretation of objectivity is not applicable to examination of a sphere of conscious states and therefore it is limited. However, by this assertion he does contradict objective existence of these states. Nonetheless, it is necessary to find such interpretation of objective method as a *comprehension method* not excluding mental phenomena from the natural world framework and assigning them an objective status.

Thus, we should focus on the objective method not attempting to abstract from so–called secondary qualities of objects and taking into account also their subjective aspects except for their properties — i.e. a way how they tend to show.

When philosophically examining subjectivity, is it really necessary to apply also other type of objectivity than the so–called physical interpretation of objectivity? Should we consider the consciousness to be a part of the objective world, or does it exclude from this world by the fact that it is our only and unique mediator of this world as "causa sui generis" as the "thing about itself", so preoccupied even fascinated by itself that it is unable to accept its nature?

What if recognition of necessity of several explanation theories is, indeed, the only way out from a labyrinth of dissimilar nature of physical and mental phenomena crossing in a human consciousness? Those should proceed from existence of two approaches to examination of consciousness — from the point of view of its constitutive function in a sphere of subjectivity of experiencing and from the perspective of physiological properties. The first theory is based on introspective experience and uses its vocabulary, while the second one applies a vocabulary, for instance, of neuroscientific explanation. "Except for the functional role when explaining behaviour and concrete physical substance, conscious mental states have also a property of a third type known to everyone, i.e. the subjective quality of experiencing; what they are like or how they are perceived or what they seem to be like from the point of view of their subjects. Regardless of truthfulness of the fact that mental states and processes play the functional role in a field of behaviour of organism, experiential or phenomenological qualities of conscious

experience and these functional roles are simply not equivalent. Irrespective of the fact how closely these phenomenological qualities reconnected with their specific neurophysiological conditions are, they certainly cannot be analysed on the basis of physical description of these conditions. If such an assumption is correct, then the adequate general theory of position of consciousness in the order of nature has to put three seemingly unrelated things: functional organisation, physical composition and subjective perception into a mutual relation."(Nagel 1994, p. 58). Nagel appeals for the search of "new objectivity", not the scientific objectivity based on elimination of the subjective viewpoint and so–called secondary qualities of examined objects. The reality composed in this way is denoted by him as "whitewashed" and he determines it to be a source of a lot of difficulties, if we wanted to use it as a method when searching for complete comprehension of reality (external and internal). He terms current attempts to achieve scientific objectivity when explaining any field of our life "modern weakness for reduction". According to Nagel, already the process of objectification of natural phenomena as such is something that cannot be explained through physical terms. On the one hand, the new objectivity should be based on a principle of objective reality of the physical, and on the other, on acceptance of subjective reality of the mental. These principles should be complementary and equal.

The very fact of objective existence of external reality represents a very complex philosophical problem. For instance, Hilary Putnam's study (1997) pointing out to an impossibility of taking of a position of the so–called God's eye is remarkable. Except for others, this problem was also solved by Kant in the Critique of Pure Reason. In his General Remarks on Transcendental Aesthetics, he writes: "We have intended, then, to say that all our intuition is nothing but the representation of phenomena; that the things which we intuite, are not in themselves the same as our representations of them in intuition, nor are their relations in themselves so constituted as they appear to us; and that if we take away the subject, or even only the subjective constitution of our senses in general, then not only the nature and relations of objects in space and time, but even space and time themselves disappear; and that these, as phenomena, cannot exist in themselves, but only in us. What may be the nature of objects considered as things in themselves and without reference to the receptivity of our sensibility is quite unknown to us. We know nothing more than our mode of perceiving them, which is peculiar to us, and which, though not of necessity pertaining to every animated being, is so to the whole human race. With this alone we have to do. Space and time are the pure forms thereof; sensation the matter." (Kant 1979, pp. 88–89). Could we term such a comprehension the recognition of subjectivity within the search for new objectivity? Because also Kant has to solve a dispute between the thesis of transcendental idealism (according to which we cannot approach things as such because we view everything just as phenomena mediated through our sense experience) and thesis on objective existence (Kant believes in objective existence of things existing independently from our perception). So there emerges a question — what relation is between objective and transcendental unity of apperception? It is a relation of dependency. Experience (transcendental unity of apperception) requires objectivity — an idea of object existing independently from our perception. We are able to realize internal experience as our own only on the basis of real existence of external world. Thus, Kant refuses the basic thesis of idealism according to which we can access only our ideas whose relation to the external world is unstable, or for some individuals, even does not exist.

