Perception Theories

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Edícia kognitívne štúdia

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Content

Introduction

> "Where in the world is a metaphysical subject to be found? You say here it is just as with the eye and the field of vision. But you do *not* really see the eye. And nothing *in the field of vision* allows the conclusion that it is seen by an eye."
>
> *Ludwig Wittgenstein:*
> *Tractatus Logico–philosophicus*, sentence 5.633

The reason for writing this text was the fact that although our knowledge is based on a collection of the most elementary facts and experiences, we usually start being aware of them and begin to study them only when something stops functioning. Perception after all is one of the basic ways of meeting reality and for many it actually is the reality. Despite this, it is usually the last thing we think of in our research.

If we want to learn something about the reality we meet, we should know something about the way we capture it or how the meeting with reality is constructed. This work, however, doesn't just look at a neuroanatomical, cognitive–psychological description of receptors and mechanisms of sensory reception, but also offers deeper thoughts about the conditions and mainly about the consequences of higher cognitive processes tied to perception. The text thus walks a line between general and cognitive psychology and philosophical epistemology while trying to map not only the origins of percepts, what influences them, but mainly where and how our perception convictions originate and the total concept of reality we live in.

The obvious intention of this exploration is not only to present a package of basic facts and theories, but also to encourage the reader to think about and to problematize the perception processes and consequences. Individual chapters are, therefore, divided with the intention to gradually walk the reader through the subject starting from basic facts (while learning key terminology and concepts) and continuing to broader problems. This should encourage the reader to individually and creatively think about the problems and solutions to the problems. The work with recommended literature, which offers more detailed information on a specific subject or provides a different view of the problem (listed after each chapter) corresponds with this system.

There are undoubtedly many books dealing with the study of sensory and cognitive abilities of humans. Therefore, I chose only the most recognized and the most accessible ones. The work of P. Rookes and J. Willson *Perception. Theory Development and Organisation* seemed to me specifically inspirational by its structure, scope and approach. It became the core of argumentation as well as the basis for structuring several chapters. The same applies to the often revised and re–published Eysenck's and Kean's work *Cognitive psychology* (Psychology Press, 2010). I thank Peter Gärdenfors and Richard Andersson from LUCS for inspiration with their version of Human Labs in humanities and philosophical sciences and to Richard Gray for his ideas about the extension of dimensions in philosophical aspects and non–visual forms of perception. Special gratitude goes to both peer reviewers Ján Rybár and Marián Špajdel, to the graphic Ladislav Tkáčik and to my students who helped me clarify and refine the terminology so that what should be heard, will be heard and helped me see what I didn't see in my own words. Because I know that *to look* and *to see* is not the same and seeing contains in itself a belief that reality is what I'm seeing.

In Trnava, July 2012 Andrej Démuth

1. The theories of perception — what, why and how to study?

Key words: *internalism, externalism, phenomenalism, the subject of the theories of perception*

1.1 What do the theories of perception study?

Cognition may be studied from many diverse points of view. We can ask what cognition is, what its conditions, validity and limits are, what the mechanisms by which we acquire it are, or what determines it, etc. One of the weightiest questions in epistemology is the question of the origin and sources of cognition. What are the sources of our cognition?

Most thinkers are convinced that the sources of cognition can be divided into two basic groups according to whether the sources exist within the subject or outside of it. Proponents of the first approach are called internalists. *The internalists* are convinced that pieces of knowledge or their sources and principles can be found within the subject, and cognition is nothing else but discovering them or developing already existing (*a priori*) pieces of knowledge. For example, Descartes who believed in innate ideas, is the proponent of this approach, as well as Plato, who asserted that knowledge is nothing else but recollecting already acquired contents.

Internalism postulates an approach which enables us to explain the existence of intuitive and innate cognition, but at the same time it does not clarify how, from where and why the ideas themselves get into the mind, why we all do not have the same knowledge, why we are not aware of it already at birth and why we have sensibility at our disposal, although the pieces of knowledge or their principles do not necessarily require the influence of sensibility.

In contrast to internalism, there is an opposite approach; authors who adhere to it, are convinced that all our knowledge has an external source — experience. *The externalists* assert that the mind is more or less a blank sheet of paper (tabula rasa) and all knowledge is being inprinted in us from external reality. The main problem of this approach is (besides problems of existence of necessity and universality in cognition) the explanation of how external reality is being perceived and imprinted in the subject. This problem, in fact, is the main determinant of whether something will be the subject of cognition, how and in which way it will present itself to us and how it is possible to comprehend it. And this issue of "meeting" with information which represents the substrata of knowledge is in fact the key question of the theories of cognition sources.

Both basic theories — externalism and internalism — face the question of how to explain the awareness of new reality in our consciousness, how information (external or internal) is elicited or, in other words — how we meet the world. Some critical philosophers are actually convinced that the world is a sum of information surrounding the subject. What we call the world is nothing else but a set of various perceptions, feelings and ideas. For example, *phenomenalists* adhere to such a point of view. They believe that only our perceptions are the subject of our cognition. What we perceive are only perceptions and there is nothing else accessible to us except perceptions. What we assume is behind our perception and what allegedly causes it, is just a rational construct. Besides perceptions, we thus possess images, rational constructs and ideas we create ourselves. The question, however, is what we created them from, on what basis and how we perceive these ideas, how we understand them. These cornerstones of knowledge — perceptions as objects which form the content and diversity of the world, but also

the starting point and the source of any sensual or intellectual cognition will therefore be the subject of our thoughts.

1.2 Why study the theories of perception?

To study the world means to study perceptions and ideas we created, and the world is mainly the world of perceptions, images or ideas. Thus, when we want to study something, first we should know where, when and how to meet and learn it. But that is not enough.

John Locke and the entire epistemological tradition following him was convinced that if we can find the answer to the question about sources and procedures of cognition, we will be able to relevantly answer the questions about its legitimacy, validity, nature and limits. Actually, the certainty of any statement is based on the trustworthiness of the authority that postulates it. Thus, if we want to believe our knowledge, we must know, where it is coming from, how it was being formed and how it was subsequently being proliferated. As said in Descartes style: we must verify the knowledge principles themselves.

In the first meditation of *Meditations on first Philosophy,* Descartes indicates that our senses sometimes lie to us. As an example, he talks about a stick dipped in water or objects in the distance. But how do we know the senses are lying to us? We do this again only by senses, either the same ones (when I take the stick out of water, using my eyesight I can see it is not broken) or through other senses (for example touch). But may I trust them now? How do I know they are not lying right now? After all, if they lied to me once, they can do it again. But is there a safer authority than one's own senses? One may claim that the human brain is such an authority. But the problem is, that the brain and its thinking about the world is based on data which arrived via senses. Then, if we want to build on someone else's testimony, there is nothing we can do but to trust or to verify it. But how may the testimony of senses be verified?

It seems, there are at least three ways of verifying testimonies. The first one is: I verify data myself. But in situations when I have to substitute my senses by a certain device this is not fully possible. One may argue that if I want to ascertain the existence of objects which are so small, that it is not possible to detect them by the naked eye, I can use a microscope. Similarly: if I am not able to measure the temperature of liquid by touch, I use a thermometer. However, this argument doesn't hold its ground because although such devices could help us to extend the scope of our sensory possibilities and render them more accurate, consequently they again present the collected data to senses — either for the same ones (I see with a microscope), or via their transformation into a different sensory form (I see a thermometer scale or hear its signal). As it seems, there is no way to "step out of myself" and perceive objects directly without using my senses. Again we have to rely on some senses which we might or might not trust.

A second possibility is to test the testimonies of senses by their mutual confrontation. If the testimonies are inconsistent, evidently, some of them will most likely be wrong. On the contrary, if testimonies of mutually independent witnesses are consistent, in all probability they are true. The problem is, that not even the testimonies made by a relatively large number of witnesses can rule out the possibility, that they are all wrong and it is just an inductive sensory mistake. While taking no account of the possibility, they are all wrong or are lying, just imagine that none of our witnesses can give a complete and doubtless testimony of surveyed phenomenon and that all the witnesses describe what they saw, but unfortunately, there is no one who saw what is essential.

We are thus left with just the third possibility and that is to critically reassess the reliability and competence of each witness and their testimonies. As in the judicial system, where the sincerity and truthfulness of witnesses and the possibility to verify it are important, cognition must, also have reliable foundations. This we can achieve by observing how the witness arrives at his own testimony

and by verifying if he had really seen (perceived) what he described in his testimony. By this process we paradoxically satisfy requirements of all three above mentioned possibilities.

Firstly, step by step, by observing the chronology of the testimony's formation, we figuratively move into a position of a witness and we experience the matter being assessed as if by our own mind. The testimony of (for example another person's) senses places the matter right in front of us so that we can experience it by our consciousness as if by "inner sight".

Since senses offer us the possibility to view facts by "inner sight" they, at the same time, enable us to confront individual sensory experience with our own perception. In this step, we are cross–examining the submitted testimony by our own perception. We verify the evidence and trust it only if we can see/hear/feel (by inner sight) that such evidence produced by senses is true. Actually, we compare what was seen with what we are seeing ourselves in this conveyed place. We verify what we see and what anybody else sees, we verify the validity of the testimony in comparison with the testimonies of other senses. Thus we move towards the third step. That means we verify the trustworthiness of the witness itself (senses) by means of confrontation with other sensory experiences, individual specifications and personal history.

If we want to study the trustworthiness of our testimonies, we must study the circumstances of their formation, but also the nature and personality traits of the witness that offers the testimony. This can be done by studying the structure and abilities of the witness and the mechanisms, by which it acquires, evaluates, and later conveys information. In order to know these factors, it is necessary to know the anatomy of our receptors, the way they work, their limits and functional determinants as well as the way of evaluating acquired data via higher cognitive processes. Moreover, it is necessary to know the conditions in which senses are able to receive information, that is later contained in their testimony and if or to what extent the truthfulness of information is limited.

Understanding of these factors enables us not only to recognize the validity and reliability of sensory data, but also to better understand the limits of our sensibility and thus helps to improve it (for example by increasing its range and sensitivity) and even to form new — artificial perceptive systems, which are able to replace missing or damaged receptors, or make the activity of already existing human sensorial systems more effective and automatic. Only by studying the way we perceive, can we recognize our own mistakes and imperfections and eventually eliminate them from our cognition. This can be applied at the perception level as well as at the level of ideas and constructs which are derived from perceptions.

