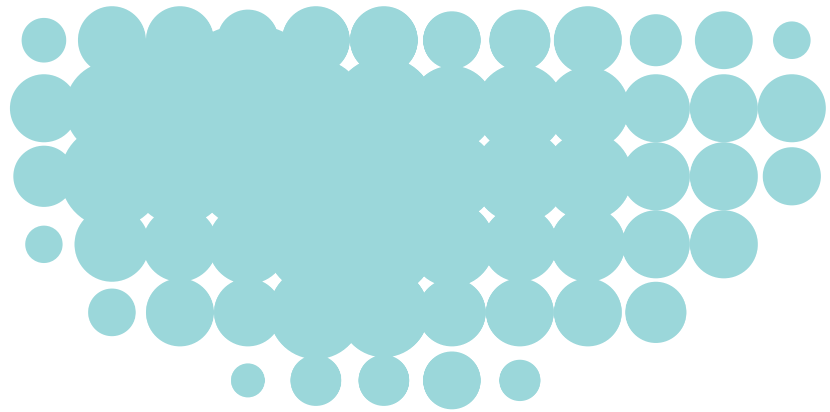
Foundations of Cognitive Neuroscience

Silvia Gáliková

Edition Cognitive Studies
fftu

Foundations of Cognitive Neuroscience



Silvia Gáliková

Edition Cognitive Studies
fftu

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 978-83-7490-601-4

Contents

Introduction

Cognitive neuroscience is a young but intensively growing discipline which aims at solving the problem of how brain manages to support human thinking, feeling, deciding, dreaming, remembering etc. The question about the relationship between mind and body has been prevailing in the history of philosophy for centuries. With the help of sciences and particularly of cognitive neuroscience, the so called *perennial* problem is on its way to disappear. Mental and cognitive states became fruitful explanada for many experimental, clinical and scientific disciplines. As emphasized in the text, cognitive neuroscience is a highly interdisciplinary endeavor which draws on a wide range of research methods and approaches, each with its own history and underlying theoretical frame of reference. One important challenge for philosophy and humanities in general, is to find ways of integrating the insights gained from the different methods to allow the field as a whole to converge on a common theoretical framework. In the textbook the predominant research approaches are briefly described and some of the prospects for integration are considered. Main objective of the following chapters is to offer a rather shortened but at the same time representative introduction to the fundamental problems and methods within contemporary cognitive neuroscience. In spite of the introductory charater of the following text I do hope, that students will consider it as a usefull starting point for further study of neural activity of the brain — the building block of human mind.

Bratislava, May, 2012 S.G.

I. Historical roots of cognitive neuroscience

Key words: *cognition, representation, information processing, thinking, interdisciplinarity, knowledge*

Cognitive neuroscience has emerged in the 1990s at the interface between the neural sciences and the cognitive and

computational sciences. On one side, it grows out of the traditions of cognitive psychology and neuropsychology, which use behavioral experiments to uncover the processes and mechanisms lying behind human cognitive functions, and of computational approaches within cognitive psychology, which rely on computational models to develop explicit mechanistic accounts of these functions. On the other side, it grows out of the traditions of behavioral, functional, and systems neuroscience, which use neurophysiological and neuroanatomical methods to explore the mechanisms underlying complex functions. It draws on findings and principles of cellular and molecular neuroscience. It joins these approaches with the use of new functional brain imaging methods, such as functional magnetic imaging (fMRI), positron emission tomography (PET), as well as other methods in cluding electroencephalography (EEG) and magnetoencephalography (MEG), and with a growing research tradition in computational neuroscience.

A starting point for cognitive neuroscience is the idea that a cognitive or mental state consists of a pattern of activity distributed over many neurons. For example, the experience an individual has when holding, sniffing, and viewing a rose is a complex pattern of neural activity, distributed over many brain regions, including the participation of neurons in visual, somatosensory, and olfactory, and possibly extending to language areas participating in representing the sound of the word „rose" and or other areas where activity represents the content of an associated memory that may be evoked by the experience.

A great deal of research has concerned the nature of the active representations the brain uses for objects of perception or cognition. There is now a great deal of support for the view that the brain's representations typically consist of patterns of activity involving fairly large ensembles of neurons. These research approaches within the field have the oldest historical roots, based as they often are in the assessment of the effects of naturally occurring brain damage on cognitive function. A seminal case study was the report by Broca (1861) of a man with a severe disturbance of language arising from a large brain lesion in the posterior portion of the left frontal lobe. Since Broca's day, neurologists and neuropsychologists have investigated the effects of accidental or therapeutic brain lesions in humans, and many key insights have arisen from these studies. The subdiscipline of cognitive neuropsychology has arisen specifically around the study of the effects of brain lesions. A complementary has grown up around the use of brain lesions in animals carried out with specific experimental intent. This tradition is relevant to human cognitive neuroscience in view of the very close homology between many structures in the human brain and corresponding structures in the primate brains. This work has obvious advantages in that lesions can be carefully targeted to particular brain areas to test specific hypotheses. Many key insights have emerged from this work, including the discovery of complementary processing streams in the visual system. However, the approach is not without its pitfalls, since a lesion may have unintended and unobserved effects in other brain regions; the refinement and extension of experimental lesion techniques is ongoing. Brain imaging studies, like lesion studies, have often been used to try to determine the loci in the brain associated with particular cognitive functions. However, in addition to this, brain imaging has begun to reveal a great deal about the plasticity of the brain, since patterns of brain activation can change dramatically with practice. Imaging is also being used in search of distributed networks in the brain that contribute to particular cognitive functions. Studies relying on microelectrodes to record from neurons in the brains of behaving animals can allow researchers to study the representations that the brain uses to encode information, and the evolution of these representations over time. Several fundamental observations have, some of which have been discussed above. These studies indicate, among other things, that the brain relies on distributed representations, that neurons participate dynamically and interactively in the construction of representations of external inputs, and that the representational significance of the firing of a particular neuron can vary as a function of context. Neuronal recording studies have had a profound impact on our understanding of the nature of representations of extrapersonal space. There are neurons in the brain that encode the location of objects in extrapersonal space simultaneously in relation to many different parts of the body, including the limbs and the head and other neurons that encode the locations of objects in relation to other objects. An important recent development is the ability to record from up to 100 individual neurons at a time. Brain imaging studies, like lesion studies, have often been used to try to determine the loci in the brain associated with particular cognitive functions. However, in addition to this, brain imaging has begun to reveal a great deal about the plasticity of the brain, since patterns of brain activation can change dramatically with practice. Imaging is also being used in search of distributed networks in the brain that contribute to particular cognitive functions. It is a commonsense to consider human brain as the most complicated object in the entire universe. The genuine feature of its uniqueness transcends the level of anatomy. Important role is played by organization of neurons,

their mutual properties and relations. Of fundamental importance are the properties of particular brain functional systems which include — organisation, integration, paralel distributon of informations, plasticity, selectivity, hierarchization etc. In the history of neuroscience there has been a long debate on the relationship between structure and functions of specific brain areas. Existence or nonexistence of a strict dichotomy between structure and functions of brain lasted within discussions on localization of brain functions since the 18th century. It has been demonstrated that the relation between specific anatomical structures and mental capacities is far from being linear and simple. In order to understand how cognitive processes arise from neural activity, we should remind two contrasting views: a) The modular approach, championed by David Marr for vision and Noam Chomsky for language, and systematized as a general approach by Fodor (1983), holds that the brain consists of many separate modules that are informationally encapsulated in that their operation is informed only by a very limited range of constraining sources of information. The modular view also holds that the principles of function are specific to each domain, and that distinct and individualized mechanisms are used to subserve each distinct function. For example, the initial assignment of the basic grammatical structure to a sentence is thought to be based only on the syntactic classification of words and their order and is thought to be governed by the operation of a system of structure sensitive rules. The module that carries out this assignment is thought to be structured specifically so that it will acquire and implement structure sensitive rules, and to contrast in the principles that it employs internally with other modules that carry out other tasks, including other aspects of language processing, such as the assignment of meanings to the words in a sentence. In Fodor's view, there are many specialized modules primary and secondary cortical areas and their subcortical inputs and output). These are complemented by a general purpose cognitive system that is completely openended in the computations that it can undertake and in the range of informational sources that it can take into consideration.

The alternative, interactive approach, has its seeds in the ideas of Luria (1966) and overlaps with the ideas of Damasio (1989). On this view, cognitive outcomes such as the assignment of an interpretation to a sentence arise from mutual, bidirectional interactions among neurons in populations representing different types of information. An example of a system addressing the representations and interactions involved in reading individual words aloud. The formation of the sound of a word from a visual input specifying its spelling arises from an interactive process involving orthographic (i.e., letter identity), semantic, phonological, and contextual information. Both the modular and the interactive view are consistent with the idea that neurons in the brain are organized into populations specialized for representing different types of information. Where they differ is in the extent and the role of bidirectional interactions among participating brain areas.

While investigations relying on lesion and behavior approaches, neuronal recording studies, and functional brain imaging have provided and will continue to provide the empirical evidence on which to build our understanding of the basis of cognitive functions in the brain, these approaches, even when used in a convergent way, may still fail to provide a complete understanding of how cognitive functions emerge from underlying neural activity. This may require the use of additional tools provided by mathematical modeling and computer simulation. Computational and Mathematical Modeling Approaches These approaches allow researchers to formulate possible accounts of specific processes in the form of explicit models that can be analyzed mathematically or simulated using computers to determine whether they can account for all of the relevant neural and behavioral evidence. Three examples of cases in which computational models have already led to new thinking will be briey considered. First, a number of computational modeling studies have shown that many aspects of the receptive field properties of neurons and their spatial organization in the brain can arise through the operation of very simple activity dependent processes shaped by experience and a few rather simple additional constraints Second, models may aid in the understanding of the pattern of deficits seen in patients with brain lesions. Certain patients with an acquired dyslexic syndrome known as deep dyslexia make a striking form or error known as semantic errors; for example the patient may misread APRICOT as „peach“. In addition, all such patients also make visual errors, for example, reading SYMPATHY and „symphony“. Early, noncomputational accounts postulated that there must be two separate lesions, one affecting visual processing and the other affecting semantic processing. However, computational models of the reading process have shown that a single lesion affecting either the visual or the semantic part of an interactive neural network will lead to errors of both types. Thus, the coexistence of these errors may be an intrinsic property of the underlying processing architecture rather than a reflection of multiple distinct lesions. A third area where computational models have shed considerable light is in the interpretation of the receptive field properties of individual neurons. While initial interpretations were based on verbally describable features such as oriented bars or edges, such properties are not always apparent, and even when they are, a more detailed characterization may be possible in computational terms. A further area of fertile research is in the use of computational models to explain and catalog the ways in which neuronal activation changes dynamically in the course of task performance.