Nagel's concept is based on a priori defining of subjective qualities as phenomenon basically ungraspable through the methodology of current natural sciences: "The first principle of science is not to ignore data, and existence of phenomenal properties of mental life is one of the most common and necessary categories of data we have at our disposal. To consider them to be unreal because they cannot be grasped through methods of current physics is a step

back. Data is not determined through methods, quite the other way, adequacy of our methods is determined by the fact whether they can gain data."(Nagel 1994, p. 155). The question whether the method limits the object of its examination, or examined phenomenon is determinative for selection of the adequate method, represents one of the "great" questions of philosophical conceptualisation of consciousness.

9.3 Recommended Literature

AKVINSKÝ, T.: *Otázky o duši*. Praha : Krystal OP, 2009.

ARISTOTELES: *O duši*. Praha : Petr Rezek, 1995.

NAGEL, T.: *The Limits of Objectivity*. *The Tanner Lecture on Human Values*. Oxford: Oxford University Press, 1979.

PUTNAM, H., RORTY, R.: *Co po metafyzice?* Bratislava: Archa, 1997.

10. Cognitive Sciences and the Problem of Emotions

Keywords: *emotion, thinking, agnosia, evaluation*

10.1 Emotions and the Sphere of Subjectivity

Within explanation through means of cognitive sciences our "Self" loses its "metaphysical status". However, this does not have to necessarily mean that existence of sphere of subjectivity is refuted. It might be even quite the other way. For a neuroscientist, Damasio, subjectivity represented via emotions and feelings is the most crucial subject for examination "in the case" of consciousness. Feelings hold a certain privileged position within cognitive processes due to their focus on the inside of organism. As we have mentioned before, Damasio compares feelings to a window from which we can view the country of our body. Within interaction of feelings with images of other objects and moments mutual influence takes place. And thus, the unique, subjective viewpoint within which everything is perceived and comprehended through prism of own experiencing is formed. "Feelings modify our comprehension of objects and situations. Thanks to the fact that they stand next to each other (parallelly), physical "images" bestow the quality of the good or bad, pleasure or pain on other "images".(Damasio 2000, p.43).

A famous Slovak biochemist, Ladislav Kováč, asserts: "Human evidence of existence of the world is emotional, not conceptual — "I feel therefore I am"." (Kováč 2000, p. 14). He terms this assertion a fundamental ontological postulate of cognitive biology.

Representative functions of nervous system enable us the primary contact with our environment. Emotional representative states help create the world image already before constructing of cognitive and conceptual reality. So, the spontaneous process of continuous evaluation of accepted information plays a vital role from the point of view of adaptation of organism. Every sensory percept is structured on the basis of two aspects — sensory and emotional, affective. This affective means of perception is inherent already in the simplest organisms (such as, for instance, fruit fly Drosophila). It is evolutionary developed in such a way that enables affective evaluation to correspond with what is useful for survival. The principle is that what is emotionally evaluated as pleasant is also useful for preservation of life. According to professor Kováč, there also exist theories which work with the hypothesis that brain is a gland and various mental disorders (for instance psychoses and schizophrenias) are not caused by dysfunction of cognitive processes but disruption of emotional evaluation processes. Basic elements of such an affective evaluation are on the one hand, innumerable external stimuli and on the other hand, limited amounts of chemical components of nervous system. Emotional disorientation is connected with abnormal internal chemical environment. Cognitive processes might remain unaffected within these mental disorders.

An interesting example of significance and irreplaceable position of emotionality in shaping of our identity and subjectivity represents a case of man who was termed "the man who mistook his wife for a hat" by his treating doctor, Oliver Sacks, (Sacks 2009, s. 15–31). It is a case of the man who suffered from visual but mainly internal agnosia as a consequence of massive tumour or degenerative process in the vision centre of brain. However, at the same time, cognitive abilities of this patient, abstraction and categorisation, remained fully–functioning even got strengthen. The patient (Dr P.) oriented only on the basis of two aids — by creation of schemes and abstractions and thanks to music, particularly trough singing of various melodies (Dr P used to be a music teacher). Each melody accompanied a certain particular action. As his wife explains: "He does everything singing to himself. But if he is interrupted and loses the thread, he comes to a complete stop, doesn't know his clothes—or his own