Besides the pragmatic and the noetic reasons, there are many different motives to study the issues of perception. One of the reasons can be sincere interest in understanding why things seem the way they seem, why illusions, hallucinations or sensorial defects exist. Another reason is an aesthetic motive (Blake, Sekuler, 2006) and last but not least — a desire to understand oneself and the world in which one lives. On one hand, to study perceptions means to study the world which is made of them, on the other hand, it also means to study oneself, one's cognitive apparatus and sensory perception as well.

1.3 Who and how studies perceptions?

Perceptions and sensing represent a unique source of how to experience something at all. Since cognition was at first the domain of philosophy, it is obvious philosophers were also the first group of people to study the issues of perception. Antique thinkers such as Democritus and others developed mainly speculative theories (about atomic structures — eidolon — being received by our senses), on the basis of which they tried to explain how we perceive something. Aristotle chose a similar way of thinking, although a less materialistic one (the shapes entering our mind) and the stoics had their own conception as well. The theories of perception became the domain of epistemologists (epistemology = philosophic theory of knowledge), but as the thinkers started to see the differences between sensed entities and real ones very soon, gradually they were forced to integrate mathematical knowledge (mainly geometry — Euclid, Ptolemy), optics and physics into their explanations. Later (especially in the Middle Ages — Ibn al Haytham — Alhacen), the focus of the study of perceptions shifted to geometry and physics (conversed physiology — sight as the light of a reflector) in order to become in the early years of modern science an individual branch of scientific exploration but at the same time still be a part of naturo–philosophical thoughts of mainly those philosophers who were trying to reshape the modern age of science (F. Bacon, R. Descartes, W. Snell, I. Newton). Despite the fact that in the 17th century, the original antique theories of perception were brought back and turned into more psychological ones (J. Locke, W. Molynaux, G. Berkeley, D. Hume), generally we can say that philosophers of modern times (from R. Descartes to I. Kant) studied mainly the relation between sensory perception and intellectual knowledge.

A real interest in systematical and experimental study of receptors and sensory physiology came into existence much later — towards the end of the 19th century. This was connected mainly with the creation of experimental psychology and with the application of physical tools and methods of studying and describing perception–receptive mechanisms. G. T. Fechner and M. Weber tried to focus their attention on the study of stimulus increase and its modifications in perception, as well as on the analysis of basic conditions, scopes and capacity of perception. At this period we may encounter the birth of attempts to experimentally verify most psychological and philosophical theories of perception postulated by W. Wundt, H. Von Helmholz, E. Hering and others. Thus psychology was separated from philosophy and it was established as an individual discipline with the primary domain of studying psychics (and thus perception as well) in scientific ways. The formation of experimental psychology as a university discipline and publication of ground–breaking work by Robert Woodworth (Experimental Psychology 1938) may be regarded as the height of this emancipation effort.

In the second half of the twentieth century, due to the influence of behaviorism and the arrival of neuropsychological approaches, attention was turning to scientific testing of sensory discrimination abilities and to studying the neuroanatomical correlation of perception (A.R. Lurija). As the knowledge of neuroanatomical, physiological and functional dependencies as well as the new display and examination processes and mainly of the electrophysiological records which were developing, the neuroanatomical "substrata" of receptivity became one of the best analyzed fields of perception and as a result of this the structure and function of individual receptors as well as their functional connections with neural centers were becoming relatively well mapped. However, a one–sided emphasis on the study and description of "external" mechanisms of perception resulted in a deficiency of learning about "the contents" of perception.

In the 1930s, many thinkers (philosophers, psychologists) turned their attention from studying basic elements of perception to studying entire patterns (mental ones mainly). The holists believed that studying such a complex matter as perception cannot be done by just studying the individual qualities which can be usually described only from the outside (by a third party). Therefore the mentalists, the representationalists and the gestaltists looked for the essence of perception "from within" by searching for the patterns of perception organization and of the sensory field and its structure. Phenomenal experience and mentalistic concepts which are able to describe it, became the main object of their study. Deriving from the works of a brentanist Christian von Ehrenfels and from the phenomenology of Edmund Husserl, they did not understand perception as just a physiological and mechanical process of acquiring data, but they considered its subjective understanding and interpretation as the key point.

The beginning of the second half of the last century can be characterized by divergence from behaviorism, by a synthesis of the two main directions and by a turning to a so–called "cognitive revolution". As a result of rapid development of new research technologies and of interdisciplinary studies, a whole area of sciences and disciplines with a common interest in cognition came into existence, and both receptivity and perception play a crucial role in this area. Along with concentration, memory, language, problem–solving and other abilities, they represent the core of cognitive sciences which include philosophy, psychology, neurosciences, linguistics, education, artificial intelligence and anthropology, but also many other studies (biological, evolutionary ones, etc.). The issue of perception thus becomes the central question in the theory of communication, in modern design as well as in the newest advanced, so called "smart" technologies. Therefore we might say that it is now an inter–disciplinary and multi–aspectual study. It seems that while at the beginning, the theories of perception used to be mainly the domain of philosophers trying to explain their own knowledge, today the center of research is shifting away from a purely human dimension (development of artificial retina, automated perception — security systems, separation of stimuli — Picasa etc.), and they are becoming more and more a scientifically–technological utilitarian matter which involves various scientific approaches and methodologies of study.

1.4 The task of philosophy

It may seem that with gradual specialisation of individual science disciplines and with their orientation to certain aspects or problems of perception, the issue of sensory reception has become almost solely the domain of science. Over the course of history philosophy has gradually lost its competence in this subject (as well as in other areas). Philosophers used to play an important role of valuable sources for perception theories, staring with Democritus' mechanistic teachings through Alhacen's unconscious inferences, Descartes' optics, the Boyle — Lock separation of primary and secondary qualities, Descartes' and Berkeley's perception of distance (Hatfield 2009) or Kant's theory of knowledge. Also Goethe's or Schopenhauer's inspirations for Hering, suggestive Brentano's thoughts as well as phenomenology, plus many other philosophical ideas found their place in later scientific theories.

Philosophy, however, used to enrich science not only via concepts and ideas, but also through distinctive methodology and ways of thinking. As good examples we can mention the introspective method as well as the phenomenological reduction and the description of phenomenological experience.

Even more inspirational than the methods are questions that philosophers used to formulate. The most dramatic example of this is the historical search for the answer to the „What is colour?" question. What we actually see often depends on how we ask the question. The question pre–determines what we concentrate on, what we consider important and how we could approach the problem. Philosophy is implicitly present in every perception theory in explanatory background, which is the building block of each of these theories. Besides this, it is present there especially through things it asks about or things it doesn't ask. Things we do not debate because we don't know about them or, on the contrary, because they are so obvious are often more essential than those we explicitly enquire about. And philosophers, most of all, are those who dare to ask things that leave others untouched.

The philosopher's task is to ask obscure questions in places where scientists see no problems. These are not just questions of metaphysical, epistemological or methodological character of the problem being researched. These questions often cause a whole area of new unsuspected issues to arise, as was the case with the birth of Mind Philosophy (mind–body problem) or with the question of quale. This type of question, questions using mind experiments (for example Mary and quale) allows us to thoroughly

examine the accuracy of new theories and test them in not very probable or not quite possible conditions.

It is a special task of philosophy not to ask "How?" as science does, but to enquire "Why?". It poses totally different types of questions. A philosopher is interested not only in the process of perception but also in the character of perceived data, reasons for existence of this mechanism, conditions and consequences. This puts the philosopher into a meta–scientific position and forces him/her to synthesize and guess the information produced by concrete scientific disciplines. One of the biggest problems of contemporary science is the issue of compatibility of individual scientific findings which are a result of different scientific methods, theories and approaches. Philosophers are thus able to function as some sort of a link between individual theories and place them into accurate circumstances while, of course, using scientific knowledge.

Philosophy possesses another crucial role and that is to work with language. Philosophers are able to clean and linguistically stabilise terminology and the meaning of certain concepts. Philosophy tries to clarify and unite different terms used by different sciences and at the same time it seeks to dispose of deep deposits of shady and unclear notions.

In addition, philosophy is also left with a whole other group of uniquely philosophical queries concerning the issue of perception. One of them is whether it is possible to separate perception from higher cognitive functions or whether it is inseparably joined to them. Most thinkers distinguish between sensory and post sensory processes of information. It is questionable however, in what way do higher sensory functions influence the discrimination and processing of information on a sensory level. In other words: Does our previous experience influence whether and how we perceive something? In what way does the structure and function of the receptor determine the quality of the reception? Is it even possible to grasp raw sensory data? How does a random group of stimuli turn into a united sensory experience? Do we perceive the world directly or do we create our own pictures and interpretations? How does it happen? (Rookes, Willson 2007) Why don't we all perceive the same objects in the same way when we have typologically identical receptors? Does culture, language and education have an influence on our perception? Why is our knowledge and our ability to see or not see something changing if our receptors are staying the same? Is sensory perception merely a biological process? (Blake, Sekuler 2006)

This text attempts to focus on perception theories from a philosophical point of view. Besides a terminology definition and a short introduction to anatomy and physiology of specific receptors, it will try to focus on the overall complex of sensibility and receptivity and will try to introduce basic (up–to–date) theories of perception. It will at the same time take into account ontological, epistemological, and methodological aspects of perception and questions tied to its teleology, evolution and further development.

1.5 Recommended literature:

Audi, R.: *Epistemology: A Contemporary Introduction to the Theory of Knowledge*. London : Routledge, 1998, 15 — 54.

Hatfield, G.: *Perception & cognition.* Oxford Press, 2009, 1 — 35.

Gepshtein, S.: Two psychologies of percepction and the prospect of their synthesis. In *Philosophical Psychology.* Vol 23, No 2, April 2010, 217 — 281.

Hamlyn, D. W.: Perception, sensation and non–conceptual content. In *The Philosophical Quarterly*. Vol 44, No 175, April 1994, 139 — 153.

Locke, D.: *Perception*. Routledge, 1967, 13 — 15.

2. Basic theories of perception and processing of information

Key words: *realism, constructivism, computationalism.*

Most relevant theories and explanations of perception as a process of acquiring and processing of information may be divided into two basic groups, according to the direction of information flow.

The first is a group of theories which suppose using only bottom–up processes when acquiring and processing sensory data. By bottom–up processes, we mean processes that start at the lowest sensory levels — that means(from the cortex's point of view) at the most distant levels of cognitive apparatus — and then they gradually lead to more complicated and complex processes which take place in higher (cortical) structures which are responsible for more global and abstract ways of thinking.

On the contrary, the top–down theories suppose that in the process of discrimination, but mainly when processing sensory stimulus, we start by "feeling" sensory data on receptors, but their processing presumes a downward influence of higher cognitive contents which organize and later determine them. Such influence we can call the top–down effect. The core of this approach is the fact that in order to process sensory stimulus, one needs to have prior experience or knowledge, or other influences which help to organize and form cognitive contents.