There are still many open issues in cognitive neuroscience and theory as well. Cognitive neuroscience is young, and there is a great deal of work to be done. No aspect of cognition is fully understood, and in general, the more abstract or advanced the cognitive function, the less is known about its neural basis. A few of the most important and interesting issues that remain to be addressed are formulated in the following questions, such as: How does the brain learn?, What makes an experience conscious?, What is the basis for the unique cognitive capacities of the human brain, relative to that of other, simpler organisms?

There is a great deal known about the basic mechanisms of synaptic plasticity, but typically these are studied in highly reduced preparations such as brain slices. The basic processes that are studied in slices surely play a role in the shaping of neural connections in the whole, living brain, but they are also undoubtedly modulated by processes that are usually eliminated in slices. We know that attention and engagement in processing is essential for learning, and there is good reason to believe that learning is gated by various neuromodulatory mechanisms in the brain, but the details of the modulation and gating processes are only beginning to be explored. Although some considerable progress has been made in characterizing the concomittants of consciousness, there is no overall understanding of exactly what it is about the activity of the brain that gives it the attribute of consciousness. It appears likely that consciousness will not be localizable; although it may be highly dependent on specific brain structures (e.g., those that regulate sleep vs. wakefulness, etc.), it may well depend on the intact functioning of many interacting parts of the brain. Exactly why or how onsciousness arises from these interactions is not at all understood. The issue of what sets humans apart from other organisms remains one of the central unresolved questions. The similarity of the human genome to that of closely related species can be taken in different aspects and approaches. Cognitive neuroscience is a highly interdisciplinary endeavor, and draws on a wide range of research methods and approaches, each with its own history and underlying theoretical frame of reference. One important challenge for the field is to find ways of integrating the insights gained from the different methods to allow the field as a whole to converge on a common theoretical framework. In the follwing chapters the predominant research approaches are briefly described and some of the prospects for integration are considered.

Suggested readings

Bechtel, W., Graham, G.: *A Companion to Cognitive Science*. Oxford: Blackwell, 1999.
Gardner, H.: *The Mind's New Science: A History of the Cognitive Revolution*. New York: Basic Books, 1985.
Green, D. W.: *Cognitive Science: An Introduction*. Malden, MA: Blackwell, 1996.
Harnish, M. R.: *Minds, Brains, Computers: An Historical Introduction to the Foundations of Cognitive Science*. Oxford: Blackwell, 2002.
Thagard, P.: *Úvod do kognitivní* vědy. Praha: Portál, 2001.

II. Building blocks of mind

Key words: *neuron, synapse, neurotransmiter, action potential, dopamine*

Foundations of neuroscience are based on the inquiry of the nature of nervous system, its functioning and impairments.

In 1780 Lavoisier and Laplace initiated the idea about the analogous nature of processes in living and nonliving systems. Scientists have discovered that breathing, inhaling oxygen and carbon oxide is the product of burning processes in the body.

At birth, the human brain weighs approximately 400 g. It grows to an average of 1,450 g in adults and is roughly the size of a ripe grapefruit. The basic building block of the brain, indeed of the entire nervous system, is the *neuron*, *a cell that is specialized for receiving and transmitting a neural impulse.* Neurons are the components that form nerve tracts throughout the body and m all brain structures. How many neurons are there in the brain? Available estimates vary tremendously — some scholars suggest a grand total of 180 billion cells of all types in the brain, including not only neurons, but nonneural cells, too (e.g., connective and circulatory tissue). Some 80 billion of these cells, as estimated, are "directly engaged in information processing". To put that figure in perspective, consider that the Milky Way Galaxy has about 100 billion stars. The details of the structure of neurons vary, but each neuron within the nervous system has the same general features. At one end of the neuron, many small branchlike fingers called *dendrites* gather a neural impulse into the neuron itself. In somewhat more familiar terms, the dendrites are the *input* structures of the neuron, taking in the message that is being passed along in a particular neural tract. The central portion of each neuron is the cell body, or *soma*, where the biological activity of the cell is regulated. Extending from the cell body is a longish extension or tube, the *axon*, which ends in another set of branchlike structures called *axon terminals* or sometimes *terminal arborizations;* the latter term derives from the treelike form of these structures. The axon terminals are the *output* end of the neuron, the place where the neural impulse ends within the neuron itself. Obviously, this is the location where an influence on the next neuron in the pathway must take place. *Receptor cells* react to the physical stimulus and trigger a pattern of firing down *sensory neurons.* These neuron tracts pass the message along into the spinal cord. For a simple reflex, the message loops quickly through the spinal cord and goes back out to the arm muscles through a tract of *motor neurons* that terminate at *effector cells,* which connect directly to the muscle fibers and cause the muscles to pull your arm away. As the reflex triggers the quick return of a message out to the muscles, it simultaneously routes a message up the spinal cord and into the brain. Thus the second route involves only the central nervous system, the spinal cord, and brain. There is only one kind of neuron in the central nervous system, called an *interneuron or association neuron.* Because we are concerned only with the brain here, we are interested only in the interneurons of the central nervous system. For simplicity, I will just refer to them as neurons here.

There may be relatively few or many axon terminals emanating from a single neuron. In either case these terminals are adjacent to dendrites from other neurons. Thus an impulse within a neuron terminates at the axon terminals and is taken up by the dendrites of the next neurons in the pathway, the neurons whose dendrites are adjacent to the axon terminals. The *region where the axon terminals of one neuron and the dendrites of another come together* is the *synapse***.** For the most part, the neurons do not actually touch one another. Instead, the synapses in the human nervous system are extremely small physical gaps or clefts between the neurons. Note that the word *synapse* is also used as a verb: A neuron is said to synapse on another, meaning that it passes its message on to that other neuron. A general law of the nervous system, especially in the brain, is that any single neuron synapses on a large number of other neurons. The evidence for this *divergence* is that a typical neuron synapses on anywhere from 100 to as many as 15,000 other neurons. Likewise, many different neurons can synapse on a single destination neuron, a principle known as *convergence*. For the bulk of the nervous system, the bridge across the synaptic cleft involves chemical activity within the synaptic cleft itself. A neuron releases a chemical transmitter substance, or simply a *neurotransmitter*, from small *buttons* or *sacs* in the axon terminals. This chemical fits into specific receptor sites on the dendrites of the next neuron and thereby causes some effect on that next neuron. Two general effects are possible, excitation and inhibition. Some 60 or more different neurotransmitters have been identified and studied. Many seem to have rather ordinary functions, maintaining the physical integrity of the living organism, for instance. Others, especially acetylcholine and possibly norepinephrine, seem to have major influences on cognitive processes such as learning and memory. Interestingly, decreased levels of acetylcholine have been found in the brains of people with Alzheimer's disease, with very low levels of acetylcholine associated with more severe dementia. It has been suggested that this as part of the explanation for the learning and memory deficits observed among such patients, although it could be a side effect of the disease instead of a cause. In either case the result suggests that acetylcholine plays some kind of essential role in normal learning and memory processes. Before leaving the neuronal level of the nervous system, note that significant research is being done on various psychobiochemical properties of the neural system, such as the direct influence of different chemical agents on neurotransmitters and the resulting behavioral changes. In *neuromodulation* several classes of neurotransmitters in the nervous system regulate diverse populations of neurons — one neuron uses different neurotransmitters to connect to several neurons. As opposed to direct synaptic transmission, in which one presynaptic neuron directly influences a postsynaptic partner (one neuron reaching one other neuron), neuromodulatory transmitters secreted by a small group of neurons diffuse through large areas of the nervous system, having an effect on multiple neurons. Examples of neuromodulators include dopamine, serotonin, acetylcholine, histamine and others. A neuromodulator is a relatively new concept in the field, and it can be conceptualized as a neurotransmitter that is not reabsorbed by the presynaptic neuron or broken down into a metabolite. Such neuromodulators end up spending a significant amount of time in the CSF (cerebrospinal fluid), influencing (or modulating) the overall activity level of the brain. For this reason, some neurotransmitters are also considered as neuromodulators. Examples of neuromodulators in this category are serotonin and acetylcholine. Just as various psychoactive drugs affect the functioning of the nervous system in a physical sense, current research is now identifying the effects of drugs and other treatments on the functioning of the nervous system in a psychological or cognitive sense, the effect of alcohol intoxication — the greatest enemy of human organism and mind.

References

Mysliveček, J. a kol. (2009): *Základy neurověd*. Praha: Triton.
Petrů, M. (2008): *Fyziologie mysli — Úvod do kognitivní* vědy. Olomouc: Triton.
Rybár, J., Beňušková, Ľ., Kvasnička, V. (2002): *Kognitívne vedy*. Bratislava: Kalligram.
Sternberg, R. (2002): *Kognitivní psychologie*. Praha: Portál.

III. Functional brain anatomy

Key words: *automatic nervous system*, ascending reticular activating system, *cortex, homeostasis*

The central nervous system is composed of millions of nerve and glial cells, together with blood vessels and a little connective tissue. The nerve cells, or neurons, are characterized by many processes and are specialized for reception and transmission of signals. The glial cells, termed neuroglia, are characterized by short processes that have special relationships to neurons, blood vessels, and connective tissue. The brain is the enlarged, head end of the central nervous system; it occupies the cranium, or brain case. The term cerebrum (L., brain; adjective cerebral) generally means brain, but sometimes is used for the forebrain and midbrain only. Encephalon, of Greek origin, is found in such terms as encephalitis, which means inflammation of the brain. The brain presents three main divisions: forebrain (prosencephalon), midbrain (mesencephalon), and hindbrain (rhombencephalon). The forebrain in turn has two subdivisions, telencephalon (endbrain) and diencephalon (interbrain). The hindbrain likewise has two subdivisions, the metencephalon (afterbrain) and the myelencephalon (marrowbrain). The bulk of the brain is formed by two cerebral hemispheres, which are derived from the telencephalon. The hemispheres are distinguished by convolutions, or gyri, which are separated by sulci. The diencephalon lies between the hemispheres. It forms the upper part of the brain stem, an unpaired stalk that descends from the base of the brain. The brain stem is formed by the diencephalon,