body. He sings all the time—eating songs, dressing songs, bathing songs, everything. He can't do anything unless he makes it a song."(Sacks 2009, p. 29). The description of means how he got to know things which used to be common for him before is also remarkable. After asking of question concerning identity of object placed on the table before Dr P. (it was a glove), the patient behaved as follows: he started to examine the glove very closely as if it were an abstract object and finally said that it is: "'A continuous surface,' he announced at last, 'infolded on itself. It appears to have'— he hesitated — 'five outpouchings, if this is the word.'" Sacks 2009, s. 26). So, he answered the question about its identity just through observing and guessing of function of this unknown object, and stated that it is a container of some sort. And to the additional question about what it should contain, he answered: "'It would contain its contents!' said Dr P., with a laugh. 'There are many possibilities. It could be a change purse, for example, for coins of five sizes.'" (Sacks 2009, s. 27). Yet, it is remarkable that during their dialogue, he just accidently got it on and immediately exclaimed and recognised the glove. What the patient missed was an ability to make a judgement. He recognised things only thanks to almost absurd abstraction (which led to such a situation that he mistook head of his wife for a hat due to shape similarity). He did not recognise people, only examined various features of their faces. He perceived face as an object, as it, never You. The problem with making of judgement occurred probably because Dr P. was not able to relate any person or thing to himself. "...he did not have a real visual world, as he did not have a real visual self."(ibid.). This patient missed the world of internal experience which constitutes an image of own self and at the same time, it is continuously protected by this image. The ability as if of machine, computer thinking remained unimpaired (he could

play chess excellently through visualisation of the chessboard) yet, it became his only cognitive method what resulted in absurd situations and alienated him completely from all his relatives. Since he did not have the image of his own self, he could not also evaluate things and phenomena, put them into a relation to himself, determine their certain particular place within his internal world and thus create his value system and continually build his personality. Because making of any judgement necessarily conditions consciousness of subject, person which is implicitly and also explicitly present in every cognitive process. "A judgment is intuitive, personal, comprehensive, and concrete—we 'see' how things stand, in relation to one another and oneself. It was precisely this setting, this relating, that Dr P. lacked (though his judging, in all other spheres, was prompt and normal)." (Sacks 2009, p. 31).

10.2 Emotions and Cognition

Damasio formulates a hypothesis according to which damage of ventromedial prefrontal area of brain manifests by a disrupted ability of efficient thinking and decision–making and also of emotionality and experiencing of feelings. This dysfunction is shown through modification of patient's personality and his social relations. The damage of dorsolateral area of prefrontal cortex manifests especially in defects in attention and working memory. Thinking and decision–making in the personality and social sphere usually remain unchanged. Thinking and emotions "cross" in ventromedial prefrontal cortex and amygdale. These neuronal systems play a vital role when creating emotional states and experiencing feelings, and they are likewise responsible for a potential to store images of an object no longer accessible to senses.

It follows that seemingly "contradictory" processes (of thinking and decision–making on the one hand and of emotional states on the other) are generated by identical cerebral structures. Classical antinomy between rationality and emotionality seems to be overcome. Damasio explains this functional division through its advantageousness in fight for survival within a process of natural selection. As a substantial part of biological regulation, emotions, feelings, passions and instincts create a complex apparatus for useful decision–making and planning for the future in cooperation with a process of thinking, memory and attention. Emotions can be classified into primary and secondary. The primary emotions are innate and depend especially on the limbic system. Amygdale and the long curved structure called gyrus cinguli play significant role here. During evolution, the mechanism of secondary emotions has developed on the system of genetically "programmed" emotional states. Increase of adaptability due to survival represents the reason of their origin. The secondary emotions are formed through realizing of own emotional states when we create systematic connections among categories of objects or events and primary emotions. However, subcortical structures cannot create the secondary emotions. Their origin is conditioned by an activity of frontal areas of frontal lobes and somatosensory cortical areas.

The whole process commences with a mental image reflecting a certain situation. Sets of topographically organised representations created in vision, auditory and other cortical areas in cooperation with dispositional representations contained in association cortical areas form a neuronal base of this image. Dispositional representations containing information on our individual experience with previous emotional answers follow the created image.

10.3 Recommended Literature

DAMASIO, A.: *The Feeling of What Happens. Body, Emotion and The Making of Consciousness*. London: Vintage 2000.

SACKS, O.: *Muž, který si spletl manželku s kloboukem*. Praha: Dybbuk 2009.

THAGARD, P.: Úvod do kognitivní vědy. *Mysl a myslení*. Praha: Portál 2011, pp. 161–179.