2.1 The bottom–up theories of perception explanation

The characteristic feature of bottom–up theories of perception is the fact that the content and quality of sensory input play a determinative role in influencing the final percept. Sensory input, in their view, represents the cornerstone of cognition and by its own nature it determines further sensory data processing. For example, when perceiving a tree, our sensors collect the basic data (such as points, horizontal or vertical lines) as the main individual characteristics of the object which are later connected to build more complex, assembled surfaces and shapes in order to create complex perception of the object we identify as a tree. Therefore we call this data–driven processing perception. With respect to the emphasis these theories put on the nature of sensory input, it is no surprise that most of them significantly correlate with philosophical realism, which suggests that our percepts are directly induced by external objects and more or less correspond to them. A typical prototype of such direct realism is Gibson's theory of direct perception.

2.1.1 Gibson's theory of direct perception

J. J. Gibson believed that our cognitive apparatus was created and formed by a long evolutionary influence of external environment which is apparent in its structure and abilities. We learned to extract precisely the information which is necessary for our survival. In accordance with Darwin's assumption, the pressures of the environment caused our receptors to be created and formed so that they became sensitive to relevant stimulus from the environment and they adapted to the environment. Such interpretation of perception is called the ecological one because it attributes the determinative role to the environment and to its influence on the whole process of perception.

The basis of Gibson's theory is the conviction that our perception is determined by optical flows — optic arrays, which Gibson regarded as some sort of structures or patterns of light in the environment. The visual terminology he was using is not important since, analogically, it can be used for auditory or tactile components of perception.

Gibson believed that a human perceives objects (their sensory qualities) in a way by which packets of information — arrays determined (structured) by objects, enter his sensors. The beams of light reflect off the surface of objects and thus carry the information about their shape, size, texture, etc. Similarly, our ears are impacted by arrays of vibrating waves or by the influence of tangible objects. These information beams — arrays — form an extremely broad set of information flows, as in our environment there are billions of beams impacting our receptors from the entire perception field we happen to be in.

It may seem that in Gibson's view an observer is more or less a passive space into which the information coming from the environment is being imprinted. However, the opposite is true. Gibson realized that, to some extent, our perception is effected by our active approach. And it doesn't mean only focusing our attention and perceptual accommodation. For perception the most significant thing is movement. For example, when we are sitting at a table in a room, there are beams which strike the retina from the perception field of our eyes and which carry some information. Thus, for example, we can see a book we are reading, the table, but not many other objects that are out of our visual field. If we change our position, for example, if we stand up (or if we just turn our head slightly), the group of optical arrays falling on our receptors will change. This allows us to see some other objects or the same objects from a different angle. And exactly this change of position of our body or position of our receptors is the key matter for environment mapping. Only by this change can we catch surrounding information beams and acquire or be aware of the information present in our environment.

Nevertheless, Gibson thought, the main part of information contained in information beams around us is invariant. This is a result of the fact that we perceive reality which is independent of us and our position is only a slight determinant of what we are able to capture from the world. So, if we change our position, we are changing a set of information that is available to us, but we are not changing reality itself. Information structures such as texture gradient, optical array and horizon–ratio relation are some of the key points of our environment.

The texture gradient is created, if there are elements which, by gradual increase of distance from the observer, gather in his vision field into more and more compact formations. An example of such grouping can be a cluster of trees, a large cornfield or a pebbled beach. The larger the distance, the less we perceive particular stones and the more we perceive the texture of this background. Gibson regards texture gradient as an important matter because of the information it brings, especially information about the depth or the distance between elements. Wherever we look, the texture of individual elements increases with their increasing distance and becomes more and more dense.

Another informatively important invariant is an optical flow. If the observing subject is moving, it seems to it as if all the objects close to it are moving faster than those in the distance. Gibson believed that an optical flow of information beams grows as their distance decreases. Such effect can be viewed during piloting (determining distances according to the position of other objects), for example when landing an airplane, when the point we are heading to (focus of expansion) is seemingly still, whilst the objects in its periphery are flowing in direct proportion to their distance from the visual field center. This enables pilots to get fairly explicit information about height, distance and speed of movement (Gibson, 1950).

Similarly, when we determine the distance according to the proportion of the objects height to the horizon, Gibson found, that two objects of the same height are divided by the horizon in the same proportion, which indicates their equal height despite the fact that the size of the picture on retina changes according to their distance from the observer.

On the basis of these findings, Gibson arrived to a conclusion that by detailed analysis of data collected from the environment we may acquire all the essential information about objects — by direct perception of their perceivable qualities. And this is not only information about their size or structure, but also about their importance and potential application. In his work (1979) he introduced a thesis — it is possible to perceive, using senses, the potential use of particular objects the same way as it is possible to perceive the structure of these objects. Affordance is the quality of an object or it is the thing we might be able to do with this object.

Gibson was convinced that if we take a look at a ladder we might also see the possibility to climb up or down. Similarly, we can see the use of a hammer for driving nails or the possibility that a certain object can be thrown or vice versa — that it might have an aesthetic function only. This can be applied to all common activities we do with objects, but also to atypical, original or highly abstract ways of use. Gibson used an example of a post box which can be used for receiving letters and at the same time serve as a communication point (Gibson, 1979, 139). What's interesting, though, is the fact, that to uncover what an object might be used for doesn't require any learning about or any prior experience with the object, but rather to learn to pay attention and to see. In this context we can see certain similarities between Gibson (Gibsonians) and the phenomenological approach.

The core of Gibson's concept is a conviction that our perception is based on information volume of sensory inputs, which we further process only via revealing and explaining the available information. Therefore, from the point of view of processing information it is not necessary to operate with images of sensory representations or with some mental objects. Gibson believed all necessary information is already contained in optic arrays, that is, directly on the retina — which in fact makes him to be a proponent of direct perception. Similar to Losskij, he also believed that we view objects directly, in their original form. He also points out that sensory stimuli provide us with more information than we are usually aware of and therefore, we must learn to simply scan them. This process of learning, however, is not some sort of learning about how to use objects or any other type of learning or memory. It is a process of careful tuning to things and resonating with them. By resonating we mean that we let the object influence our sensors and subsequently we are able to decode the qualities of objects directly from the feelings and perceptions they evoke in us. Learning plays no important role here, since our cognitive apparatus is tuned evolutionarily to be able to extract such data from the world and then evaluate it correctly. An example of such ecologically caused intuitive data evaluation is a perception (except the perception of texture gradient and other physical structures) and assessment of mental states such as happiness, sadness or anger, but also a „reading" of physiological processes such as hunger, thirst or tiredness. We don't learn to interpret them by learning and experience, but rather they are just an immediate response to inner states or sensory data.

2.1.2 Pros and cons of the theory of direct perception

Gibson's theory of direct perception represents one of the most interesting, but also one of the most controversial concepts in the history of interpretation of perception. Not surprisingly, it often becomes the object of critics and wide scientific testing.

From the philosophical point of view, we can appreciate that Gibson's ecological approach considers a human as well as any other animal to be an inseparable part of the environment, in which it came into existence, lives and exists, what is then reflected in its sensory and cognitive equipment. Thus, it is quite natural that he trusts the senses and the nature of sensory data, which he finds not only true, but sufficient for relevant data evaluation in the

environment. This means, Gibson belongs among critical realists and pragmatic advocates of cognition.

An important feature of his approach is a reminder that both sensory field and sensory apparatus contain much more information than we normally acquire from them. Gibson believes that sensors are able to extract and register all the relevant data and its evaluation is more or less automated and intuitive. According to Gibson, the higher cognitive processes are not fundamentally necessary for perception. This idea corresponds with Fodor's modular theory which presumes that perception processes are informatively encapsulated and even reflexively automated.

The great advantage of Gibson's theory is that it is able to explain the accuracy but also the speed of perception operations. During information detecting experiments it was found that visual processing of information took some time, but it was just a few milliseconds. The fact that it is an automated and fast process makes Gibson's theory advantageous in comparison with some computational models which require relatively dense and complicated mathematical operations.

In spite of the fact that Gibson did not attach any great importance to higher cognitive operations and cortex centers, on the basis of later experiments it has been proven that some of these centers are functionally specialized, e.g. for processing of vertical or horizontal lines or face recognition in the extrastriate cortex (Bruce et al., 1981). Similarly, some experiments imply innate sensory reactions (reflex), which could support Gibson's statements.

However, the theory of direct perception faces many serious problems. By a series of experiments it has been proven, that starting first with rodents, it is necessary and quite effective to form mental representations and involve memory tracks when integrating with the world. Rodents, mammals and mainly all the primates reach better results in an environment they had lived before, which points out the importance of mental maps. Gibson's theory is also unable to explain the plethora of visual illusions such as the Ames room, which prove the importance of previous experience for assessing visual stimuli.

The most significant shortcoming of the herein presented theory is the concept of affordance. The statement that a visual field can offer us a sufficient amount of information about the usage of objects independent of our previous experience is very problematic. If it is so, why can't we see most of the meanings before someone teaches us to do so? Another serious question is — where does the originality and genius of a certain view come from, if our cognitive apparatus is more or less identical and we all have all the significant information in our field of vision? And if our sensory apparatus is developed ecologically and our perception is being led by stimulus, why is this resonance (in the sense of forgetting about other forms of evaluation) necessary and why isn't such a huge amount of information utilized?

Besides being limited to some visual problems, the distinctive issue of Gibson's theory is the fact that it doesn't discriminate between seeing and understanding stimuli. The theory of direct perception does not address the question of visual field organization, to gestalt figures and it completely ignores the difference between seeing the object and understanding it as a particular object. This is precisely the moment that may be considered as one of the most significant differences between the ecological theory of J. J. Gibson and constructivist theories.

2.2 The top–down indirect perception theories

The key feature separating the top–down theories and the bottom–up theories is the participation of higher cognitive functions in the process of perception in the form of support of discrimination and interpretation of perceived contents. While top–down theories prefer direct perception without participation of knowledge and previous experience, according to the theories of indirect perception, perception is possible only by means of mental representation, computation or creating a picture of a given reality. Sensory data must be organized and captured by cognitive apparatus and then interpreted on the basis of available knowledge. The philosophical basis for this approach to perception is *The Critique of Pure Reason* by Kant. According to this work, thoughts without content (*Inhalt*) are empty (*leer*), intuitions without concepts are blind (A50–51/B74–76). Only by understanding (*begreifen*) the image (*e. Anschauung)* via a concept (*r. Begriff*) one realizes, what he is experiencing and only then can we call this cognition.