midbrain, pons, and myelencephalon, or medulla oblongata. The last is continuous with the spinal cord at the foramen magnum. The cerebellum is a fissured mass of gray matter that occupies the posterior cranial fossa and is attached to the brain stem by three pairs of peduncles. Twelve pairs of cranial nerves issue from the base of the brain and brain stem. The cerebral cortex, which is the most superficial part of the hemispheres and is only a few millimeters in thickness, is composed of gray matter, in contrast to the interior of the hemispheres, which is composed partly of white matter. Gray matter consists largely of the bodies of nerve and glial cells, whereas white matter consists largely of the processes or fibers of nerve and glial cells. Behaviour of men can be partially considered as the outcome of a complicated activity of specific systems of the brain. Perception, memory, attention, thinking, speech, emotions etc. help to regulate reproductionand optimal adaptation to the environment. Investigating the nature of specific functional areas of the brain has been supported by experimental research and the study of impairments of particular brain structures and functions. Importance of functional brain anatomy lies in the usage of an integral approach on the origin, evolution and treatment of neurological and mental diseases. In a number of impairments and syndromes the ethiology has been proved to be multifactorial — formed by the variety of genetic, anatomical, personal, social and other determinants. Within the evolution of human brain a certain type of conservancy has been recognized, either on the biochemical, cellular or anatomical level. Brains of animals work according to a similar plan which has evolved from the nervous system of more primitive organisms. We are bearly aware of the fact that inside our heads there is the “seat” of a creamy coloured object. Ignoring many levels of intermediate neural functioning and complexity, we now take a tremendous leap from the level of single neurons to the level of the entire brain, the complex “biological computer.” To account for all human behavior, including bodily functions that occur involuntarily (e.g., digestion), would entail an extensive discussion of both the central and the peripheral nervous systems. But to explore neurocognition, we have to limit ourselves to just the central nervous system, the brain and spinal cord. In fact, our discussion even omits much of the central nervous system, save for the neocortex (or cerebral cortex), which sits at the top of the human brain, and a few other nearby structures. The physically lower brain structures are collectively called the old brain or brain stem. This portion of the brain is older in terms of evolution, for the most part governing basic, primitive functions (e.g., digestion, heartbeat, and breathing). The old brain structures are present in all mammals. The **neocortex,** or **cerebral cortex,** *the top layer of the brain, responsible for higher–level mental processes.* The neocortex is a wrinkled, convoluted structure that nearly surrounds the old brain, the two halves or hemispheres cover about 2500 cm2 and are from about 1.5 to 3 mm thick, about as thick as the cover of this textbook. The wrinkling comes about by trying to get such a large surface area in a small space. It would be like trying to get a piece of paper into a cup. To get the paper in, you wrinkle it up. The neocortex is; the m recent structure to have evolved in the human brain ***(****neo* means new) and is much larger in humans than in other animals; compare the average weight in humans, 1,450 g, with that of the great apes, 400 g. And because the neocortex is primarily responsible for higher mental processes such as language and thought, it is not surprising it is so large relative to the rest of the brainabout three–fourths of the neurons m the human brain are in the neocortex. The side, or lateral, view ***(****lateral* means "to the side") reveals the four general regions, or *lobes*, of the neocortex; clockwise from the front, these are the *frontal lobe, parietal lobe, occipital lobe,* and *temporal lobe,* named after bones on top of them (e.g., the temporal lobes lie beneath your temples). Each hemisphere of the neocortex is a single sheet of neural tissue. The lobes are formed by the larger :o Ids and convolutions of the cortex, with the names used as convenient reference term the regions. As an example, the central fissure, or fissure of Rolando, is merely one of the

deeper folds in the brain, serving as a convenient landmark between the frontal and parietal lobes. Three other subcortical (below the neocortex) structures are especially important — deep inside the lower brain structures is the *thalamus,* meaning "inner room" or "chamber." It is often called the gateway to the cortex because almost all messages entering the cortex come through the thalamus (a portion of the olfactory sense of smell is one of the very few exceptions). In other words, the thalamus is the major relay station from the sensory systems of the body into the neocortex. Just above the thalamus is a broad band of nerve fibers called the *corpus callosum.* As described later, the corpus callosum is the primary bridge across which messages pass between the left and right halves the hemispheres of the neocortex. The third structure is the *hippocampus,* from the Latin word for "sea horse," referring to its curved shape. The hippocampus lies immediately interior to the temporal lobes, that is, underneath the temporal lobes but in the same horizontal plane. The autonomic nerve fibers form a subsidiary system that regulates the iris of the eye and the smooth–muscle action of the heart, blood vessels, glands, lungs, stomach, colon, bladder, and other visceral organs not subject to willful control. Although the autonomic nervous system's impulses originate in the central nervous system, it performs the most basic human functions more or less automatically, without conscious intervention of higher brain centers. Because it is linked to those centers, however, the autonomic system is influenced by the emotions; for example, anger can increase the rate of heartbeat. All of the fibers of the autonomic nervous system are motor channels, and their impulses arise from the nerve tissue itself, so that the organs they innervate perform more or less involuntarily and do not require stimulation to function. Autonomic nerve fibers exit from the central nervous system as part of other peripheral nerves but branch from them to form two more subsystems: the sympathetic and parasympathetic nervous systems, the actions of which usually oppose each other. For example, sympathetic nerves cause arteries to contract while parasympathetic nerves cause them to dilate. Sympathetic impulses are conducted to the organs by two or more neurons. The cell body of the first lies within the central nervous system and that of the second in an external ganglion. Eighteen pairs of such ganglia interconnect by nerve fibers to form a double chain just outside the spine and running parallel to it. Parasympathetic impulses are also relayed by at least two neurons, but the cell body of the second generally lies near or within the target organ. For A. Damasio activity of the autonomous nervous system is analogous to a large branched tree. Metaphore of a high robust tree encompasses according to Damasio the history of uman evolution because permanently growing branches pertain reccurent communication with their roots. Funamental function of this innate and automatized "make–up" of the tree (brain) is to achieve *homeostasis* — most convenient adaptation to the inner and outer environment. Tree representing a homestatic system is made up of a number of levels from the lowest to most high levels. At lowest levels metabolic processes work such as controle of heart beat and blood preasure, basic reflexes and immunity system. On the middle branches the pain behavior occurs and pleasure (chemicals — endorphines). At higher level organism feels hunger, thirst, sexuality and at the highest level there appear emotions — „crown jewel of automatic life regulation" (Damasio, 2000, 44). It is highly important that the ongoing processes on above mentioned levels are active since birth. Whether and when they will be activated depends on further evolution and experience of an individual. Examination of mutual relations between particular parts, levels and properties is the topic of next chapter.

Suggested readings

Damasio, A. (2000): Descartesův omyl. Praha: Mladá fronta.
Koukolík, F. (2000): *Lidský mozek*. Praha: Portál.
Penfield, W., Rasmussen, T. (1950): *The Cerebral Cortex of Man: A Clinical Study of Localization of Function*. New York: MacMillan.

IV. Methods of cognitive neuroscience

Key words: *positron emission tomography, transcranial magnetic resonance, electroencephalography, lesions*

Cognitive neuroscience embraces classical methods of neuroscience, neurophysiology, neurology and contributes with new technologies and approaches. Similarly as in neuroscience, there is a number of diagnostic, experimental and research methods. Amongst most frequent are so called direct and direct methods. Aim of direct methods in cognitive neuroscience is identification of the neural correlates of particular cognitive states, such as thoughts, feelings, imaginations, decisions etc. Search for neural correlates goes hand in hand with optimism in achieving a reduction explanation of mental states, for example in neurobiological terms. The problem of this approach lies firstly in the parallel distributed nature of neuronal activity and secondly in the existence of a huge number of levels of explanation, briefly said, from the molecular to the social level.

The methods for investigating the structure and functioning of the brain fall into two broad categories, those involving medically based techniques and those based on behavioral assessments. One of the fundamental neurobiological methods are *lesions* — the study of brain impairments. Needless to say, the investigation technique — deliberate lesioning of the brain, was used by R. Sperry. Only two kinds of subjects —laboratory animals and patients with medical conditions requiring brain surgery — can be used.

A longstanding tradition, however, reports case studies of people or groups of people who by disease or accident have experienced damage or lesions to the brain. Much of the evidence comes from victims of strokes, diseases, aneurysms, head injuries, and other accidental circumstances. In all cases, the site and extent of the brain lesion are important guides to the kind of disruption in behavior that is observed and vice versa (a clear description of the lesion method is found in Damasio & Damasio, 1997). A variety of other techniques have also been used to study localization of brain functions. In particular, it is the method of *direct stimulation*, pioneered by Penfield, the famous Canadian neurosurgeon. In Penfield's technique, the patient in brain surgery remained conscious during the surgery, with only a local anesthetic used to prevent pain in the scalp. The surgeon then applied minute electrical charges to the exposed brain, thus triggering very small regions. The patient was then asked to answer questions or report out loud the thoughts and memories that entered awareness. By comparing the patient's reports with the different regions that are stimulated, a map of cerebral functioning can be developed. The patients in Penfield's procedure reported ideas or episodes that had a dreamlike quality. Although they occasionally reported seemingly distinct memories, it was seldom possible to check on the accuracy of these reports. Their dreamlike nature suggests that they were heavily influenced by reconstructive processes; that is, they may not have been genuine memories. On the other hand, by stimulating different regions of the exposed brain, a great deal was discovered about the localization of different functions, kinds of knowledge, and so on, in different parts of the neocortex. Although such research often yields fascinating evidence, it has some clear difficulties. For one, it is restricted to clinical settings (i.e., patients needing brain surgery). Second, there is the caveat again that at least some evidence that the organization of a patient's brain function may differ substantially from the normal pattern (e.g., in epileptic patients), thus limiting the generalizability of such results.

Much work is now being done with the recent developments in the medical technology of brain imaging. Imaging techniques such as the **computed tomography (CT)** scan and **magnetic resonance imaging (MRI)** can give surprisingly clear pictures of the structure of a living brain. Other techniques that yield images of the *functioning* of the brain are the **positron emission tomography (PET)** scan or **functional MRI (fMRI)** techniques. In this technique the image shows regions of the brain with heightened neural activity, with different colors reflecting high or low levels of blood flow, oxygen uptake, and the like. If a region becomes active because of mental processing, the metabolic rate of that region increases, so increases in oxygenated blood flow are seen. An advantage to these techniques, at least from the perspective of cognitive science, is that they show the brain in action rather than just the physical structures. Such scans are called *functional* because they show the brain as it is functioning, as it performs some mental task. A second advantage is that they can he applied with (apparently) minimal risk to normal people.