NORMAN, D., N.: *Twelve Issues for Cognitive Science*. Available on: http://psych.stanford.edu/~jlm/pdfs/Norman80TwelveIssues.PDF

11. Cognition in Connection to Quantum Phenomena

Keywords: *quantum phenomenon, computation, non–computability, microtubule*

11.1 Theory of Consciousness as Roger Penrose's Physical Theory

Roger Penrose is one of the most respected and progressive mathematicians, cosmologists and philosophers of nowadays and at the same time, he is a supporter of explanation of conscious states as quantum phenomena. He postulates his comprehension of mind, consciousness and experience broadly, on the basis of a relation of three worlds — *Platonic world* representing a world of absolute mathematical truths, *physical world and world of our conscious experiences*. Penrose recognises two components of cognition — passive where realising is categorised and active one — i.e. all manifestations of our free will, our decision–making. A significant role in an effort to comprehend consciousness is played by a description of *connections* among these phenomena and also by its specification in a relation to a "computation" or "non–computation" character. The non–computation character is not identical with randomness because it is possible to simulate here also by computation at least to a high degree of approaching. It is not chaotic structuredness where one small change in the initial state results in great modifications in the final state. The non–computation character represents a substantial impossibility to formulate an ongoing process into certain equations through which we could simulate this process mathematically, i.e. systematically. As a matter of fact, conscious states include also a certain share of intelligence, insight, comprehension or free choice which cannot be formalised into any predictable system (again, a common feature with Chalmers' "hard" problem, as a problem which is not explicable through specification of any functions).

This method led to postulation of several basic assertions. Penrose characterises the process of thinking as making of a particular calculation. "The sense of consciousness is arisen purely by execution of a particular calculation."(Penrose 1999, p. 88). Penrose comprehends realizing as a feature of physical activity of brain. On the other hand, he accepts that although the respective physical activity stimulates the sense of consciousness, it cannot be completely simulated by a calculation mechanism. Also other thesis postulating inexplicability of consciousness through physical, information science or other scientific terms proceeds from this assertion.

Penrose sees a way to the satisfactory theory of consciousness in construction of theories, although physical ones, nonetheless theories of some new type. Contemporary physics lacks a complex theory which would reflect quantum mechanics principles and as well rules of classical physics concerning structures of great dimensions in its explanation principles. The problem actually lies in the fact that "fundamental principles valid in great and small scales differ from themselves significantly."(ibidem). The quantum field theory principles (i.e. quantum mechanics, Maxwell's electrodynamics and Einstein's special theory of relativity) are applied when explaining plenty of processes taking place in a human body on the level of atoms. They, for instance, explain a hereditary mechanism depending on quantum mechanical behaviour of DNA molecules, or describe chemical forces keeping molecules together. Classical physics rules (i.e. Newton's motion laws, Maxwell's electromagnetic field equations and Einstein's general theory of relativity) are used when describing phenomena of our everyday experience including

phenomena occurring on the cosmic level. So, if we wanted to formulate a homogenous set of laws enabling explanation of natural phenomena — from elementary particles to cosmic scopes on a level of current physics, we would stand before the same problem as when we try to find a homogenous theory explaining consciousness without a necessity to postulate any — ontological or epistemological — chasm. From existence of such a unifying theory, Penrose expects important breakthrough in explanation of brain activity.

Even if explanation of consciousness should have a nature of physical theory, non–computability remains a substantial feature of this phenomenon. Mathematical comprehension cannot be even simulated through a computation process. Even if we had perfect Turing machine whose basic characteristic is just a computation algorithm and which would be able to calculate endlessly without making any mistake, it would never achieve a quality of mathematical comprehension. Penrose sees mathematical formulation of reality as an apex of development which phenomenon of consciousness has passed. This process proceeds from consciousness present in animals through evolution of human thinking which further continues in development of human comprehension to mathematical formulation of reality. These levels form a linear continuum. The basic property of all conscious processes is their *non–computation* character. However, if the processes are controlled by physiological processes taking place in a human brain and the theory of consciousness has to be postulated on principles of physical theory, it necessarily follows that we have to look for the characteristic feature of "non–computability" somewhere within physical laws. Principles of Newton's mechanics as well as Maxwell's equations explaining electromagnetic and light phenomena and Einstein's equation applicable on quickly–moving objects and strong gravitational fields represent deterministic laws and are basically of computation character. But also quantum mechanics laws explained by Schrödinger's equation are deterministic laws with a significant computation character. It is thanks to these laws that we can successfully avoid randomness and non–computability on the level of elementary particles what the classical level of physical description did not enable. In the quantum mechanics, phenomenon of unpredictable behaviour of photons is explained through introduction of the so–called superposition state which we have already mentioned. "In classical physics, either one or the other thing can happen, while in the quantum mechanics, they can both happen at the same time." (Penrose 1994, p. 246). It is, indeed, a remarkable feature of this theory which might be also very helpful when constructing the theory of consciousness, because it is also characterised by bipolarity between neurobiological processes and subjective experience which seems to be unbeatable in majority of current concepts of consciousness. Yet, the basic property of conscious experience — its non–computation character cannot be grasped even by a medium of quantum physics laws, because also they are characterised by such formalisation of reality of elementary particles which is strictly deterministic and computable. However, a problem emerges when we want to move smoothly from one — microscopic level of reality to another — macroscopic one. It is in this moment that randomness and non–computability perfectly illustrated by a famous example of cat which is dead and alive at the same time come into play. So, if we had a gun whose trigger could be moved by a single photon, during emission of this photon hitting against an obstacle a quantum state of linear superposition of its two states — when the photon bounces from the obstacle and when it gets through it — would take place. The photon does not behave as the atom or molecule, it does not uses one way or the other, in the end it uses both ways offered *at the same time*. However, in this case, the cat to which the gun is pointed would represent the "first state" of the photon in which it bounces from the obstacle and it would not die, but in the "other state" in which the photon goes through the obstacle, it would be sentenced to be shot down. And thus, phenomenon commonly observable and explicable on