Participation of higher cognitive functions is characteristic for interpretation of viewed sensory inputs. According to the way we arrive at this interpretation, we can divide the theories into constructivist, computational and synthesizing ones.

2.2.1 Constructivist theories

Constructivist theories assume that the process of perception is a highly active process of extracting sensory stimuli, their evaluation, interpretation and backward organization of sensory stimulus. Perception is the end product of the interaction between stimulus and internal hypotheses, expectations and knowledge of the observer, while motivation and emotions play an important role in this process. Perception is thus influenced by a wide range of individual factors that can lead to an inadequate interpretation. (Eysenck, Keane, 2008, 74).

While behaviorist background is typical for the theory of direct perception, constructivists accepted Helmholz's principle of sensory data processing by means of unconscious inference (inference of color constancy). They also took into account the knowledge of Gestalt Psychology, which enabled them to look for unconscious patterns of perception as well as to study the influence of conscious experience on irreversibility or reversibility of perceived shape.

2.2.2.1 Gregory's theory

One of the most popular constructivist theories of perception is Gregory's theory. While Gibson integrated the phylogenetic flow of time (the influence of evolution on cognitive apparatus) into the process of perception, Gregory used also the flow of ontogenetic time. He claims that sensory data found on receptors are just some sort of energy samples, but they are of no great importance themselves. Their importance is based on our previous experience. Data „have the past and the future; they change themselves and they influence each other. They have some hidden aspects that emerge only if influenced by various conditions. (Gregory, 1990, 219).

What Gregory is trying to suggest is what we call the importance vagueness of sensory data. Similarly to Gibson, he does not doubt the importance of receptors for acquiring data but he disagrees that sensors possess the ability „to read" the meaning of particular data (e.g. affordance). Gregory believes this process, just like any other similar process of reading, requires higher cortex centers activity and learning. Perception is a matter of receptors as well as of brain. The name of his book Eye and Brain follows this idea.

Material acquired by sensory organs is non–specific and raw, so we must approach it by higher cognitive functions. In this contexts Gregory talks about searching for a hypothesis that would be able to grasp and interpret sensory data in the most pertinent way. Subsequently, we test the given hypothesis (e.g. this is the letter A) and if it seems to be congruent with the model, we accept it. So sensory data are only clusters of physical stimuli and our brain tries to interpret them in the most meaningful and the most likely way.

A typical example of such a procedure are various optic illusions or gestalt figures. Many of these figures are based on our endeavor to grasp some non–specifically outlined shapes in the most meaningful way. The model itself is neither a duck, nor a rabbit, only a group of some points we tend to connect and interpret as lines that are somehow connected. We believe, if there are two points close to each other, there must be a connection (the law of closure). It means that the cortex is searching for an appropriate explanation of what the retina is offering. We do not know exactly how and by what principles the cortex does this. It is, however, obvious that it concerns the rule of similarity and association, and thus it is based on previous experience. When searching for the appropriate answer, the cortex is forced to use already existing contents and knowledge. Among them it tries to pick and choose the best and the most likely one, consequently it tries to subject the sensory stimulus to this hypothesis.

Verifying particular hypotheses is considerably constructivistic. When talking about constructions we mean that when grasping sensory data on receptors we do not accept them as they are, but we try to construct a sensory object — to organize it — according to hypotheses that should describe it. Ultimately it means we ignore data, which do not support the hypothesis (e.g. an incomplete object and its imperfection) and we emphasize those which agree with the hypotheses. If we succeed in doing this and sensory data do not oppose the hypothesis, it is certain the hypothesis is correct.

Many psychological experiments have proven that when we search for hypotheses we are very sensitive to either slight simplifications leading to a clear conclusion (an oval as a circle) or vice versa, to tiny obstacles which violate the ideal shape which leads to a search for totally different hypotheses (an unclosed circle with the gap on the top we interpret as the letter u, with the gap on the right side as letter c). It is quite interesting, however, that to find the right interpretation, neither the perfection or completeness of sensory data nor the ratio of these data to those that contradict the hypothesis are important. In fact, only a small amount of information and its correspondence with the whole idea is sufficient. Taking this into account, Gregory thinks, that a subject needs contents and ideas more than a great sum of sensory information. Experience is the key point of interpretation.

Gregory often points out that for interpretation of sensory data, experience is more important than sensory image. Our conclusions about stimuli such as the Müller–Lyer Illusion or the Ponzo Illusion prove that. We perceive both by using our experience with spatial perception, which we apply to two–dimensional outlines. We suppose that two parallel lines of the same size are not of the same length because they are bordered by opposite oriented arrows. Gregory believes, we interpret this illusion (drawing) through our experience with the distant corner of a room versus the near corner of a building. Also in a Ponzo Illusion, we use the rules of perspective to interpret the size of objects.

A distinctive example of using perspective for identifying stimulus is the Necker Cube. The cube portrayed in a two–dimensional surface is a slightly illusionary object. In fact, we should see and identify some sort of polygon rather than a spatial object. But our previous experience with representing perspective forces us to interpret this object as a three–dimensional one, portrayed according to the rules of the Renaissance perspective. What's peculiar about this cube is the fact that it immediately offers at least two equally correct interpretations and those are the top–view as well as the view from below. Both views are reversible and we can switch between them according to our approach to object organization we happen to adopt at that particular moment. There are some other similar unreal or infinite objects (the Penrose Triangle, Escher's Infinite Staircase).

It is quite remarkable that these illusions are somehow forcing us to spontaneously interpret them the wrong way even after we had just realized that the first hypothesis was wrong. It is the same with the Ebinghaus Illusion. In this experiment we incorrectly identify the size of circles based on context in which we see them. If there are two identical circles surrounded by circles of different size (one is surrounded by smaller circles, the other by larger circles), we tend to think that the one surrounded by smaller satellites is larger than the one surrounded by the larger ones. This

phenomenon applies mainly when evaluating visual stimuli (for the tactile ones it is less significant) and it may be attributed to the fact that we are trying to perceive the contrast and the context at the same time.

Research has shown (Bruner, Goodman, 1947) that overestimating the size of an object relates also to attributing specific values to a larger object. Poor children, for example, tend to overestimate the size of coins, while more affluent ones (perhaps because of a lot of experience) do not trust this illusion so much. The context, the motivation and the expectations are some of the key theorems of Gregory's theory. From our own experience we know that when evaluating stimuli we are often led by what we are mostly expecting. We do not take into account atypical features and we see what we want to see, or on the contrary what we don't want to see; it means what we are afraid of, but are convinced, we are in danger of it. Allport and other constructivists in this context talk about perceptual sets and setting. Gregory, therefore, says that to see means to believe, that the given object is what it is, but also, that our perception is determined by attitudes, emotions and expectation.

One of the most significant examples is operating with incomplete objects. And this applies to completing pictures as well as to more abstract objects such as the letters. If we look at a written text, we focus not as much on the structure and visual aspect of a particular letter, but rather try to integrate it into a meaningful unit consisting of other letters — into a word. According to the holistic reading method, it is possible to apply this strategy even when reading whole words in sentences. What we are attempting here is to identify a letter according to the already read context and expectations arising from the following letters. Psychologists carried out a wide range of experiments, in which they used incomplete letters and found out that this obstacle does not necessarily play a major role in reading and identifying the content. Similarly, if we use a letter font, which makes it impossible to identify differences between some letters (e.g. cl and d), despite the fact, that typographically it will be the same object, the reader often, based on context, has no problem to distinguish them and reads the text as if these were two totally different letters. This means that the way we identify stimuli is not "literal", but it is driven by most likely context.

2.2.2.2. Evaluation of Gregory's theory

One of the main features of Gregory's concept is the fact that it is able to clarify the reasons of our errors and inaccuracies quite well. It seems that contrary to Gibson, Gregory found mechanisms for explaining illusions and reasons why our perception is so complex and holistic. One of the greatest advantages of his approach is that when speaking of the process of perception it takes into account our personal history and that he understood that to operate with sensory data does not necessarily mean to perceive, but to perceive always means to integrate feelings into a broader context of our beliefs and opinions.

On the other hand, it is necessary to add, that there are some shortcomings to be found in Gregory's theory. One of them is its inability to satisfactorily explain the relative correctness and universality of most of our daily perceptions. Despite having quite different personal histories, motivations, expectations and emotional statuses, our perceptions are nearly identical. If our perception is determined by construction of internal hypotheses and mental models, it is surprising that they are so universally widespread and that they are so similar, almost identical when dealing with the same stimuli.

Another problem is that most of our hypotheses are relatively correct, although the probability that we would be just „guessing", and almost always getting the correct hypotheses, is very low. Of course, we can say that if our experience confirms the accuracy of a particular hypothesis, we tend to use it in all subsequent similar situations. The question, however, is how we acquire these

hypotheses, where do they come from, because in early childhood we possess mainly sensory data and hypotheses (experiences) are created via grasping and interpretation of this data.

To express this in a lighter way we can say, that while Gibson studies correct perceptions in optimal conditions, Gregory's theory is based on analyses of incorrect perceptions and perceptions in borderline or limited conditions. This allowed him to demonstrate that perception is a more complicated and complex phenomenon than Gibsonians had thought, and that besides mere collection of information, it involves also active participation of higher cognitive functions responsible for constructing.

2.2.3 Computational theories

Another example of the bottom–up theories are computational theories. The core of their approach is the expansion of Helmholz's belief in unconscious inference and evaluation of sensory stimuli. Proponents of computational theories are trying to solve the issue of perception by eliminating the question of conscious experience, while at the same time utilizing some of Gregory's premises. They believe that perception is not determined by conscious intentionality or motivation, but that it is being operated by relatively easy mechanical rules which can be applied to unconscious entities as well.

A typical example of developing computational theories is the field of applied informatics and artificial intelligence. Although the area in which they study perception is not totally conscious or alive in the biological sense, in their theories they often utilize biology or comparisons of different cognitive apparatuses. By studying particular systems, by which organisms acquire and evaluate sensory data, they find the fundamental patterns — algorithms which can be applied to apprehend human perception as well as in the area of inanimate nature. The example of such procedure may be the analysis of scent tracks by a snake's vomeronasal organ.

In their environment, snakes acquire information about food using their sense of smell, that is using their tongue. The tongue of a snake works as a device, by which a reptile collects information from the environment. In order to optimize this process, Nature has developed a special mechanism and a tool — a forked tongue, which can be flicked out quickly. The speed of this movement has a special task. The faster the tongue is flicked, the larger number of air molecules (and thus smell molecules, too) it acquires from the environment into its oral cavity directly to the vomeronasal organ. Snakes, in fact, gather air samples to evaluate them. Due to the fact, that the tongue is forked, the snake can gather samples from two different parts of the environment. Then, the snake „knows", if the intensity of scent is increasing or decreasing in comparison to the previous sample, but also whether the scent is stronger on the left or on the right side. This urges it to turn its head in the direction, in which the scent is more intensive until it finds the right direction of its source. On the basis of a simple evaluation of two pieces of data, it is precisely able to find hidden prey.