Data from neuroimaging studies can be used not only to verify and expand theories of cognition, but can also be used to help solve more applied and clinical problems. Other technique's measure the brain's electrical activity online, immediately. Traditionally, brain wave patterns were studied rather crudely with electroencephalogram (EEG) recordings. In this technique, electrodes are placed on the person's scalp, and the device records the patterns of brain waves. More recently, researchers have focused on *event–related potentials* **(ERPs)**, *the momentary changes in electrical activity of the brain when a particular stimulus is presented to a person*. Another important ethical issue raised by neuroscience is the safety of some of its newly developed research methods. One such method is transcranial magnetic stimulation (TMS), which alters brain function using powerful magnetic fields. It is noninvasive in the sense that the magnet remains outside the head, but the magnetic fields pass through the skull and other tissue and induce electrical currents in cortical tissue. For some applications, a single pulse (onset followed by offset of magnetic field) is used, but more commonly repetitive pulses are used (rTMS). The effects of TMS vary according to where the field is focused, its strength, and its pulse frequency and can either increase or decrease cortical activity near the stimulation site as well as in other brain regions to which the stimulated area projects. The ability to target specific brain areas for temporary activation or deactivation makes TMS a valuable research tool, and cognitive neuroscientists have embraced it. The impressive ability of TMS to bring about scientifically informative brain changes raises the question: What other kinds of brain changes does it cause? Concern about the side effects of TMS, especially rTMS, has accompanied its use from the start. TMS also shows promise as a treatment modality for a variety of neuropsychiatric illnesses and was approved in 2008 by the U.S. Food and Drug Administration (FDA) for the treatment of depression in specific kinds of patients. FDA regulation of medical devices is generally less stringent than regulation of drugs. This was all too apparent, in the view of many, when the FDA in 2005 approved vagal nerve stimulation as a treatment for depression based on extremely weak evidence of effectiveness. Brain stimulation with TMS and with implanted devices are among the most promising new therapeutic modalities, which lends urgency to questions of clinical trial design and the approval process for devices. Safety, efficacy, and regulatory controls on brain stimulation are neuroethical issues, as they concern the way in which society manages advances in clinical neuroscience, but their ethical, legal, and social dimensions do not differ substantially from those in the evaluation and regulation of other biotechnologies. A more widely used application of magnetism in neuroscience is functional magnetic resonance imaging (fMRI). This technique has been the workhorse of cognitive neuroscience research since the 1990s, thanks to its ability to measure brain activity with a useful degree of spatial and temporal resolution, without the need for radioactive tracers or injected

contrast media. Current research involves placing the human subject in a magnetic field of strength 1.5 or 3 tesla, and all indications are that this is safe. Until recently, technical limitations prevented the use of stronger fields; they could be created only across spaces too small to accommodate a human head. However, it is now possible to scan humans at 7 tesla and higher. Strong static magnetic fields can affect blood pressure, cardiac function, and neural activity. In addition to static fields, image acquisition with MRI involves exposure to varying magnetic fields and radiofrequency fields, which pose risks that range from activation of nerves and muscles to heating of tissue. Subjects in high–field scanners sometimes report seeing lights as a result of induced currents in their retinas and/or optic nerves. Although safety studies have suggested that such effects are benign, little is known about the long–term effects of these newer and more powerful scanning protocols. As with TMS, high–field MRI raises important questions about the risks to which we put human research subjects. How thoroughly should such methods be tested for safety before they are used in research with humans? Who should decide? These are important ethical questions that must be addressed as researchers push the envelope of brain fMRI. However, they are not substantially different from questions regarding the safety of new methods for studying any other part of the body. Although high–field scanning is mainly of interest in the study of brain function, the ethical issues it poses are not fundamentally different from those surrounding any new scientific method that has potential risks and benefits and that is used in the study of any organ system. Another bioethical issue that arises in connection with fMRI concerns brain abnormalities found by chance in the course of research scanning. fMRI studies generally include a nonfunctional scan of brain structure to enable localization of the brain activity revealed by fMRI relative to the anatomy of each research subject. The structural scans are of sufficient sensitivity and resolution that anatomic abnormalities and signs of disease will often show up. This raises the question of what researchers should do with these incidental findings. There is currently no universally accepted procedure for dealing with incidental findings from research scans (Illes et al., 2004). Of course, the ethical issues raised by incidental findings from brain scans are not fundamentally different from those that would be raised by imaging other organ systems. Indeed, one of the most relevant legal precedents does not come from imaging at all but from testing of blood lead levels. In 2001, a Maryland state appeals court decided that researchers studying the effects of lead abatement should have notified families of children with dangerously high levels of lead in their blood. The issues just reviewed are the most commonly discussed "classic" bioethical issues of neuroethics, but they are not the only ones. Most bioethical issues have some intersection with neuroscience. For example, stem cell therapy has been the focus of much discussion in bioethics, and therapeutic targets include neurologic diseases such as Alzheimer's and Parkinson's diseases. Future genetic technologies for selecting or altering the traits of a child are likely to include mental traits such as intelligence and personality, which are functions of the brain, as well as other physical traits. Issues of drug industry marketing, regulation, and safety are nowhere more relevant than with drugs for neuropsychiatric illness, as the chronic nature of such illnesses make treatments more profitable and questions of longterm safety more pressing.

According to recognized Czech neuropathologist — František Koukolík (2000) functional brain imaging technology have changed the map of human brain similarly as the first overseas discovery have changed the map of Earth. The most fundamental practical an ethical objective in using novel neurotechnologies is diagnosis and treatment of diseases and achieving highest possible level of minimizing human pain and suffering.

Suggested readings

Andreansen, N.: *Brave New Brain*. Oxford: Oxford University Press, 2001.

Crick, F.: *The Astonishing Hypothesis: The Scientific Search for the Soul*. New York: Scribner, 1994.

Damasio, A.: *Hledání Spinozy.* Praha: Dybbuk, 2004.

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

Sternberg, R. J.: *Kognitivní psychologie.* Praha: Portál, 2002.

V. Disorders of functions of the nervous system

Key words: *Parkinson*'s *disease, schizofrénia, akinetic mutism, neurodegenerative*

The nervous system is vulnerable to various disorders and can be damaged by the following factors: trauma, infections, degeneration, structural defects, tumors, blood flow disruption, autoimmune disorders. What are the symptoms of nervous system disorders? The most common symptoms of nervous system disorders include: delays in developmental milestones, increase or lack of growth in head size, changes in activity, reflexes, or movements, lack of coordination, changes in level of consciousness or mood, muscle rigidity, tremors, or seizures, muscle wasting and slurred speech, severe headaches, loss of feeling or tingling, or visual changes. However, each individual may experience symptoms differently and different disorders will cause different symptoms to occur. Moreover, the symptoms of a particular nervous system disorder may resemble other conditions or medical problems. In the following text I will concentrate on specific disorders and syndroms. *Huntington's disease*, hereditary, acute disturbance of the central nervous system usually beginning in middle age and characterized by involuntary muscular movements and progressive intellectual deterioration; formerly called Huntington's chorea (it is sometimes confused with chorea or St. Vitus's dance, which is not hereditary). A faulty gene produces a defective protein attacks neurons in the basal ganglia, clusters of nerve tissue deep within the brain that govern coordination. The onset is insidious and inexorably progressive; no treatment is known. Psychiatric disturbances range from personality changes involving apathy and irritability to bipolar or schizophrenia form illness. Motor manifestations include flicking movements of the extremities, a lilting gait, and motor impersistence (inability to sustain a motor act such as tongue protrusion). In 1993 the gene responsible for the disease was located; within that gene a small segment of code is, for some reason, copied over and over. Genetic counseling is extremely important, since 50% of the offspring of an affected parent inherit the gene, which inevitably leads to the disease.

Tulving (1989) described a patient known as K. C., a young man who sustained brain damage in a motorcycle accident. Some nine years after the accident, he still showed pervasive disruption of long–term memory. The fascinating thing about his memory impairment was that it was selective: K. C. remains perfectly competent at language, his intelligence is normal, and he is able to converse on a number of topics. But when he is asked about an experience from his own past, he doesn t remember; m Tulving's words, "he cannot remember, in the sense of bringing back to conscious awareness, a single thing that he has ever done or experienced in the past. For example, even though he remembers how to play chess, he does not remember ever having played it before. He knows his family had a vacation house on a lake, but he doesn't have any recollections of being there. K. C.'s brain damage seemed to destroy his ability to access what we'll call episodic memory, his own autobiographical knowledge, while leaving his general knowledge system, his semantic memory, intact. This pattern is called a *dissociation*, *a disruption in one component of mental functioning but no impairment of another.* How must the cognitive system be organized for disruptions such as these to take place? The area of investigation we are introducing here is sometimes called *cognitive neuropsychology.* As important as the evidence from brain damage is, we also need other kinds of evidence, for example information about the neurochemical and neurobiological activities that support normal learning and thought or about the changes m the brain that accompany aging. We are therefore interested in contributions from all the various neurosciences — neurochemistry, neurobiology, neuroanatomy, and so on, as they relate to human cognition. Understanding cognitive handicaps is an obvious goal; no one can dispute the importance of rehabilitation and retraining for patients with brain damage. But our interest in cognitive science goes a step further. We want to understand *normal* cognition from the standpoint of the human brain. Toward this goal, more and more investigators are examining the behavioral and cognitive effects of brain damage, using those observations to develop and refine theories of normal cognition. Sometimes the great misfortune of brain damage leads to a clearer understanding of normal processes. Likewise, cognitive science is now putting to good use the new, hightech brain imaging capabilities we have adopted from medicine. We can now use brain images based on positron emission tomography (PET) scans and magnetic resonance imaging (MRI) to localize regions of activity during different kinds of cognitive processing, testing not just brain damaged individuals but normal, intact ones as well.