the level of elementary particles would become completely absurd on the level of our experience. In the physics, this phenomenon of impossibility of continual move from the quantum to classical level is termed as the wave function collapse.

It is in this connection that Penrose points out to absence of new or different physics. Such physics would conceptualise approximations and probabilities brought by the conventional theory enabling reconnection of two levels of reality into a coherent theory. In Penrose's view, it should have a nonlocal character in order to enable explanation of things significantly separated from each other. And at the same time, it should be a theory which could also include the non–computation character of conscious processes. Penrose calls this theory the objective reduction (OR). If we looked on functioning of human brain in the scope of this theory, a very interesting perspective of explanation of consciousness — the perspective of consciousness as a consequence of quantum mechanics phenomena taking place in our brain — would open to us. Yet, where to search for a place where these processes could occur? According to the theory constructed by Penrose in cooperation with Stuart Hameroff, this space is represented be a so–called microtubule.

11.2 Microtubules as the Venue of Quantum Processes

The microtubule is a structure similar to a straight tube consisting of thirteen columns of tubuline dimmers. Except for erythrocyte cells, microtubules can be found in every eukaryotic cell and are very crucial when monitoring behaviour of cells. However, it is their shape what Penrose as a physicist interests most in these tube structures. In order to be able to observe quantum phenomenon on the level of cells, we need a structure which would enable its uninterrupted course and thus it would "protect" these processes from random effects of external environment. According to Penrose, it is randomness of this effect that is, to a great extent, responsible for approximation and non–computability which the reduction (R) between two levels and two explanatory theories brings with itself. “What I say is that randomness of R arises from environmental effects.” (Penrose 1994, p. 248). Since microtubules in cells have a form of continuous structure which is hollow from inside, they would enable continuous, coherent course of quantum processes. “Microtubules are also remarkable from a mathematical perspective. If we look down through a microtubule and describe a way in which tubuline dimmers are arranged, spirally rising in thirteen columns, eight in one way, five in the other. Five, eight and thirteen are Fibonacci numbers and indicate very precise mathematical construction in microtubules.” (ibidem). All this, according to Penrose, focuses on a possibility to term these structures quantum processes venues. Nonetheless, the mentioned processes have to be also mutually connected among individual microtubules in a certain way. “We would need quantum — coherent oscillation within microtubules where tubulines would participate on a certain very complicated activity. Then the crucial idea would be that if we had enough of them together, they would reduce themselves in accordance with this non–computation new OR procedure which we need due to the reasons mentioned above.” (Penrose 1994, p. 249). Penrose finds connection even between a so–called readiness potential which was measured by a neurologist, Benjamin Libet[1], in a famous experiment with freedom of our conscious decision–making and comprehension of time within quantum mechanics.

Penrose’s theory of consciousness represents an original attempt to include the problem of consciousness in wide scope theories of current physics. Here, consciousness is not phenomenon indescribable by scientific methods because impossibility of its present–day satisfactory explanation is given by imperfectness and incompleteness of current physical theory of reality — on the one hand, reality of elementary particles, while on the other, reality of our everyday experience.

1) From results of Libet’s research follows that electric activity of brain precedes a volitive act in 550ms. Subjective realising of own decision takes places 200ms before the volitive act itself. (Libet, 1999)

11.3 Recommended Literature

PENROSE, R.: *Makrosvět, mikrosvět a lidská mysl*. Praha: Mladá fronta 1999.

PENROSE, R.: Mechanisms, Microtubules And The Mind. In: *Journal of Consciousness Studies*, 1, No. 2., Winter 1994.

PENROSE, R., HAMEROFF, S.: What Gaps? — Reply to Grush and Churchland. In: *Journal of Consciousness Studies*, 2, No. 2, 1995.

WILSON, R. A. — KEIL, F. C. (ed.). 1999. *The MIT Encyklopedia of the Cognitive Sciences*. Cambridge, Mass. : The MIT Press.