Wilson's studies of ants (The Ants, 1990) moving pieces of forest according to predetermined rules as well as Reichert's studies of spiders' aggression (1978) by using explanation mechanisms of game theories prove wide use of computational theories to explain perception and processing sensory data in living nature . More and more, computational models are finding their application in the creation and development of artificial intelligent systems.

2.2.3.1 Marr's model of perception

Despite the fact that we have mentioned computational models in the context of color perception and determining the final color (e.g. in Land's Retinex Theory), we must also say that Marr's model of seeing is an excellent representative of computational theories.

David Marr approached perception as problem solving. According to him, to find a solution, it is important to analyze what the visual system should do in order to make the perception successful. Marr called this level computational since it assumes that each function (perception is a function) can be understood as a computational operation (consisting of sequenced steps) leading to a desired outcome. A fundamental feature of this sequence of steps is the fact that it contains hidden analytic — computational processes — and the aim of computational analysis is to describe a strategy, by which we ensure the achievement of a result (Marr. 1982, 23).

Marr's second level specifies a representation system which identifies inputs with algorithms, which transform inputs into representations. A second level of solving a problem is a detailed analysis of specific actions which we must take when transforming physical stimuli into mental representations. At this algorithmic level we study formulas — algorithms as well as representations (representational level) which enable us to achieve the result.

A third problem is the analysis of the means enabling us to carry out a specific operation. This level is called the hardware level (Rookes, Willson 2000, 34) or implementation level. In the case of living systems, it includes neural network analysis, in the case of AI (artificial intelligence) it is the description of functional connections described in the language of a specific material base.

The core of Marr's concept was a belief, that receptors are able to detect sensory data by each receptor cell itself. Since Marr's explanation is based on the description of visual perception, it assumes that each photoreceptor detects an amount of light impacting it and consequently stimulates it or not. Accuracy of detection is given by the number of receptor cells and their connections.

Gray level description is the first level of data processing. At this level, our cognitive apparatus evaluates light intensity in every single point of the model we are looking at. It means we are evaluating lighter and darker spaces or points which the model consists of. This level represents just a preliminary stage (early vision). Based on the perception of edges, stripes, endings and points, we are forming the first rough sketch of the perceived model. Due to constant variability of sensory cells' excitation, we evaluate and update the rough sketch according to the principles of flocking and merging into graphics. Because the image we are perceiving is projected on the retina as a two–dimensional object, which is characterized by various colored or black and white spaces, we must process it implicitly in order to grasp it. Such process involves merging adjoining points and similar or contrasting spaces and leads to a development of some sort of primal two–dimensional object. Marr thought, while mapping brightness takes place mechanically as a bottom–up process, at the level of the first primal sketch we take into account also hidden patterns of field organization, although the main part of this process is still regulated by stimulus. Thus a two–dimensional picture of the object comes into being, although we are not aware of it.

In the next stage, we read a given model according to previous experience. Thus, Marr calls it $2^1/^2$D sketch of the scene. In this stage, we interpret various textures, shadows, colorations and brightness by forming a picture of the object according to perspective rules, as we experience them in daily life. We suppose, the objects seem different from different angles and we ascribe them a certain plasticity. $2^1/^2$D dimension means that objects seem more–than–two–dimensional, at the same time it documents that we realize this "as if" and we don't possess full 3D understanding.

Full 3D vision assumes a high level of conceptualization. While in $2^1/^2$D, a sketch we suppose the plasticity of the object, understanding of the 3D vision also involves what we do not see. If we are looking at a sphere or a cube, we never see the front and the back part at the same time. The fact, that it is three–dimensional, or it has the back part as well, is just our belief — our understanding of the object as a 3D geometrical entity. Such understanding is not based on visual experience (we never see the back part), but on logic — on our understanding of things as three–dimensional objects. It follows that 3D sketch is a fully top–down process which assumes a specific kind of comprehension. So if a native Indian

looks at a map, for him it is difficult to read, because he does not understand its three–dimensional representation.

6.2.3.2 Evaluation

Marr's theory arouses a wide range of polemics and interpretations among philosophers, psychologists and mathematicians as well.

Owing to Marr's theory, philosophers such as Robert Audi and Dan O'Brien distinguish between raw data and their cognitive interpretation. They also open up questions of existence and the nature of perception beliefs, and thus the question of reality and belief in cognition. We will deal with these problems in later chapters.

Marr's model had a great influence over informatics and found its application in machine evaluations of visual stimuli. Both Marr and Hildreth developed a program which analyzes sensory data and creates an analogy of a raw primal sketch (Rookes, Wilson 2000, 36). This is based on the mechanism of identifying simple outlines of a visual field (for example horizontal lines). This also inspired computer experts to develop artificial intelligent systems, which would be able to recognize, notice and evaluate given models. The height of their effort is the development of an artificial retina and intelligent observation systems.

Without any doubt, the great advantage of the theory introduced here is that it enables us to distinguish between particular levels of cognitive processes and mathematize them as well. This way, Marr used the advantages of Gibsonian process because it finds sensory data more dominant at the first levels — as the data by its nature pushes the retina to transform experienced data into primal sketch. However, unlike Gibson, Marr considered the process of physical invariants' detection to be identical with processing of information, although it is more complicated than Gibson supposed. Recognizing areas of light and dark on a model involves not only identification of borders and shades, but also a whole range of unmerged outlines and their mutual organization. However, at a higher level he takes into account the positive aspects of Gregory's approach, which assumes the influence of learning and of data stored in our memory. What's happening when using $2^{1}/{}^{2}$D sketch is then a calculation of the most likely possibility on the basis of one of the available variants. Thus, Marr created a basis for a combined concept of theory of perception, which is well represented by Ulric Neisser.

2.2.4 Synthesizing theories

Similar to the two–level theory of color perception as well as to a general theory of perception, the existence of contradictory and partially satisfactory theories led scientists to attempts of reconciling them. One example of such projects is Ulrics Neisser's analysis–by–synthesis model.

2.2.4.1 Neisser's analysis–by–synthesis model

Neisser, an author of the first textbook of cognitive psychology (1967) and a specialist in memory processes (a case study of Dean's testimony for the Watergate Scandal), defined „cognition" as a set of all processes by which sensory input is transformed, reduced, stored, recorded and used. Thus, he illustrates his behavioristic understanding of cognition as a transformation of inputs into behavior in S–R scheme. However, he is aware of the fact, that perception involves all the complex and dynamic processes such as mechanisms used to perceive patterns, mechanisms of figurative syntheses, visual memory, concentration, perception of speech etc. (Hatfield, 2009, 116). The basics of perception process are physical stimuli we are exposed to in the environment. The process of their detection in his view is a pure bottom–up process that goes on inside the cells of sensory receptors, but it is only a process of so–called preliminary sampling. According to Neisser, the process of preliminary sampling is unconscious and more–or–less automatic

and at the same time it uses principles described by Gibson. What is special about it, though, is that the great part of our sensory pre–conditioning behavior uses this information without any further processing. We detect but don't think about given information or in other words it doesn't enter our consciousness, if it isn't necessary. But if important information occurs during the data preliminary sampling process, for example movement, great contrasts etc., an observer directs his attention to it.

By means of this mechanism Neisser pointed out that a great amount of acquired sensory stimuli is left unnoticed or consciously unprocessed, though it can influence our behavior (unconscious avoidance of objects, squinting of the eyes against high intensity light etc.). Only data that somehow draws our attention, either by its evolutionary importance (innate mechanisms) or by our own deliberate intentionality (we focus our attention to it because we are searching for it) enter our consciousness. So, if we don't want to see, we are only looking.

When directing our attention to interesting or important data, we may feel as if we were attracted by it. It is only spontaneous attention caused by bottom–up processes. But there may also exist a purposeful attention — then we deal with the top–down processes. Neisser believes that directing attention involves a combination of both processes.

The main feature of this second phase of information processing is that stimuli which are neutral in their importance are subsequently gathered and organized by image–conceptual schemas. They come out of "storage" via learning, experience and through classification schemas collected by language and they help in developing a perception model which represents some sort of mental representation of the stimulus. This is illustrated by a dorsal direction of processing.

While Gregory's conception is known for characteristic construction of objects, Neisser's model is somehow more about re–construction and re–presentation of an object. This is also an indirect perception, but the difference is, that the mental object is constantly being reconstructed and compared with preliminary sketch or with data acquired on receptors. Thus preliminary mental representation, which is the object of mutual (dorsal and ventral) influence, comes to existence.

The third stage includes comparison and potential modification of the mental representation in order to suit the sensory data, but at the same time to be part of the context of already gathered experience and knowledge. Neisser calls it the modification stage. If we find an interpretation model, that suits the perceived experience and our knowledge, it is validated and then there is no need to look for a different model. But if our preliminary interpretation is not validated, we try to modify it until it is accepted. Neisser thinks our memory and recalling works like this.

2.2.4.2 Evaluation

Neisser's model represents a cycling model of perception interpretation. It does not necessarily start with acquiring raw data, although without it and without sensors being present there is no cognition. Neisser noticed that cognition may start with the top–down processes by means of intentional focusing and paying attention. If we pay attention to something, our conscious attention makes stimuli detection faster and better, although, on the other hand, it may have a negative impact on the process of applying schemes to sensory data. On the other hand he considers the detection of physical information to be a bottom–up process which leads to higher cognitive functions and to memory, and then back to sensory representation.

However, the problem of his research is, that it does not offer quite a precise explanation of why and how preliminary representation comes into existence. The problem of preliminary interpretations is the fact that they are supposed to manage both the data from the bottom (sensory data) as well as the concepts from the

top (knowledge and experience). Neisser focused his attention to work with classification schemes and to research made by Eleonor Rosch, but he didn't manage to offer a satisfactory explanation. The question of how we identify an object we see for the first time and have no knowledge about remains a serious problem. Are we even able to identify it, and if so, aren't we in this identification being led more by sensory data than the concepts? On the other hand, if we are led by sensory data scanning as they are being received by our receptors, how is it possible that we succumb to lies and illusions?

Even though Neisser's answer is a compromise, it offers a wide range of new questions, mainly about the nature and the status of perceived objects (about their reality and relative independence of higher cognitive functions), but also about the patterns and determinants of organizing sensory field and mental representation, which refers to an object or interprets it.