Dissociations and Double Dissociations two mental processes that "go together" in some cognitive task, called process A and process B. By looking at these processes as they may be disrupted in brain damage, we can determine how separable the processes are. Complete separability is a double dissociation. Evidence of a double dissociation requires at least two patients, with "opposite" or reciprocal deficits. For example, patient X has a brain lesion that has disrupted process A. His performance on tasks that use process B is intact, not disrupted at all. Patient Y has a lesion that has damaged process B, but tasks that use process A are normal, not disrupted by the damage. In a simple dissociation, process A could be damaged while process B remains intact, yet no other known patient has the reciprocal pattern. For example, semantic retrieval

(retrieving the meaning of a concept) could be intact while lexical retrieval (finding the name for the concept) could be disrupted; this is called anomia. In this situation lexical retrieval is dissociated from semantic retrieval, but it is probably impossible to observe the opposite pattern; how can you name a concept if you can't retrieve the concept in the first place? In a full or complete association (lack of dissociation), disruption of one of the processes always accompanies disruption in the other process. This pattern implies that processes A and B rely on the same region or brain mechanism, such as recognizing objects and recognizing pictures of those objects. There is just one other kind of disordered seeing with normal eyes. Some patients with damage to the primary visual cortex claim to be completely blind in the affected part of the visual field yet their behaviour is influenced by what appears there. This paradoxical finding, was given the name *blindsight* by Larry Weiskrantz (1989). In experiment brain–damaged patients were asked to move their eyes in the direction of a spot of light that was flashed briefly in the blind part of their visual fields. Although the patients were sure that they saw nothing they tended to move their eyes in the right direction. Even a more striking result was reported in the study of a 34 year old man — DB, who had lost most of his right primary visual cortex in an operation to remove a tumour, and, as a result, was blind in the left visual field except for a crescent of vision in the left upper quadrant. DB was asked to point to where he guessed the flash occurred, and found him surprisingly accurate. In later experiments, when asked to guess between alternatives, he could distinguish between a vertical and a horizontal line (97 per cent accuracy for an exposure of 100 milliseconds), and between a circle and a cross (90 per cent accuracy). It was even possible to measure his visual acuity by seeing whether he could detect the presence of bars in a grating. This extraordinary performance was not accompanied by any visual sensation. If by chance the stimulus extended beyond the blind area, DB immediately reported it, but otherwise he denied having any visual experience. In some parts of the blind field he claimed to have 110 sensation of any kind; in other parts he said there was no sensation of vision but there were sensations of, for example, “smoothness” or “jaggedness” in the discrimination of a circle and a cross. Experiments with other patients with blindsight have shown similar results; some are even able to distinguish between light of different wavelengths, though without any sensation of colour. Attempts have been made to explain these findings, and others subsequently reported by other investigators, as the result of the scattering of light onto the seeing portion of the retina. Scattering of light certainly occurs but is unlikely to be the explanation because the position of a stimulus falling on the blind spot in the blind half–field could not be “guessed” by DB, though he could guess the position of the same stimulus in other parts of the blind field. It is significant, too, that he could guess the position of black stimuli on a white ground and could distinguish between a uniform field and a coarse grating of the same average brightness; both abilities are difficult to explain on the basis of scattered light. Blindsight seems very strange because it is impossible to imagine getting visual information and at the same time being unable to see. Researches invented a method that allows normal people to experience something rather like blindsight. People were shown visual displays in which a particular area was defined by some alteration of the background pattern in one quadrant of the display. For example, if the background pattern consisted of short lines tilted slightly to the right, the target area would have similar lines tilted to the left. The viewer was shown the display for a quarter of a second and was then asked to state in which quadrant the target was, and to give an estimate (on an arbitrary 1–10 scale) of his confidence in his statement. With the pattern just described, the position of the target was obvious, but it could be made more difficult to identify by presenting the two eyes with what might be called complementary patterns. For example, if the left eye sees a display with the background lines tilted to the right and the target lines tilted to the left, the right eye

sees a similar display but with the tilts reversed. In this situation, with binocular vision and very brief exposures, the viewer sees little crosses, both in the target area and the background, and the target is not consciously distinguishable (presumably because the viewer has no way of knowing from which eye each bit of information is being received). But when asked to guess where the target is, the extraordinary thing is that viewers guess correctly in nearly 80 per cent of the trials, despite claiming not to be able to see any target. Since random guessing would give a success rate of only about 25 per cent, this result is highly significant. It means that the viewer’s response to the examiner’s question is being strongly influenced by visual information that he or she is quite unconscious of. At one time it seemed that blindsight might be the result of subcortical activity, perhaps activity in the roof of the midbrain — the centre for vision in lower vertebrates, and still involved in eye movements in mammals. However, the ability of some patients with blindsight to discriminate colours makes it probable that visual areas in the cortex are also involved. Whatever the explanation, and however counterintuitive the phenomenon is, we have to accept that it is possible to discriminate using information acquired through vision without being conscious of the visual features providing the information. *Akinetic mutism* is a persistent state of altered consciousness, in which the patient appears alert intermittently. He demonstrates a sleep/wake cycle, but is not responsive, although the descending motor pathways appear intact; caused by lesions of various cerebral structures. *Parkinson’s disease* is a condition in which part of the brain becomes progressively more damaged over many years (a progressive neurological condition). The three main symptoms of Parkinson’s disease are related to movement: a) involuntary shaking of particular parts of the body — known as tremor, b) muscle stiffness that can make everyday tasks such as getting out of a chair very difficult — this is known as rigidity, c) physical movements become very slow — known as bradykinesia. A person with Parkinson’s disease can also experience a wide range of symptoms unrelated to movement (non–motor symptoms) such as depression, daytime sleepiness and dysphagia (difficulties swallowing). There is currently no cure for Parkinson's disease though a medication called levodopa has proved effective in relieving symptoms. Unfortunately after around 3–5 years use the effectiveness of levodopa is reduced. After this time people can experience a sudden return of symptoms (this is known as an "off episode") as well an involuntary jerking of their muscles (dyskinesias). At this point additional medication is usually required. There are also a range of nonpharmaceutical treatments that can be used to manage symptoms, such as speech and language therapy and physiotherapy. Parkinson's disease is caused by a loss of nerve cells in part of the brain called the substantia nigra. This leads to a reduction in the amount of a chemical called dopamine in the brain. Dopamine plays a vital role in regulating the movement of the body and this reduction in dopamine is responsible for many of the symptoms of Parkinson's disease. Exactly what causes the loss of nerve cells is unclear. Most experts think that a combination of genetic and environmental factors is responsible.

Contemporary research and theory on the nature of human mind requires more theoretical work in clarifying the basic concepts and methods of investigation. This objective is also based on avoiding prevailing oldfashioned dichotomies, such as conscious/unconscious, Consciousness/Unconsciousness, subjective/objective, free/determined, organic/unorganic, rational/emotional etc.

Suggested readings

Murphy, D.: Psychiatry in Scientific Image. Cambridge: Mass. MIT Press, 2006.
Raboch, J., Zvolský, P. et al.: Psychiatrie. Praha: Galen, 2001.
Sacks, O.: *Muž, který si pletl manželku s kloboukem*. Praha: Mladá fronta, 1993.
Svoboda, M., Češková, E., Kučerová, H. (ed.): *Psychopatologie a psychiatrie*. Praha: Portál, 2006. Tulving, E.: Memory: Performance, knowledge, and experience. *European Journal of Cognitive Psychology,* 1989, 1, 326.

VI. Judgements, decisions and justifications

Key words: *heuristics, cognitive biases, will, automatisms, posthypnotic sugession*

A cognitive bias is any of a wide range of observer effects identified in cognitive science and social psychology including very basic statistical, social attribution, and memory errors that are common to all human beings. And biases related to probability and decision making significantly affect the scientific method which is deliberately designed to minimize such bias from any one observer. Cognitive bias is considered as a distortion in the way we perceive reality. Many of these biases are often studied for how they affect business and economic situation. Exposure effect is a psychological artifact well known to advertisers: people express undue liking for things merely because they are familiar with them. Memory biases may either enhance or impair the recall of memory, or they may alter the content of what we report remembering. *Illusion of control* is the tendency for human beings to believe they can control or at least influence outcomes that they demonstrably have no access to. In psychology and cognitive science, *confirmation bias* (or confirmatory bias) is a tendency to search for or interpret information in a way that does not contradict the previously held ideas and habits. *Self perception biases* are the tendency to allow one's dispositions to affect one's way of interpreting information. Self perception biases are distortions of one's own view of self. The affectation or tendency to be ignorant of one's own biases is a case of the blind not knowing or ignoring that they are blind. This also includes viewing completed events as more predictable than they actually were. Hindsight Bias can easily be observed outside the science building as Yorkies walking out of a math test will ask one another what they got on the Option A and frustratedly proclaim they knew that was what they were supposed to do, but for some reason didn't apply it at the time. **Observer expectancy effect —** known as the "**observer effect**", this is a fallacy that can very easily skew results in qualitative scientific experimentation. It is the tendency to manipulate or misinterpret data so that it will support (or disprove) a hypothesis. Essentially, it is the tendency to see what you want or expect to see. **Framing Effect** is the tendency to interpret information differently based on changes in context or description. A Yorkie might exhibit this in the stress they put on studying for a chemistry quiz in comparison to a chemistry test. Even though Ms. Trachsel will explain that test and quiz scores are valued equally, and this quiz will be the same length as an average test, you might still hear one Yorkie telling another that "It's just a quiz," implying that being a quiz makes it somehow less imperative or important, regardless of how many points it's worth. **Choice Supportive Bias** — the propensity to believe your choices were better or more righteously chosen than they actually were. This tends to happen when an individual remembers only the positive aspects of the chosen option of a decision, and only the negative aspects of the rejected options. For example, a second semester senior who hasn't taken any AP classes might justify his choice by concentrating on how much stress he would have now had he taken any AP classes, while not thinking about the benefits of passing the AP test and potentially getting college credit. **C**ognitive biases in logic and decisions are shown mostly through how people go about solving problems in different ways, make various choices, and judge different situations. *Base rate fallacy* is the inclination for someone to base his judgements on specifics rather than the big picture. An example of this could be a York Senior who chooses a college for having a strong chemistry program and ignores other aspects such as its location in the middle of a desert. Rather frequent is also the *zero–risk bias* — the tendency for someone to try to eliminate a small risk rather than lower the likeliness of a great risk. An example of this could be a Yorkie that decides against joining the cross country team because they run on trails adjacent to areas that could contain unexploded ordinance. Rather than always choosing public transportation over driving a car to greatly reduce the risk of death in a transportation accident, the Yorkie reduces a small chance of getting blown to bits. This bias stems from a desire to reduce risk based on proportion rather than by chance. *Anchoring* means the inclination for someone to allow one piece of information to outweigh others when making a decision. An example might be a couple considering the fact that the girl they hired to babysit their children goes to Stanford to be more important than the side facts that that girl skips half her classes, rides a motorcycle and brings her boyfriend with her to babysitting jobs. *Belief Bias* — the tendency for someone to ignore logical error in an argument based on how believable a conclusion may be. For instance, people often buy into weight loss commercials that promise you could lose 20 pounds despite the illogical claim that you don't have to diet and only have to use their method for 10 minutes everyday for two weeks. *Semmelweis reflex* is known as the reflex like tendency to ignore or reject any contradictory information against what one already believes. An example might be some one who does not believe that high fructose corn syrup is alright for their children after being told it was unhealthy, despite solid research and facts disputing that misconception. A probability bias arises when someone misinterprets precedents or past information and acts on this inaccuracy. Dangerous is also **gambler's fallacy,** the propensity to believe that happenings of the past determine what will happen in the future. Just as its name predicts, this is most commonly exemplified by gamblers whom mistakenly tend to think along the lines that since they lost their game the last 6 times, they have a much greater chance of winning this time, or the next time, or the time after that. Predictive biases are most usually related to someone holding the inaccurate belief that they prematurely know information about events or people based on large or general ideas rather than specifics. *Conformity biases* are the most socially based cognitive biases hat are exemplified by people young and old in instances varying from politics to surfing.