Bibliografia

ARISTOTELÉS: *O duši*. Praha: Rezek 1995.

AKVINSKÝ, T. 2003. *O pravdě. O mysli*. Praha : Krystal OP.

AKVINSKÝ, T. 2009. *Otázky o duši*. Praha : Krystal OP.

ARMSTRONG, D., M..: The Causal Theory of Mind. In: Rosenthal, D. (ed.): *The Nature Of Mind*. Oxford: Oxford University Press 1991.

AUGUSTÍN. *De Trinitate*. (on–line) (citované okt., 10., 2012). Access form the internet: URL:http://www.newadvent.org/fathers/1301.htm

BAARS, B., J.: *In The Theatre of Consciousness*. In: Journal of Consciousness Studies, 4, No. 4, 1997.

BECHTEL, W. (ed.): *Philosophy and the Neurosciences*. Oxford: Blackwell Publishers 2001.

BERMUNDÉS, L., J.: *Cognitive Science. An Introduction to the Science of the Mind.* New York: Cambridge University Press 2010.

BIERI, P.: Why Is Consciusness Puzzling? In: Metzinger, T. (ed.): *Conscious Experience*. Schöningh: Imprint Academic 1995.

BLACKMORE, S.: *Consciousness*. London: An Introduction. Hodder & Stoughton 2003.

CALVIN, W., H.: *Ako myslí mozog.* Bratislava: Kalligram 2000.

CLARK, A.: *Mindware. An Introduction to the Philosophy of Cognitive Science*. Oxford: Oxford University Press 2001.

CLARK, T., W..: Function And Phenomenology: Closing the Explanatory Gap. In: SHEAR, J. (ed.): *Explaining Consciousness. The Hard Problem*. MIT Press 1997.

CRICK:, F.: *The Astonishing Hypothesis. The Scientific Search for The Soul*. New York: Simon & Schuster 1995.

McCULLOCH, G.: *The Mind And It `s World*. London: Routledge 1995.

DAMASIO, A.: *Descartův omyl*. Praha: Mladá fronta 2000.

DAMASIO, A.: *The Feeling of What Happens. Body, Emotion and the Making of Consciousness*. London: Vintage 2000.

DAMASIO, A.: *Hledání Spinozy. Radost, strast a citový mozek*. Praha: Dybbuk 2004.

DENNETT, D., C.: *Consciousness Explained*. London: Penguin Group 1991.

DENNETT, D., C.: *Záhada ľudského vedomia*. Bratislava: Európa 2008.

DÉMUTH, A.: *Čo je to farba? Alebo historicko — psychologicko — filozofická expozícia do problematiky vnímania farieb.* Bratislava: IRIS 2005.

DÉSI, I.: *Tajemný mozek*. Praha: Orbis 1976.

DREDSKE, F.: *Naturalizing The Mind*. Massachusetts: The MIT Press 1997.

EYSENCK, M., W., KEANE, M., T.: *Cognitive Psychology. A Student's Handbook*. New York: Psychology Press 2010.

FODOR, J. 1976. *The Language of Thought*. Cambridge, Mass. : Harvard University Press.

GÁLIKOVÁ, S., GÁL, E.: (ed:): *Antológia filozofie mysle*. Bratislava: Kalligram 2003.

GÁLIKOVÁ, S.: *Psyché*. Bratislava: Veda 2007.

GÁLIKOVÁ, S.: *Úvod do filozofie mysle. Prípad psychofyzického problému*. Bratislava: Honner 2001.

McGINN, C.: *The Character of Mind*. New York: Oxford University Press 1982.

GOLDMAN, A., I. (ed.): *Readings in Philosophy and Cognitive Science*. London: The MIT Press 1993.

GREENFIELDOVÁ, S.: *Ľudský mozog*. Bratislava: Kalligram 2001.

VAN GULICK, R.: *Understanding the Phenomenal Mind: Are we Just Armadillos*? In: Davies, M.–Humphreys, G. W. (ed.): Consciousness, Psychological and Philosophical Essays. London: Basil Blackwell 1993.

VAN GULICK, R.: *What Would Count as Explaining Consciousness?* In: Metzinger, T. (ed.): Conscious Experience. Schöningh: Imprint Academic 1995.

HUNDERT, E., M.: *Philosophy, Psychiatry and Neuroscience: Three Approaches to the Mind. A Synthetic Analysis of the Varieties of Human Experience*. NewYork: Oxford Universisty Press Inc. 1989.

HUT, P., SHEPARD, R. N.: Turning "The Hard Problem" Upside Down. In: METZINGER, T. (ed.): *Conscious Experience*. Schöningh: Imprint Academic 1995.