2.3 Recommended literature

Rookes, P., Willson, J.: *Perception. Theory development and organisation.* London and New York : Routledge, 2007, 13 — 38.

Matlin, M.: *Cognition.* John Wiley and Sons, Inc. 2005, 44 — 52.

Eysenck, M. W., Keane, M.T.: *Cognitive psychology.* Psychology Press 2010, 121 — 152.

3. Philosophical problems of perception

Key words: *ontology, reality, quale*

Basic types of perception theories problematize mechanisms of creation and the task of specific centres for the formation of a percept. Besides describing bottom–up or top–down processes (dorsal or ventral schemes) they open up a question of metaphysical status of perceiving objects as well as the problem of the origin of perception convictions and beliefs. The question of the source of reality and fiction in our perception seems an interesting one as well.

3.1 Metaphysical status of objects

The problem of metaphysical status of objects being perceived is an ancient philosophical problem. Democritus was convinced that the atomic structure of things or of things that come out of things (by separation or emission) is the object of our perception. On the other hand, even Plato was aware of the difference between the sensory object and the subject of our knowledge. According to him the subject of knowledge is clearly idealistic which he documents by giving it the name "idea". An idea is something which is principally intangible and it is available only to our mind which according to other Greeks (Pythagoras' heritage) is perceptible by an internal view. *Eidos* therefore points to this untouchable but visible object and the only thing that remains questionable is the issue whether these objects are actually objective

and independent from our minds or whether they are just our creation.

The history of philosophical thinking about perception can be seen as a history of the basic metaphysical argument between realism and idealism. According to Hegel's dialectics it is only obvious that by their mutual confrontation these two concepts have smoothed out unacceptable attitudes, modified and gone through a process of looking for new variants. Starting with Aristotle who had realized that an object doesn't enter the mind in real terms but only through its picture (*eidos aestetos*), through the stoics and the middle ages (*species sensibilis*), we come to British sensualists who (even in the case of Hume's empirism and associanism), take into account also the active role of the subject in the process of sensory object construction.

Realism not only assumes a certain level of direct or indirect view of things as such but especially the fact that perceptions are a result of their direct influence on us. This is the basis of each causal theory which explains the mechanism of perception in realism. Nevertheless, the fundamental problem of this attitude is that it doesn't show how to prove the existence of independent objects. What we usually encounter is not the thing or its causal influence but its result, which means the reaction of the receptor on the stimulus which (because of the reaction) we suppose.

An important milestone in this aspect was Kant's differentiation between the thing and the object or his differentiation between *noumen* and *phenomenon*. Even if we take no account of the problem of how we even know about the existence of (thing, per se) *Ding an sich*, the perception of the phenomenon is problematic in itself.

Kant supposes that a thing somehow appears to our cognitive apparatus and just this thing (the way it appears) he calls the phenomenon. Phenomenon, therefore, is a collection of qualities which our (human, not individual) cognitive apparatus is able to grasp. This causes the difference between the knowledge about a thing (in itself) and our image of it.

Phenomenalists (J. S. Mill, E. Mach) (, therefore, identified physical objects with phenomena and they point out that if we want to say something about things, we should limit our statements only to the description of our sensory statuses. According to them, perceptual phenomena or sensory stimuli are the objects of knowledge. It is not possible to step beyond the border of feelings. So, if I'm looking at an object, I'm perceiving it as, for instance, red (but I'm not supposing it is also materially so). Similarly, when I'm feeling the temperature of a certain object, what I'm perceiving is the collection of qualities that are being presented, for example, on a mercury scale of a thermometer. An object can therefore be identified by sensory data (sense data). The problem of phenomenalism is whether it is even possible to map sensory data. Sensory data as objects of receptors are actually not the object of perception. Perceptions themselves which are supposed to arise from data are in fact the objects of perception. How can we actually recognise the congruity between sensory data and perceptions? And how do we know that we have any sensory data at all if they are not the object of perception? Can we connect the activity of receptors with sensory data?

There is another solution to this problem and it is the approach of phenomenology. Phenomenologists believe that things are identical to how they are presented to us. The trouble is that our knowledge is marked by incorrect interpretations of things (culture, education, illusions). Phenomenologists are convinced that this can be eliminated (it's called phenomenological reduction) and that things can be seen (as objects) in their reality and nakedness. What they are trying to get to is the thing and the actual structure of self–representation of the object. But, is it really possible to see things in a way they present themselves to us independently from our language, experience and previous knowledge? Isn't this request for complete phenomenological reduction at the same time a request for elimination of the subject? Or should a result of this reduction be a type of perception that is without any object? Kant pointed out that all we perceive is determined not only by the forms of perception but also by the overall architecture of our cognitive apparatus. That means that perception really starts with a stimulation of senses, the final sensation is, however, influenced by the structure of the cognitive apparatus (for example the structure of the organisation of a sensory field), but also by its content. We can name a few of these: subject–object structure, the unification of perception, space and time issues, etc. In other words, if we had different cognitive devices, we would see objects differently.

Adverbalists, while speaking of this issue, say that we don't know what objects really are like, we only know how we see them. We can see an object as red although theoretically it doesn't have to be red at all. What we have here is just our representation of the object. Adverbalists think that color is not part of the object (or at least there is no way to find out), but (similarly to objects as a whole) we just plant color into objects ourselves. In this way, adverbalists are similar to social contructivists. They question the existence of any independent objects and believe that we create all objects in our minds. Objects are products of the architectonics of our mind/brain. However, if we doubt the existence of things or sensory data and believe in the construct of objects, how can we explain the remarkable match of perceived objects? Where does the unity of our perceptions come from, if we don't have identical experiences and knowledge and our sensory organs and our brains are unique and in a certain sense different?

On the other hand, the fact that our mental representations are just a construct also necessarily means that they are not as real as things that cause stimulation in realism. Isn't realism, while referring to causal influence of physical stimuli, working with the same ideal constructs, which are sensory data and causality?

3.2 Perception beliefs

Several philosophers such as Audi and O'Brian believe (following the example of Russell's sensory data) in the existence of primary raw stimuli (seeing raw). They explain their beliefs by pointing out that subjects must have some building blocks that act as a basis for their convictions. Raw data in their opinion corresponds with the birth of a belief that something exists. Thanks to vagueness of its significance and structure, raw data is unable to inform the subject about any particular content, but it can at least draw attention to itself.

Audi, while using Marr's and Gregory's model of seeing, suggests that raw data is the initiator of the process of organization or re–organization of stimuli and of the grasping of it through the search for a hypothesis of what this object could be. Organizing the object of perception into a meaningful unit he calls „seeing as". Identifying an object as an object is a key moment. The question is how that happens. Audi postulates that it happens through aspectual perception which breaks up raw data into individual details and if some of them remind us of something from previous experience, we then reorganize and assemble them in order to create a meaningful entity. This seems similar to sorting by features or comparing of patterns.

One of the key points of Kant's theory is precisely this linking of sensory images with some meaning. Whether we identify an object as a book is, according to Kant, a matter of determining judgment, which (via schematism) chooses from the sensory material (image) what is important for it. Kant, however, does not offer a satisfactory explanation as to how this happens and suggests that this problem actually belongs to the 13th chamber of the theory of knowledge.

Willfrid Sellars (Sellars, 1978) in his analysis of sensuality (in his work The Role of Imagination in Kant's Theory of Experience)(enumerates) several important aspects. Firstly, he says that perception is a matter of productive imagination. Sellars documents this fact with an example of a book or an apple. When we look at an apple we see an object that we identify as an apple. We see its shape, size, surface but all of it only partially. What we don't see is the inside

of the apple, although we somehow naturally assume it. But where from? Previous experience? What we saw in our previous encounter with an apple, for example when someone took a bite of it or when it was cut in half, wasn't actually the inside, it was again only a surface of this partial object. How do we know then that things have their inside?

Similar reasoning applies to a closed book. Sellars points out the difference between these statements:

a) I see a book
b) the book has pages inside / cover in the back
c) I see a book as having pages inside / back cover
d) I don't see inside pages / cover in the back (Sellars, 1978, 15)

While with the first statement we are able, with a certain amount of tolerance, to accept Gibson's claim about affordance, while with the second it is evident that the content of our perception had been mined from our memory and previous experience and with the last statement even from the understanding of the meaning of the object as a specific, three dimensional identity (I'm seeing what I am not seeing).

Sellars therefore reasons that perceptual consciousness invokes construction of a sensory–pictorial model of an external object (Sellars 1978, 25). And not only that. It reaches all the way into a decision process about reality and non–reality.

The third type of perceptual belief is a belief that a specific object really exists. In this type of conviction, we know whether a certain perception is real or not and we come to the problem of dreams, illusions or hallucinations. A perception, in its essence, is always trying to convince us that something is one way or another. Perception is therefore more or less affirmative and that applies even in cases when it claims that a thing, a characteristic or an event is there or isn't.

In epistemology we tend to believe that the issue of reality is a matter of judgment. But judgments draw their reality or non–reality from perceptions and their mutual harmony or disharmony.

I think that in principle, perceptions always claim that what they are seeing is true reality, therefore they are so convincing. Even if we encounter a sensation we don't trust, it is either because it contradicts other sensations which we trust or because it is not clear enough and that's why we question it.

A classic example of vivacity or lifelessness of perceptions is discrimination between an on–line and off–line system. Current perceptions (on–line) are considered clearer and livelier while memories and artificially produced images are just their faded prints (Hume) although from the time of Descartes, we have known that even dreams can be so alive that it becomes too hard not to call them reality. Then, what is the difference between fiction and reality? Productive imagination is indeed part of both the on–line perception and the fantasy. And memories are mental representations similar to current perceptions. Moreover, as it has been shown, the production of memories or often fantasies activates the same areas of the sensory cortex as if they were produced by a signal from concrete sensors. In addition, numerous experiments have shown that for creation of a convincing sensation, no activation of a sensor is needed, it could be validly substituted by the activation of the cortex using, for example, an electrode. To what object or to what place is this thing which we call reality tied to?

We have shown that perception of colors is a matter of establishment of a special quality of psychological sensation which usually happens by a transduction of the energy of photons impacting retinal cones. Our sensations, however, often convince us that things appear in one way or another. The Ishihara pseudo–isochromatic plate tests suggest that what one subject sees as a red number eight, another subject can perceive in a very different way. On certain plates some subjects see nothing, while others see something specific. How do we decide which observations are correct? Who is right and what is the real color of shown objects? What determines the reality?

3.3 The issue of quale

The above example with colors, but also a perception of any model in general, suggests that a mental reality which we believe relates to a certain external reality is the object of our perception. Because of the difference between recipients and conditions of their receptions, we need to also consider the question of subjectivity as well as individuality of perceptions.