In *The Illusion of Conscious Will*, psychologist, D. Wegner (2002) has finessed all the usual arguments in a remarkable demonstration that psychology can sometimes transform philosophy. Instead of struggling with the usual debates about the compatibility of determinism and free will, Wegner shows how the *feeling* of willing arises. This means that we might at last understand why "all experience is for it" without having to invoke the real thing. The feeling of willing, says Wegner, arises because we have to decide whether actions are caused by ourselves or by other people. This decision depends on three principles; priority, consistency, and exclusivity. Put simply, if our thoughts come *before* an action, are compatible with that action, and there are no other likely causes, then we conclude that we did it, and we get the feeling of conscious will. Many ingenious experiments provide evidence for Wegner's theory. The spiritualists' ouija board might seem a strange choice, but lends itself well to investigating the feeling of control. In a classic ouija session, people sit around a table with their forefingers on a upturned glass or a little wheeled board which, without them deliberately pushing, soon begins to move about and point to letters placed in a circle around it. In Wegner's modern version a small board is fixed to a computer mouse. Wearing headphones, his two participants hear the names of objects while letting the mouse roam freely over an "I–Spy" board covered with little pictures. They then stop the mouse on any picture they like. The first participant is asked to rate how strongly she felt that she chose the stopping place herself. Unbeknown to her, the other person is a confederate and, on some trials, forces the mouse to a particular picture. Even

on these occasions the dupe is often convinced that she willed the choice herself. Further experiments confirm Wegner's *priority principle* — that the stopping place is experienced as "willed" when the picture name is heard just before the stop. In the traditional Ouija board, the messages are supposedly from spirits of the dead but, as was showed in 1853, the pointer is actually moved by unconscious muscular action, or ideomotor influence. Wegner reviews the evidence for ideomotor effects, and it is most refreshing, in a twenty–first century book, not only to find the early studies are not ignored, but to read such a thorough and engaging review of them. When, for example, Wegner asked people not to think of a white bear, they were plagued by thoughts of white bears, but the same effect can happen with actions. This can explain that peculiar conviction I sometimes have that I might do something terrible, like throwing myself under a train. Once the dangerous thought comes up I try to suppress it, which makes me think about it more. Then, by ideomotor action, I am more likely actually to do it. So I do not, after all, have some repressed death wish or dire mental sickness. It is just the feeling of willing. By the illusion of conscious will Wegner does not mean to reject the very existence of the feeling, but the false idea that our *conscious thoughts* cause our actions. This is caused by the simple mistake of confusing correlation with causality. When we decide to do something, we are first aware of our conscious thoughts about the action, then we observe the action happening, and finally we conclude that our thoughts *caused* the action. In fact, says Wegner, unconscious processes caused both the conscious thoughts and the action. Finally, it seems, that revealing the nature illusions is not and perhaps will never be popular. It is as if the magician decided to unfold the secret of his illusion. Audience is not willing to hear that, it prefers to shut their ears. The reason might lie in the fear of somehow destroying the experience of the illusion or the illusion itself. Explained illusion is no more an illusion. Explained freedom of will is no more freedom of will.

Suggested readings

Dennett, D.: *Freedom Evolves*. London: Allen Lane, 2003.
Sternberg, R.J.: *Kognitivní psychologie*. Praha: Portál, 2002.
Wegner, D.: *The Illusion of Conscious Will*. Cambridge: MIT Press, 2002.

VI. Dominance and hemispheric specialisation

Key words: *contralaterality, split–brain, dichotic test, tachitoscopic test*

Hemispheric lateralization refers to the distinction between functions of the right and left hemispheres of the brain. If one hemisphere is more heavily involved in a specific function, it is often referred to as being dominant. Lateralization is of interest with regards to language, as it is believed that language is a heavily lateralized function: certain aspects of language are found to be localized in the left hemisphere, while others are found in the right, with the left hemisphere most often dominant. This was initially proposed by early lesion–deficit models and studies with split–brain patients, and has been shown in more recent years through tests like the Wada test and imaging studies. There have been studies which show that there are anatomic asymmetries located near and around the regions associated with language, and each hemisphere has shown to play its own but separate role in the production and comprehension of speech. The hemispheric lateralization of language functions has been suggested to be associated with both handedness, sex, bilingualism, sign–language, and a variance amongst cultures. It has also been proposed that a reorganization occurs following brain injury that involves a shifting of lateralized function, as long as the injury occurs early in life. French physician Jean Baptiste Bouillaud (1796–1881) was one of the earliest proponents of hemispheric language lateralization. On February 21, 1825, Bouillaud presented a paper to the Royal Academy of Medicine in France which suggested that, because so many human tasks are performed using the right hand (such as writing), the left hemisphere might be the in control of that hand. This observation implies that language, at the core of writing, would be localized in the left hemisphere. It was already known at this time that motor function was primarily controlled by the hemisphere ipsilateral to the side of the body through lesion studies. Bouillaud also proposed that speech is localized in the frontal lobes, a theory that was carried on by Bouillaud's son in law Simon A. E. Aubertin, who went on to work with famed French neurologist Paul Broca in 1861. Together, Aubertin and Broca examined a patient with a left frontal lobe lesion who had lost nearly all ability to speak; this case and several others similar to it became the basis behind the earliest theories of language lateralization. French neurologist Paul Broca (1824–1880) is often credited as being the first to expound upon this theory of language lateralization. In 1861, a 51–year–old patient named Leborgne came to Broca; Leborgne was almost completely unable to speak and suffered from cellulitis of the right leg. Leborgne was able to comprehend language but was mostly unable to produce it. He responded to almost everything with the word "tan" and thus came to be known as Tan. Broca theorized that Tan must have a lesion of the left frontal lobe, and this theory was confirmed in autopsy when Tan died later that year. In 1863, Broca published a paper in which he described eight cases of patients with damage to the left frontal lobe, all of whom had lost their ability to produce language, and included evidence of right frontal lesions having little effect on articulate speech. These findings led Broca to propose, in 1864, that the expression of language is controlled by a specific hemisphere, most often the left. German anatomist Carl Wernicke (1848–1904) is also known as an early supporter of the theory of language lateralization. In 1874, Wernicke found an area in the temporal lobe of the left hemisphere, distinct from that which Broca had described, which disrupted language capabilities. He then went on to provide the earliest map of left hemisphere language organization and processing. Since then, a great number of studies using a variety of methods have shown that the left neocortex of most people is specialized for processing and perception of speech, especially with regard to temporal features, semantics and syntax of languages (Gazzaniga, 1987). This left hemisphere specialization is found already in new–borns and is present even in deaf people using a sign–language (Damasio et al. 1986). These facts and a left hemisphere lateralization of speech functions not only in the neocortex but also in the thalamus and the automatic discrimination and categorization of speech phonemes in the left hemisphere even without will and without special attention and also for speech played backwards all indicate that the left hemisphere dominance is not necessarily bound neither to an acoustic speech channel nor to the understanding of the semantic content of spoken words nor to neocortical functions alone. This suggests that the hemisphere dominance of speech processing may be based on the lateralization of more general mechanisms of handling communication–relevant information in the brain. Left hemisphere dominance has been shown from primates down to frogs for a) detecting phonetic information important to separate the meaning of species–specific calls of macaque monkeys, b) production of social contact calls in marmosets, c) perception of ultrasonic communication calls by mice in a communicative context, d) conditioned responding to a two tone sequence in rats, e) song control in song birds, and f) control of vocalizing in a frog. Additional evidence from monkeys and mice demonstrates that the left hemisphere advantage for processing species specific vocalizations is not genetically fixed but may be induced through a priming process during social contact with the senders of the vocalizations. The left hemisphere advantage comes into play only in a communicative situation in which ultrasound can release an instinctive behavior or, in other words, conveys a message that fits into innate releasing mechanisms for the extraction of meaning. In terms of natural selection, the "understanding" of the message in the context of infant to mother acoustical communication in the mouse is critical for the survival of the pups if they get out of the nest and thus, the mother's response is a well adapted one. These results on the left–hemisphere dominance for semantic processing and species–specific call recognition in mice and monkeys demonstrate no basic differences with the left hemisphere advantage of human speech perception. A good deal of what we know about language lateralization comes from studying the loss of language abilities following brain injury. Aphasia, the partial or complete loss of language abilities occurring after brain damage, is the source of much of the information on this subject. As shown in the studies of Bouillaud, Aubertin, Broca and Wernicke described above, lesion studies combined with autopsy reports can tell us a a lot about the *localization* of language, which ultimately has supplied information on *lateralization*. Lesion studies have shown that, not only is the left cerebral hemisphere most often dominant for language, but also that the right hemisphere generally is not, as lesions in the right hemisphere rarely disturb speech and language function. The dangers of using lesion studies are, of course, that they may overemphasize the relevance of particular localized areas and their associated functions. The connection between brain regions and behaviours is not always simple, and is often based on a larger network of connections. This is shown in the fact that the severity of an individual's aphasia is often related to the amount of tissue damaged around the lesion itself. It is also known that there is a difference in the severity of the deficit depending on whether the area was removed surgically, or was caused by stroke. This is the case because strokes affect both the cortex and the subcortical structures; this is due to the location of the middle cerebral artery, which supplies blood to the areas associated with language, as well as involvement of the basal ganglia, and is often the cause of stroke. Necessary background knowledge for understanding the effects of brain function on cognitive processes include principles based on the ideas of contralaterality and hemispheric specialization. When