CHALMERS, D. J.: Absent Qualia, Fading Qualia, Dancing Qualia. In: Chalmers, D. J.: *The Conscious Mind*. Oxford: Oxford University Press 1996.

CHALMERS, D. J.: Facing Up To The Problem of Consciousness. In: *Journal of Consciousness Studies*, 2, No. 3, 1995.

CHALMERS, D. J.: Moving Forward on The Problem of Consciousness. In: SHEAR, J. (ed.): *Explaining Consciousness — The „Hard Problem"*. London: The MIT Press 1996.

CHURCHLAND, P. M.: *The Engine of Reason, the Seat of the Soul*. Cambridge, MA: MIT Press 1995.

CHURCHLAND, P. S.: Eliminative Materialism and the Propositional Attitudes. In: ROSENTHAL, D. M. (ed.): *The Nature of Mind*. Oxford: Oxford University Press 1991.

CHURCHLAND, P. S.: Neurobiological Basis of Consciousness. In: MARCEL, A. J., BISIACH, E. (eds.): *Consciousness In Contemporary Science*. Oxford: Clarendon Press 1988.

CHURCHLAND, P. M., CHURCHLAND, P. S.: *On The Contrary.* Critical Essays. London: The MIT Press 1998.
JACSON, F.: What Mary Didn`t Know. In: *The Journal of Philosophy* LXXXIII 5 (May 1986), London.
JAMES, W.: Existuje vedomie? In: VIŠŇOVSKÝ, E., MIHINA, F. (ed.): *Malá antológia filozofie XX. storočia*: PRAGMATIZMUS, I. zväzok, Bratislava: IRIS, 1998.
JONES, T. 2004. Reduction and Anti–Reduction: Rights and Wrongs. In *Metaphilosophy*, č. 25, s. 614 — 647.
JONES, T. 2008. Unification. In PSILLOS, S. — CURD, M. (ed.). *The Routledge Companion To Philosophy of Science*. New York : Routledge.
KANT, I.: *Kritika Čistého rozumu.* Bratislava: Pravda 1979.
KIRK, R.: How Is Consciousness Possible? In: METZINGER, T. (ed.): *Conscious Experience.* Schöningh: Imprint Academic 1995.
Kognotívne vedy III., The collection of lectures from the seminar taking place on March 22, 2000 at CHTF STU in Bratislava.
KOUKOLÍK, F.: JÁ. *O vztahu mozku, vědomí a sebeuvědomování.* Praha: Karolinum 2003.
KOUKOLÍK, F.: *Mozek a jeho duše.* Praha: Makropulos 1995.
KOUKOLÍK, F.: *Sociální mozek.* Praha: Karolinum 2006.
LEVIN, J.: *Qualia.* Routledge Encyklopedia of Philosophy, Version 1.0, London and New York: Routledge (1998)
LIBET, B.: Can Conscious Experience Affect Brain Activity? In: *Journal of Consciousness Studies*, 10, No. 12, 2003.
LIBET, B.: Do We Have A Free Will? In: *Journal of Consciousness Studies,* 6, No. 8–9, 1999.
LYONS, W. (ed.): *Modern Philosophy of Mind*. Dublin: Trinity Colledge 1995.
LYCAN, W, G.: Consciousness as Internal Monitoring. In: BLOCKS, N., FLANAGAN, O., GUZELDERE, G. (eds.): *The Nature Of Consciousness*. Masachusetts: MIT Press 1997.
MARGOLIN, U.: *Kognitivní věda, činná mysl a literární vyprávědní*. ÚČL AV ČR, Praha 2008.
NAGEL, E. 1961. *The Structure of Science*. New York : Harcourt, Brace, Jovanovich.
NAGEL, T.: What Is It Like to Be A Bat? In: *Mortal Questions*. Cambridge: Cambridge University Press 1979.
NAGEL, T.: Consciousness and Objective Reality. In: WARNER, R., SZUBKA, T. (ed.): *The Mind — Body Problem*. London: Basil Blackwell 1994.
NAGEL, T.: *The Limits of Objectivity*. *The Tanner Lecture on Human Values.* Oxford: Oxford University Press 1979.
NOSEK, J.: *Mysl a tělo v analytické filozofii.* Praha: Filosofía 1997.
PENROSE, R.: *Makrosvět, mikrosvět a lidská mysl.* Praha: Mladá fronta 1999.
PENROSE, R.: *Mechanisms, Microtubules And The Mind*. In: Journal of Consciousness Studies, 1, No. 2., Winter 1994.
PENROSE, R., HAMEROFF, S.: *What Gaps? — Reply to Grush and Churchland*. In: Journal of Consciousness Studies, 2, No. 2, 1995.
PEREGRIN, J., SOUSEDÍK, P., SOUSEDÍK, S. (ed.): *Co je analytický výrok?* Praha: Oikoymenh 1995.
PETRŮ, M.: *Fyziologie mysli. Úvod do kognitivní vědy.* Praha: Triton 2007.
PLACE, U. T.: Is The Consciousness A Pprocess of Brain? In: *British Journal of Psychology*, No. 47, 1956.
PLATON 1990. *Dialógy*. Bratislava : Tatran.
POPPER, K. R., ECCLES, J., C.: *The Self and It`s Brain.* London: Routledge 1993.
PUTNAM, H., RORTY, R.: *Co po metafyzice?* Bratislava: Archa 1997.
RESTAK, R. M.: *Krajiny mozgu.* Bratislava: Slovenský spisovateľ 1998.
REY, G.: *Contemporary Philosophy of Mind. A Contentiously Classical Approach.* Masachusetts: Blackwell Publishers Inc. 1997.
ROBINSON, D. (ed.): *The Mind.* Oxford: Oxford University Press 1998.
ROSENTHAL, D. M.: *The Nature of Mind.* Oxford: Oxford University Press 1991.
RUSSELL, B.: *Human Knowledge.* London: George Allen & Unwin 1948.
RYLE, G.: *The Concept of Mind.* London: Penguin Group 1990.
RYBÁR, J. (ed.): *Filozofia a kognitívne vedy*. Bratislava: Iris 2002.
RYBÁR, J. (ed.): *Kognitívne paradigmy*. Bratislava: Európa 2012.
RYBÁR, J., KVASNIČKA, V., FARKAŠ, I. (eds.): *Jazyk a kognícia*. Bratislava: Kalligram 2005.
SACKS, O.: *Muž, který si spletl manželku s kloboukem.* Praha: Dybbuk 2009.
SARKAR, S. 1998. *Genetics and Reductionism*. New York : Cambridge University Press.
SEARLE, J.: Consciousness, Free Action and The Brain. In: *Journal of Consciousness Studies,* 7, No. 10, 2000.
SEARLE, J.: *Myseľ, jazyk, spoločnosť.* Bratislava: Kalligram 2007.
SEARLE, J.: *Mysl, mozek, věda*.. Praha: Madá fronta 1994.
SEARLE, J.: *The Rediscovery of Mimd.* Massachusetts: MIT Press 1992.
SEARLE, J.: Why I Am Not A Property Dualist. In: *Journal of Consciousness Studies*, 9, No. 12, 2002.
SHOEMAKER, S.: Qualities And Qualia: What Is in Mind? In: *Philosophy and Phenomenological Research,* 1990, 50, Supplement.
SMELSER, N., J., BALTES, P., B.(ed.): *International encyclopedia of the social & behavioral sciences.* Amsterdam: Elsevier 2002.
SORABJI, R.: *Aristotelés: O paměti.* Praha: Rezek 1995.
SPINOZA, B.: *Etika*. Praha: Dybbuk 2004.
STILLINGS, N., A. (ed.): *Cognitive Science. An Introduction.* Cambridge: The MIT Press 1995.