Previous chapters have shown that perception of any object is determined mainly by the composition and functionality of individual receptors and by the organization of the sensory cortex. This raises the question whether percepts acquired by different types of receptors are in fact the same perception process or it is an altogether different type of perception (echolocation of a bat vs. seeing, thermo–detection of a viper vs. seeing — Gray, 2005), but also whether receptors offer identical contents. Philosophers are looking for criteria for evaluation of identity of processes and contents (for example, the criterion of the stimulus, representation, phenomenological character and sensory organ — Gray, 2012) and they are aware of the potential difference in the perception content of various perception processes and types. Inter–species comparisons lead some of them to accept differences between perception worlds of different species. However, what about the experience contents of identical types of perceptions (for example within the same species)? Are our perceptions identical?

While examining biological conditions of perception, we have stated that each individual possesses a unique number and sensibility of receptors which causes for example that not all of us see the same shade of color or actually that all of us would probably see colors in a unique way, depending on the unique structure of his/her receptors. It is even clearer when we consider that the cortex of each of us is constantly being formed by each new experience and by each stimulus. This in fact means that even identical twins' cortexes would not be the same (they have different experiences if for no other reason than just their different place in space) and therefore their interpretation of sensory stimuli might not be identical.

The problem of quale (subjective aspects of experience) is considered an important issue of philosophy (Gáliková, 2013). It seems (if the opinion of those who claim their existence is accurate) that there is something in the interpretation of perceptions which can not be reduced or expressed and the unique organization and quality of specific subjective sensation (how it is according to me) is the very thing. There is a problem with this attitude and that is that if it really applies it is principally unprovable (because there is no way to perceive the world using the sensors and cortex of someone else), although it seems highly logical.

To sum up this reflection, we can say that our perception is most likely unique. It is unique in what stimuli we detect, but mainly in how we process them. That explains why, when looking at the same thing, not all of us see it the same way. But, is it really so?

Methodologically it is extremely hard to find out what is the content of specific subjective perception. Mainly with colors, sounds, feelings and tastes (or in general with so called secondary qualities), we realize that we are not able to share their contents. It seems that the only way this can be done is via the use of language which gives these qualities some objective meaning, but which does not give us any certainty that the terms we choose to express our perceptions really describe what we imagine. While analyzing so called primary qualities of objects, we usually don't encounter such problems.

If recipients are asked to draw, count or express the amount, shape, size, and structure of a perceived object in a different way, they do so with a high rate of consistency. That means that despite unique characteristics of our cognitive apparatus, expression of perception of a certain object is extremely consistent. How is it possible that while being unique we in fact perceive many things in the same way? On the other hand, how do we know that we see a thing in the same way if just one confrontation of my perception with the sensation of another person is again adjusted by my own optics?

3.4 Recommended literature

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4. Individual differences and cultural influences

Key words: *universality, genetic and empiric uniqueness, linguistic relativism*

Previous chapters have called attention to the significance and task of existing experiences and individual peculiarities of perception as well as to the presence of universally valid mechanisms. It seems that our environment determines the way in which we perceive as well as its content. On the other hand, individual differences of our sensory and cognitive apparatus, specifics of personal history and uniqueness of our location in space and time open up a question of subjectivity or objectivity of perception and the problem of individual dissimilarities or universality of perceptions.

One of the key problems of subjectivity and individuality is the fact that if we try to express exactly what is unique about our perception, the thing that is characteristic only for us — quale — then, strictly speaking, that is exactly the thing which is impossible to express. Expressing anything in language presumes objectivisation and taking no account of the specifics and thus the problem of quale becomes more or less academic and resembles mysticism. Any science can exist only on the level of something that is somehow general. It is impossible to talk about something that is unique — about individuality of an individual himself. Submitted theories, therefore, face a compelling dilemma. On one hand we are trying to study individual specifics of perception compared with their universal aspects, on the other hand we will want to describe this individuality. We thus encounter an uneasy problem troubling also proponents of quale existence and that is — how do we even know that our perception is different from or the same as the perception of another individual.

4.1 Presumption of individual distinctions

The basic reason for presumption of individual distinctions in the perception of objects is frequently occurring inconsistencies in the description of individual experiences. We assume that our perception is realistic and that we grasp objects as they really are. We start doubting this assumption only when we encounter a conflict between perceptions or if someone calls our attention to this conflict. How can we explain the existence of these distortions? How is it possible that individual percipients acquire different perceptions if they are induced by the same stimuli?

One of the possible answers is that we are not alike. Previous chapters show that perception is largely influenced by education and by past experiences. And this experience is not always (or never) the same. Francis Bacon, in his study of idols, calls attention to the "idols of the cave" (idola specus) whose influence results in the fact that our individual histories, progression of obtaining information and experiences are never the same and therefore they determine our perception. Many authors thus refer to psychological and educational peculiarities.

It is quite evident that in top–down processes, age and the progression of learning are key elements of consequent organization and interpretation of stimuli. It may seem that individual differences are more or less psychological and cultural. However, that is not the case.

With respect to the fact that individual receptors are tied to the sensory cortex, it is apparent that if, how and when our receptors are stimulated ultimately results in the formation and malleability of the sensory cortex itself. In other words — each sensory experience evokes establishment of synaptic connections in our brain and forms the cerebral cortex by forming new connections. This means that the chronology of individual experiences influences all following experiences because latter ones adjust to the former. Two uniovular twins have identical DNA. However, with each experience they differ more and more not only in terms of experience or psychologically, but also morphologically. Despite developing in the same womb, asynchrony of their sleeping and waking times, different position toward some sensory stimuli from the beginning determines the uniqueness of their brains. By being born and by taking a different place in space, this difference deepens with each new experience and despite having the same genotype, the environment and external conditions of perception form their cortex into a unique shape. This is the reason why there are no two identical brains (Brodmann's map is a useful illusion) and all individuals are morphologically unique. In fact the shape of our brain is not finalized at birth, but by each perception and by each individual experience it is being shaped each day.

A specific question is uniqueness not caused by conscious experiences. The fact that we have unique finger prints, structure of the optic iris or different number of rods and cones in our retinas, etc., is not just a result of our unique DNA. As František Koukolík states, what makes us truly unique beings, starting with our somatic equipment all the way to complex psychological abilities, which are called temperament or personality, is the impact of a huge number of factors such as level of sugars and hormones in the blood streams of our mothers during prenatal development, many various ions or cations, current temperature, pH levels of the surrounding environment as well as something which is simply called chance (Koukolík, 2003, 146 — 147). From this point of view it is quite clear that each individual is a biologically unique organism with certain sensitivity and number of sensors, a specifically and individually developing cortex and generally unique cognitive apparatus and whole organism. This results in certain specific differences of perception.

Despite being unique, we can still observe certain common features of perception based on specific characteristics. With respect to the receptor and brain sensory centers development, children are likely to see (perceive by eyesight) differently than adults because they are just learning to focus. Their lens is thicker, cones are not developed which results in different discrimination of green, blue, yellow or white. Similarly, with increasing age we can observe a change in taste, sensitivity and preference (starting with sweet–salty and later preferring more spicy tastes). Likewise, tactile or hearing sensitivity develops and decreases with age. Gender is another specificity.

Gender itself is discreetly outlined by the presence or absence of the X chromosome. However, in an individual's psyche, we can't clearly differentiate male or female behavior; in fact it is more of a fluid continuum of features and behavioral patterns that distinguishes typically male or female characteristics. One of the important determinants of formation of a male brain is the level of testosterone or estrogen in the first trimester (from day 36) of the fetus' life (Démuthová, 2012, 44). This level influences not only what experiences we seek, but other behavioral patterns as well. In general, we can say that men prefer mainly serial processing of stimuli, their logical analysis and spatial imagination. They achieve markedly better results in spatial imagination as well as in mental rotations (Démuthová, 2006, 40). To what extent they perceive differently is not fully charted. We know that male eyesight is more productive in good light (cone vision), whilst the female sight performs better in faster adaptation to darkness and is better at color evaluation. Likewise, it is well known that men tend to process visual entirety, while women prefer seeing details. Probably it is a result of gender needs because women — gatherers — had to specialize in fruit recognition and food preparation (Kimura, 2000, 15), while men — hunters — needed to map the surroundings and be sensitive to spatial relations (Kimura, 1992). Men and women also differ in sensitivity to smells and tastes with different preferences in the area of bitter and spicy tastes. Similarly, we can expect differences in auditory and tactile sensitivities. Paradoxically, men have a lower tolerance to pain despite being less sensitive to touch than women. Differences between genders are, however, relative and vary with age, exhaustion as well as with hormonal cycles (differences in results during the menstrual period and outside the period, Parlee, 1992). In general, we can thus say that universalistic understanding of sensory perception and rationality ignore irrefutable gender specifics of our receptors and brains, but despite this differences between individuals are most likely greater than gender variances.

Other individual determinants of perception are physiological states of a subject. Our perception is influenced by our emotionality, expectations, personal preferences as well as by current status and current physiological processes. Tiredness, infection, bad mood and sadness inhibit our ability to differentiate stimuli similarly to illness or the influence of narcotics and analgesics. On the other side, ecstatic states, barbiturates and stress sharpen and catalyze perception and *attention* to such an extent that they might spontaneously produce hallucinations and illusions. With respect to the varying physiological and emotional situation of an individual, emotionality and mood alter conditions for perception and influence it in either a positive or negative direction (Démuth, 2003).

4.2 Cultural influences

Analysis of top–down processes showed that learning and experience built on learning are among the most important determinants of perception. We have mentioned the influence of language and the problem of categorization as well as the importance of linear or aerial perspective, etc. To analyze cultural and social effects on a specific individual's perception, we must be able to eliminate individual differences and to identify only those influences which are characteristic for the whole group of percipients. Cross–cultural studies serve as good tools in this area.

One of the basic findings of comparative studies is the fact that previous experience enables us mainly to organize and interpret our sensory experience. Segal and his team (1963) showed that our perception of the retinal image is marked by three–dimensional interpretation. In a series of experiments, they demonstrated that percipients of the "western" world are susceptible to visual illusions, for example Müller–Lyer's illusion, but the members of primitive nations from various corners of Africa or Indonesia are not susceptible to these illusions or only to a limited extent. Likewise, Escher's illusions are relevant only to members of the "Escher" — western culture. One of the basic differences of perception is the understanding of three–dimensional drawings on a two–dimensional surface. It seems that methods of representation and interpretation of visual stimuli are to a certain extent influenced by culture and by the technique of visual display, which can be documented by the history of visual art as well as by the use of certain tools such as linear perspective, shadowing or placement. With these methods of visual display, we shouldn't talk just about crudeness of the display technique, but rather about a totally different concept of spatial and surface organization of viewed pictures.