viewed from the top, the neocortex is divided into two mirror image halves, the left and right cerebral hemispheres. This follows a general law of anatomy, that with the exception of internal organs such as the heart, the body is basically bilaterally symmetrical. What is somewhat surprising, however, is that the receptive and control centers for one side of the body are in the opposite hemisphere of the brain. This is contralaterality (contra means "against" or "opposite"). For evolutionary reasons, the right hemisphere of the brain receives its input from the left side of the body and also controls the left side. Likewise, the left hemisphere receives input from and controls output to the right side of the body. As an example, people who have a stroke in the left hemisphere will often have some paralysis in the right half of the body. There are a few exceptions, such as the olfactory nerves, in which there are ipsilateral (same side) connections. The second issue concerning lateralization involves different specializations within the two cerebral hemispheres. Despite their mirror–image appearance, the two hemispheres do not mirror one another s abilities. Instead, each hemisphere tends to specialize in different abilities and tends to process different kinds of information. This is the full principle of cerebral lateralization and specialization: Different functions or actions within the brain tend to rely more heavily on one hemisphere or the other or tend to be performed differently in the two hemispheres. This means that there is often a tendency, sometimes strong, for one or the other hemisphere to be especially dominant in different processes or functions. The most obvious evidence of lateralization in humans is the overwhelming incidence of right–handedness across all cultures and apparently throughout the known history of human evolution. Accompanying this tendency toward right–handedness is a particularly strong left hemispheric specialization in humans lor language. That is, for the majority of people, language ability is especially lateralized in the left hemisphere; countless studies have demonstrated this general tendency. In contrast, the right hemisphere seems to be somewhat more specialized for nonverbal, spatial, and more perceptual information processing. For instance, the evidence suggests that face recognition and mental rotation, both requiring spatial and perceptual processing, are especially dependent on the right cerebral hemisphere. Many people have heard of these "left brain versus right brain" issues, often from the popular press. Such treatments are notorious for exaggerating and oversimplifying laterality and specialization. For instance, in these descriptions the left hemisphere ends up with the rational, logical, and symbolic abilities — the boring ones whereas the right hemisphere gets the holistic, creative, and intuitive processes—the sexy ones. But even ignoring that oversimplification, it is far too easy to misunderstand the principles of lateralization and specialization, too easy to say "process X happens in *this* hemisphere, process Y in *that* one." Even the simplest act of cognition, say naming a picture, involves multiple components, distributed widely across both hemispheres, and complex coordination of the components. Disruption of any one of those could disrupt picture naming. Thus several different patients, each with dramatically different localized brain damage, could show an inability to name a picture, each for a different reason relating to different lateralized processes. Nonetheless, there is a striking division of labor in the neocortex, in which the left cerebral hemisphere is specialized for language. Directing language input to the left cerebral hemisphere is optimal and efficient for many people, but not for all. There has been a careful work on the topic of lateralization and specialization of different regions in the two hemispheres. Among the best known is the research on split–brain patients. Before about 1960, evidence of hemispheric specialization was rather indirect; neurologists and researchers noted the location and kind of head injury that was sustained and the kind of behavioral or cognitive deficit that was observed after the injury. Sperry (1964; Gazzaniga & Sperry, 1967) put the facts of anatomy together with a surgical procedure for severe epilepsy. In this operation, the corpus callosum is completely severed to restrict the epileptic seizure to just one of the cerebral hemispheres. For

patients who had this radical surgery, a remarkably informative test could be administered, one that could reveal the different abilities and actions of the two hemispheres. That is, from the standpoint of brain functioning, when a patient's corpus callosum is surgically cut, the two hemispheres cannot communicate in ternally with each other—information in one hemisphere cannot cross over to the other. Sperry's technique was to test such people by directing sensory information to one side or the other of the body (e.g., by placing a pencil in the left or right hand of such a patient or presenting a visual stimulus to the left or right visual field), then observing their behavior. For example, if a patient had a pencil placed in the left hand (the patients were prevented from seeing the objects and their hands), the neural impulse went to the right hemisphere but then could not cross over into the left hemisphere. The patients usually were able to demonstrate how to use the object when the sensation was sent to the right hemisphere, for example, they could make the appropriate hand movements as if they were writing with the pencil. But they usually could not name the object unless it was placed in the right hand. This is exactly what would be expected from someone whose knowledge of language is localized in the left hemisphere but whose perceptual, nonverbal knowledge is localized in the right hemisphere. Similar effects were obtained with purely visual stimuli as well, that is, when the left half of a picture was projected to the right hemisphere and vice versa. A caveat to this work is that these patients all had long–term, severe epilepsy, and this condition may have altered the organization of their mental abilities, although some of the basic separation of abilities revealed is likely to be accurate. Although the principle of laterality has been a mainstay of neurological research for a long time, recent evidence suggests that lateralization usually is not as absolute as was previously believed. Contemporary research concentrates therefore on unfolding common mechanisms correlating with lateral states of perception and other cognitive states.

Suggested readings

Eysenk, M., Keane, M.: *Kognitivní psychologie*.
Praha: Academia, 2008.

Gazanniga, M., Ivry, R., Mangum, G.: *Cognitive Neuroscience: The Biology of the Mind*. W.W. Norton: New York, 2002.

Sperry, R. W.: Cerebral Organization and Behavior: The split brain behaves in many respects like two separate brains, providing new research possibilities". In: *Science* 133 (3466): 1749–1757, 1961.

VIII. Minds manipulating minds

Key words: *forcing, illusion, confirmation, cognitive biases, magic*

Main objective of this chapter is to rethink the status of human mind from the perspective of considering the role of magic. What is Magic? At heart, magic is about producing a sense of wonder in the spectator. The performance of magic requires a method (how the trick works) to achieve an effect (what the spectator sees). Successful magic relies on the spectator experiencing an effect while being unaware of the method. For example, the effect might be the disappearance of a coin, with the method a concealment of the coin in one hand rather than an actual transfer from one hand to the other. One of the central aims in magic is to prevent the audience from etecting this method. If this is done successfully, the spectator can be made to experience effects beyond anything that could occur in everyday life. Why does magic work? Much of human cognition relies on assumptions about the world. For example, object permanence, assumes that objects continue to exist even when they are no longer visible. Although such assumptions are often correct, they sometimes are not, leading to erroneous conclusions that require considerable effort to overcome. A skilled conjurer can manipulate these assumptions, leading to a result that is entirely inconsistent with what actually ccurred. The illusions created by the conjurer are not that different from the tricks the mind plays on us in everyday life, which most of the time go unnoticed. For example, our subjective experience of colour is not only determined by the physical proprieties of the object itself, but also by the colour of the neighbouring objects, a phenomenon known as colour constancy. What magicians have done is find ways that enhance the power of these illusions and point out the discrepancy between our subjective perception and reality in often theatrical dramatic ways. What do magicians know about cognition? Successful conjuring requires a solid understanding of human cognition. Although the magicians' motives may differ from those of scientists, the methods that have led to this knowledge are similar. Any serious magician has a theory about how to deceive his or her audience. If this theory is wrong, the magic trick will fail, and the audience will spot the secret. A magician hoping for future engagements must therefore learn from such failures and change the trick so as to improve its effectiveness. As such, each performance can be viewed as an experiment that tests the magician's theory; this theory being continually revised until it agrees with experience. Years of such testing allows a magician to learn much about human cognition. Moreover, much of this knowledge is shared with fellow magicians and is passed on from one generation to the next, resulting in an extensive source of potentially valuable information. As we argue in the text, psychologists and magicians should combine forces to better exploit and further develop this resource.

It is argued here that cognitive science currently neglects an important source of insight into the human mind: the effects created by magicians. Over the centuries magicians have learned how to perform acts that are perceived as defying the laws of nature, and that induce a strong sense of wonder. This paper argues that the time has come to examine the scientific bases behind such phenomena, and to create a science of magic linked to relevant areas of cognitive science. Concrete examples are taken from three areas of magic: the ability to control attention, to distort perception, and to influence choice. It is shown how such knowledge can help develop new tools and suggest new avenues of research into human perception and cognition. Imagine a ball tossed into the air that

suddenly disappears. Or someone uncannily predicting exactly what you will do in the next few minutes. These fantastical scenarios exist not only in science fiction, but are experienced by anyone who has ever witnessed a skilful conjurer in action. Over the centuries magicians have learned how to perform acts that are perceived as defying the laws of physics and logic, leaving an audience baffled and amazed. Yet there is nothing otherworldly about these effects, they are created entirely by natural means. We argue here that there is great scientific potential in studying the ways that most people can be made to believe in such "impossible" events, even if only for a few seconds. In particular, we argue that the effects by magicians can provide us with valuable tools to investigate human perception and cognition. Although a few attempts were made in the distant past to draw links between magic and human cognition, this knowledge has been largely neglected by modern psychology. We propose that the time has come to examine these phenomena more closely, and to connect them to current theories and methodologies for exploring the human mind. The history of science has shown that theories often stem from knowledge obtained from practical applications, for example, thermodynamics from the development of steam engines. A similar situation exists here — over the centuries, magicians have accumulated considerable knowledge about inducing strking effects in human observers. Scholars believe that this knowledge can be systematized and used as a source of insight into mechanisms central to human perception and cognition. In addition, these effects also suggest new methodological techniques to investigate the relevant processes. We can illustrate these points by examining three general methods used by magicians: misdirection, illusion, and forcing. There is a common belief that magicians hide their techniques (or methods) by relying on speed. But it is simply false that "the hand is quicker than the eye": most manipulations are carried out at a normal pace. Rather than relying on speed, the success of an effect (i.e. the experience of the spectator) usually relies on misdirection, the diversion of attention away from its method, so that the audience does not notice how it was produced. This reliance on misdirection to achieve "invisibility" is closely related to recent findings in vision science that only a small part of the information that enters our eyes, the part that is attended—enters our conscious awareness. Magicians have known this for centuries, and have accumulated considerable practical knowledge about how to control the relevant mechanisms. They have proposed a framework that distinguishes between physical misdirection, based on the physical properties of the stimulus, and psychological misdirection, based on control of higher–level expectations. *Physical misdirection* refers to the control of attention via stimulus properties; this is similar to the concept of exogenous control found in psychology, in which certain stimulus properties automatically capture our attention. The goal is to create areas of high interest that capture the spectator's attention, while the method is covertly carried out in an area of low interest. A wide range of techniques have been found to be effective. For example, an important rule in magic states that the audience will look where the magician is looking. This has an interesting connection to recent work showing that eye gaze leads to automatic shifts of visual attention. Stimulus properties such as movement, high contrast, and novelty are also regarded as important; this also has been found in recent empirical studies. Although many such cues have already been investigated scientifically, the magician's use of them suggests that they will have considerably more power when combined correctly. Many methods involve attentional capture, in which attention is pulled away by an irrelevant task. These could be used to improve our understanding of how capture operates. For example, psychologists so far have focused on properties that capture attention in space, paying less attention to issues of time. Magicians have found that control can also be achieved through repetition, or "off beat" moments, which lead to a momentary relaxation, during which the spectator's attentional "hold" is relatively weak. Magicians also use non–verbal