STRAWSON, G.: *Mental reality*. London: MIT Press 1994.
THAGARD, P.: *Úvod do kognitivní vědy. Mysl a myšlení*. Praha: Portál 2001.
VARELA, F., J., SHEAR, J.: *First–person methodologies: What, Why, How?* (online). Available on: http://www.imprint.co.uk/view/JCSCHAP.htm
WILSON, R. A. — KEIL, F. C. (ed.). 1999. *The MIT Encyklopedia of The Cognitive Sciences*. Cambridge, Mass. : The MIT Press.
WITTGENSTEIN, L.: *Filozofická skoumání*. Praha: Filozofia, 1998.

Mgr. Máruia Bednáriková, Ph.D.

Introduction to Cognitive Science

Textbook
Firs edition

Peer reviewers
Prof. PhDr. Silvia Gáliková, CSc.,
Doc. Mgr. et Mgr. Andrej Démuth, Ph.D.

Translated by Ing. Danica Chames
Graphic © Ladislav Tkáčik

fftu

Publisher
Faculty of Philosophy and Arts · Tranava University in Trnava
Hornopotočná 23 · 918 43 Trnava
filozofia@truni.sk · Http://fff.truni.sk

in cooperation with

Towarzystwo Słowaków w Polsce
ul. św. Filipa 7 · 31–150 Kraków
zg@tsp.org.pl · Http://www.tsp.org.pl

ISBN 978-83-7490-613-5