signs such as body posture to manipulate the level of vigilance, which then affects attentional allocation. Experiments based on this form of attentional control could provide valuable insights into attentional modulation over time. *Psychological misdirection* controls spectators' attention by manipulating their expectations; this is similar to the concept of endogenous control found in psychology, in which attentional orienting is determined by a person's goals and intentions. The magician's aim is to reduce suspicion that a deceptive method has been used. For example, he may require a secret prop that needs to be gotten rid of by putting it back into his pocket. If the action of putting his hand into his pocket seems normal and/or justified (e.g., he put his hand into his pocket on previous occasions), the action will cause far less suspicion and will therefore be far more likely to go unnoticed. Another way of reducing suspicion is by keeping the audience in suspense as to what they are about to see. As long as the spectators don't know what to expect they will not know which aspects of the routine are important, and so will be unlikely to direct their attention to those aspects needed for the effect. Related to this, a key rule in magic states that magic tricks should never be repeated. Indeed, it has been shown that both repetition and prior knowledge about what the spectator will see increases the likelihood that the observer will detect the method. Psychological misdirection can also be done via the false solution, which a magician will highlight so as to divert attention from the real solution. For example, a magician can pretend to have been caught out, so that the spectator will ignore all other less obvious solutions. Once the spectator has been sent down this garden path this false solution can be revealed to be false. However, by this time, most of the tracks have been covered and he will find it difficult to discover the correct solution. This is likely related to the Einstellungs effect, the finding that once an idea comes to mind, alternatives are often not considered. Work in vision science has shown that much of vision is essentially a form of intelligent hallucination. To perceive depth, for example, the visual system must recover the third dimension from the twodimensional image available on the retina. However, since multiple solutions are usually possible for a given image, the result must be obtained by applying assumptions of some kind. This approach, however, can sometimes lead to errors, which take the form of illusions. Two types of *illusions* are typically employed by magicians: optical, which involve physical factors, and cognitive, which involve psychological ones. Many conjuring tricks, especially those of the stage illusionist, involve optical illusions, which rely on tricks such as intricate mirror combinations and perspectives. For example, by manipulating the perspective of an object the true size of a box can be distorted, leaving plenty of room to hide an elephant. Most sleight of hand magicians tend to rely on "higher level" cognitive factors, rather than the "smoke and mirrors" used by the stage illusionist. An example of this is the "vanishing coin illusion". Here, the spectator perceives the magician transferring a coin from one hand to the other, with the coin then vanishing. But in reality, the coin never changes hands—it is instead secretly concealed in the hand and so remains out of sight. The key to sleight of hand involves discovering the extent to which the "false" action can be altered to make the spectators still feel they are seeing the "real thing". Interestingly, spectators often report having seen a "real" event, even though it never took place. Why might such effects occur? The finite speed of neural transmission causes a delay of approximately 100 ms between stimulus arrival and conscious percep. One way of compensating for this is to "predict the present", predict the outcome of an event before it has been completely processed. This strategy is particularly useful in situations that require rapid response, such as skilled driving or sports. But such predictions can also make us vulnerable to deception. Effects such as the vanishing coin illusion and the vanishing ball illusion are experienced whenever the available evidence is consistent with the prediction made by the spectator. Effects of this kind may serve as useful starting points for the empirical investigation of the

subjective aspect of perception. Imagine picking a card from a deck of playing cards. To your astonishment, you find that the magician has predicted your choice. Although you felt like your choice was free, in reality it was highly controlled. The process by which your choice can be systematically influenced is known as *forcing*. This has interesting connections to recent work showing that observers often confabulate about the reasons for their choices. Magicians have long known of this effect. For example, they often construct a context that favours reflexive behavior, for example, putting the spectator under considerable stress to act quickly. Once the spectator has committed to the forced choice, the stress is reduced, and the magician then emphasises the freedom of the choice. Upon subsequent reflection, the spectator will generally "remember" his or her choice as being completely free. Magicians typically use two different types of force. The physical force influences a spectator's selection when asked to physically select an object, such as picking a card. The mental force influences the choice of a spectator who is instructed to think of an item. In both cases, the key is to create appropriate assumptions, and to avoid having the spectator become aware of the fact that their choice was controlled. Physical force occurs when an individual asked to physically select a card from a shuffled deck, spectators have various assumptions: the deck contains 52 distinct cards, all are equally available for selection, and the magician has no control over them. However, a magician may have a deck contain several eight of spades, dramatically increasing the likelihood of that card being selected. The set of cards displayed could also be reduced, affecting the likelihood of selection. Finally, a practiced magician can use sleight of hand to control the order of the cards, allowing them to later be forced upon the spectator, who has assumed that they have been randomly shuffled. In the mental force, the spectator is asked to simply think of a card; the magician then manipulates the presentation of the cards so as to favour a particular choice. The magician's force may also suggest a better way to investigate nonconscious perception.

Successful forcing is achieved not only by providing the spectator with assumptions, but also by taking care that the spectator is subsequently given no evidence that these have been violated. Magicians exploit the formation of false memories by providing the spectator with false information. For example, a magician may falsely suggest that the cards were shuffled by the spectator rather than the magician, enhancing the impression that the selection was truly fair. Such effects may have potential for investigating the formation and distortion of human memory.

It has been demonstrated that people do not accept validity of the third person approach to their inner states. Introspection, however, is unable to unfold the nature of mechanisms and principles of functioning of our memories, imaginations or feelings. Capacity to distinguish conditions under which manipulation of mind takes place, is of pivotal practical importance. Not only in the effort to minimize abusement of these capacities but also for treatment and therapy of specific mental disorders.

Suggested readings

Blackmore, S.: *A Very Short Introduction to Consciousness.* Oxford: Oxford University Press, 2005.

Brown, D.: *Magie a manipulace mysli.* Praha: Argo, 2007.

Dennett, D.: *Záhada ľudského vedomia.* Bratislava: Európa, 2008.

Kahneman, D., Slovic, P., Tversky, A.: *Judgment under uncertainty: Heuristics and biases.* Cambridge: Cambridge University Press, 1982.

Siegel, L.: *Net of Magic: Wonders and Deceptions in India.* Chicago: University of Chicago Press, 1991.

Bibliography

Bechtel, W., Graham, G.: *A Companion to Cognitive Science*. Oxford: Blackwell, 1999.

Bennett, M.R., Hacker, M.P.S.: *Philosophical Foundations of Neuroscience.* Oxford: Blackwell Publishing, 2003.

Blackmore, S.: *A Very Short Introduction to Consciousness.* Oxford: Oxford University Press, 2005.

Brown, D.: *Magie a manipulace mysli.* Praha: Argo, 2007.

Crick, F.: *The Astonishing Hypothesis: The Scientific Search for the Soul.* New York: Scribner, 1994.

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

Damasio, A.: *Hledání Spinozy.* Praha: Dybbuk, 2004.

Damasio, A.: Descartesův omyl. Praha: Mladá fronta, 2000.

Dennett, D.: *Darwin's Dangerous Idea*. London, Allen Lane, 1995.

Dennett, D.: *Freedom Evolves*. London: Allen Lane, 2003.

Dennett, D.: *Záhada ľudského vedomia.* Bratislava: Európa, 2008.

Eysenk, M., Keane, M.: *Kognitivní psychologie.* Praha: Academia, 2008.

Gardner, H.: *The Mind's New Science: A History of the Cognitive Revolution*. New York: Basic Books, 1985.

Green, D. W.: *Cognitive Science: An Introduction*. Malden, MA: Blackwell, 1996.

Gazanniga, M.: Principles of human brain organization derived from split–brain studies. In: *Neuron* 14, 1995, 217–228.

Gazanniga, M., Ivry, R., Mangun, G.: *Cognitive Neuroscience: The Biology of the Mind*. W.W. Norton: New York, 2002.

Gray, J.: *Consciousness: Creeping up on the Hard Problem.* Oxford, Oxford University Press, 2004.

Harnish, M. R.: *Minds, Brains, Computers: An Historical Introduction to the Foundations of Cognitive Science*. Oxford: Blackwell, 2002.

Kahneman, D., Slovic, P., Tversky, A.: *Judgment under uncertainty: Heuristics and biases.* Cambridge: Cambridge University Press, 1982.

Koukolík, F.: *Lidský mozek*. Praha: Portál, 2000.
Libet, B.: Do We Have Free Will? In: *Journal of Consciousness Studies*, 6, No. 8–9, 1999, 47–57.
Marr D. : *Vision. A Computational Investigation into the Human Representation and Processing of Visual Information*. W.H. Freeman and Company, 1982).
Mysliveček, J. a kol.: *Základy neurověd*. Praha: Triton, 2009.
Murphy, D.: *Psychiatry in Scientific Image*. Cambridge, Mass., MIT Press, 2006.
Noe, A., Thompson, E.: Are There Neural Correlates of Consciousness? In: *Journal of Consciousness Studies*, vol.11, 2004, No 1.
Penfield, W., Rasmussen, T.: *The Cerebral Cortex of Man: A Clinical Study of Localization of Function*. New York: MacMillan, 1950.
Petrů, M.: *Fyziologie mysli — Úvod do kognitivní vědy*. Olomouc: Triton, 2008.
Raboch, J., Zvolský, P. et al.: *Psychiatrie*. Galen, Praha, 2001.
Ramachandran, V. S., Blakeslee, S.: *Phantoms in the Brain*. New York: Quill, 1998.
Rybár, J., Beňušková, Ľ., Kvasnička, V.: *Kognitívne vedy*. Bratislava: Kalligram, 2002.
Sacks, O.: *Muž, který si pletl manželku s kloboukem*. Praha, Mladá fronta, 1993.
Siegel, L.: *Net of Magic: Wonders and Deceptions in India*. Chicago: University of Chicago Press, 1991.
Sperry, R. W.: Forebrain commissurotomy and conscious awareness. In: *Journal of Medicine and Philosophy*. č.2, 101–126, 1977.
Sperry, R. W.: Cerebral Organization and Behavior: The split brain behaves in many respects like two separate brains, providing new research possibilities". In: *Science* 133, 1961, (3466): 1749–1757.
Sternberg, R.: *Kognitivní psychologie*. Praha: Portál, 2002.
Svoboda, M., Češková, E., Kučerová, H. (ed.): *Psychopatologie a psychiatrie*. Portál, Praha, 2006.
Thagard, P.: Úvod do kognitivní vědy. Praha: Portál, 2001.
Tulving, E.: Memory: Performance, knowledge, and experience. *European Journal of Cognitive Psychology*, 1989, 1, 326.
Weiskrantz, L.: Some Contributions of Neuropsychology of Vision and Memory to the Problems of Consciousness. In: A. Marcel, A., Bisiach, E. (ed.): *Consciousness in Contemporary Science*. Oxford: Oxford University Press, 1989.
Wegner, D.: *The Illusion of Conscious Will*. Cambridge: MIT Press, 2002.

Prof. PhDr. Silvia Gáliková, CSc.

Foundations of Cognitive Neuroscience

Firs edition

Peer reviewers
Doc. Ing. Igor Farkaš, PhD.
PhDr. Ing. Marek Dobeš, PhD.

Proofreading Doc. Ing. Igor Farkaš, Ph.D.
Graphic © Ladislav Tkáčik

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 978-83-7490-601-4