Another serious problem is the sensitivity to certain sensory stimuli. It has been proven that the surrounding environment teaches us to be sensitive to relevant stimuli which are part of this environment. Inhabitants of snowy plains as well as African natives perceive the depth and distances quite differently than inhabitants of rain forests. Since their horizon is permanently covered by trees and other objects close to them, they are reliant on perception of relatively short distances. If they happen to be in an open area, they are unable to distinguish far away objects and they have absolutely no idea about their distance. Their eyesight is adjusted to perception of nearby objects and they are unable to "read" the plasticity of the horizon, atmospheric perspective and faraway objects. On the other hand, their eyesight is well adjusted to the differentiation of details and textures, perception of colors, especially in the green–red color spectrum, etc. Numerous experiments of Gregor and McPherson (1965), Jahoda (1966) and Segall (1963) showed that Aborigines as well as Africans who have no experience with western architecture don't perceive vertical illusions and are sensitive to perception of horizontal objects. Likewise, African Zulus, living solely in rounded huts don't succumb to Müller–Lyer's illusion (Gregory, 1968).

Another example is sensitivity to colors, graininess or textures. According to SWH (Sapir — Whorf linguistic–relativistic hypothesis), perception of colors is influenced by a classic inventory of language. Sapir and Whorf assumed that Eskimos differentiate more shades of white because they have more names for them. Their concept is based also on an evolutionary explanation and that is that life on snowy plains requires the ability to distinguish color and the complex structure of snow and ice as a means of survival and orientation in the environment. Similarly, we can expect higher sensitivity of Nomads to ochre and earthy shades, which form the basis of their visual color surroundings. Although Davis' studies confirmed different merging of colors, they didn't confirm unequivocally differences in their discrimination. Also Holden's research (2005) finds more arguments for the existence of universal perception principles, but as Debi Robertson (2005) states, the debate on this subject is far from finished.

It is quite a different case when speaking about the influence of culture on differentiation of phonemes. Chomsky's thesis about generative grammar is based on a finding that the character of auditory stimuli in the environment forms the sensitivity of an individual to differentiate them. If there is a lack of certain auditory stimuli in our environment, our brain doesn't learn to recognize them and an individual becomes deaf toward specific stimuli or is unable to differentiate them correctly. That's the reason why members of certain language groups (for example Japanese) are unable to differentiate "r" or "l" or vice versa, the Europeans are not sensitive enough to certain Asian phonemes or accents. Social and cultural influences can be found mainly in rhythmics and sensitivity to specific auditory stimuli, but here, too, we should point out that although inter–cultural differences exist and influence our perception, the differences on an inter–personal level are epistemologically greater than social ones just because cultural differences can be eliminated by learning.

Learning plays the principal role mainly in more complex and interpretatively tuned perceptual operations. Therefore, some of the greatest differences can be seen in imagining three–dimensional objects and in their sketching. People usually see what they expect they should be seeing with regard to the global context of interpreting the world. Science historians, therefore, doubt if people living in different epochs, while looking at a certain occurrence saw it as the same thing and they also argue about the extent to which these visual experiences might have differed. We can think about Egyptian visual arts preferring the profile view of a face with the second eye showing (although it wouldn't be seen from this point of view) the same way as we can think about drawings of objects by using perspective versus using split objects. It turned out (Deregowski, 1972) that some aboriginal societies, similar to children, tend to draw objects in the form of a cut and using perspective is a question of experience. It means that our experience influences not only behavior, but perception itself. Isn't that just a question of expression technique?

Whatever the answer might be, many so called perceptions which we intuitively use to conclude important information from our environment, are not culturally universal and neither do their color connections carry an important message independent of the experience. It has been proven by a series of experiments involving a perception of pictograms in different cultures which resulted in ambiguous interpretation (Deregowski, 1972). If we want to contemplate the universality of perceptions and potential expression and intermediation of perceptions or their contents, it might be necessary to study things that are culturally unconditioned and uniform and thus attempt something which is a vision for many phenomenologists. To study things themselves and forget everything we know about them from previous experiences and learning. But is this phenomenological reduction really possible? Isn't perception, after all, (in any of its specific form) just some sort of previous experience conditioned by the experience of an individual with the stimuli of his environment?

4.3 Recommended literature

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5. Interspecial comparisons

Key words: *ethology, epigenetics, comparisons*

The analysis of developmental, individual and cultural determinants of perception showed changes in individual's perception despite negligible or minimal developmental changes in one's cognitive apparatus. It is thus evident that significant changes of cognitive apparatus should lead to a relatively significant change in perception.

One of the most important subjects of cognitive research is the comparison of cognitive apparatuses of specific animals and comparing pictures of the world, which these apparatuses enable them to perceive. Comparative cognition or the study of inter–species differences in cognition, enables us to a) understand the cognition process as a product of searching for, processing and interpreting information in conditions of human cognitive apparatus, b) find and become familiar with other types of detecting, processing, and interpreting information through other cognitive systems (in other conditions), c) think about cognition as a general mechanism of interaction of an intelligent system with its surroundings and about adjusting the system to the stimuli.

Previous chapters addressed mainly examination of perception in conditions of human cognitive apparatus. In this chapter, we will thus concentrate on answering questions about processing stimuli by other sensory mechanisms and examining perception via the prism of developmental and evolutionary biology.

5.1 Why do we actually perceive?

One of the key questions of the theory of cognition and cognitive systems is the question of what cognition is and why it actually exists. Analogically, we can ask what perception is and what its role in cognition is. Proponents of evolutionary epistemology understand cognition as a general strategy of any system for successful survival in its environment, mainly through mapping of relevant characteristics of the environment and through searching for effective mechanisms of its survival. The basis of this process is mainly the ability to identify and differentiate stimuli. Without it, survival is possible only if we are equipped with setup and structure which are resistant to any negative effects.

Richard Dawkins claims that an entity such as Maternhorn and others are stable enough to withstand external influences. If they hadn't been like that, they would have ceased to exist long ago. However, not all entities are so durable and in order to survive they had to find a different strategy of self–preservation and that was avoiding danger and utilizing appropriate stimuli.

While answering the question, why perception exists, we are being led to old, theological ways of thinking. We perceive in order to survive. The theological approach, however, replaces the question of cause with the vision of purpose, which is not totally correct. Purpose supposes an effect and theology presumes intentional behavior, which is not fully justified. It seems significantly more correct to use causal explanation, which doesn't interchange the existence of cause with the intention of purpose.

Since in studying about reasons for perception we see only the existence of effects (we see cognitive apparatus and not what had created it), we can only guess the real reasons or (in regards to required length of time) they could be (in unique cases) observed directly in action, for example in laboratory conditions. The basic premise of a causal approach is the conviction formulated in Newton's laws. They apply to an explanation of movement, but in

Aristotelian terms, change can be seen as movement and thus with a fairly substantial measure of analogy and simplification they can be generalized. Newton's third law suggests that if an object is under the influence of a force, this influence causes a reaction which is equally strong, but oriented in an opposite way. From a combination of the first and third laws of motion, we can conclude that each object reacts to stimuli in its surroundings and, if possible, attempts to resist them or find a way of least resistance. It means that every object is able to receive the influences of external forces. Newton doesn't clearly explain how and by which means this is done and the term "force" is in his concept marked by metaphysical implications. Similarly unclear is consciousness or the beginning of life itself. And it is the information about how an object receives the influence of external forces that is the basis for explaining the origins of perception.

As Leibniz states, we need to have some "windows" to be able to see (perceive) outside influences. But how do these windows come about? Darwin thought they occurred more or less by accident. Mutation in gene replication results in the creation of entities with a slightly different composition and selection forces and natural selection decide whether, for a given entity and its replications, certain mutation is beneficial or not. Lamarck's version of evolution takes greater account of the environment's importance and of the adaptation mechanism of an individual. In either case, however, is the origin and formation of, or the survival of a given receptor explained through reaction to conditions of the environment surrounding the organism. It is the influence of the environment which directly or indirectly forces the establishment of a specific form of receptors and cognitive organs.

Cognitive ethology and epigenetics study the influence of the environment on perception. While ethologists study mainly environmental influences on behavior and explain the development of specific behavior of different species, epigeneticists study hereditary changes in the expression of specific genes caused by factors of the external or internal environment. The original focus of epigenetics was connected to the study of factors and effects of stem cell's differentiation. These can differentiate practically into any specialized cell of a body (totipotent status). Because ontogenesis can be perceived as the analogy of phylogeny, the study of any environmental influences on the change of genomes, or an individual's phenotype, including both external as well as internal factors gradually became the subject of epigenetics.

Epigeneticists proved that different environmental as well as behavioral factors can cause activation or inhibition (switching on and off) of genes and a related cascade of processes, which demonstrate themselves as different expressions of the gene. This fact contradicts Mendeleyev's rules of heredity and points to the fact that heredity can be influenced by food, behavior and environment. Not in a sense of some sort of Lamarckian fluid or recording of the experience — information from the environment into the individual's gene, but rather by activation or de–activation of the gene, which would have normally stayed inactive (or active). It's strange that this activation might not show in an immediate generation, but can be trans–generational.

A classic example of epigenetic influence is the methylation of fish, mouse as well as plant genes in a way that was described by the epigenetics laboratory of Moshe Szyfs. Szyfs and his team found that the lack or a radical change of food influences the color of a mouse's fur. In reality, fur color is just a visible expression of other distinct characteristics. Offspring of a pregnant mouse, which during pregnancy suffered from a lack of vitamin B12, folic acid, choline, and betaine, changed fur color (from yellow to brown), compared to other offspring of the genotype. Lack of nourishment in the phase of the fetus' development (also human) causes a whole array of negative mechanisms, which are manifested in cardiovascular and endocrine problems. Szyfs proved that nourishment can block or initiate gene expressions, which wouldn't otherwise be exhibited. What's more surprising, inhibition or activation of a gene can also be influenced by the type of care and social contact we are exposed to. Szyfs' research shows that mouse offspring exposed to great maternal care are significantly less predisposed to stress and their blood stream contains less stress hormone. Satisfactory gene methylation for the glucocorticoid receptor is responsible for this.

The importance of epigenetic research lies not only in understanding what causes gene expression of a certain individual and why, but also provides an important chance for fighting against inception and triggering of negative processing, like cancer. So, what applies to the emergence of hidden predispositions (both positive and negative), applies also to the morphology and possible emergence or non–emergence of cytological structures and thus to formation and modification of receptors. El Slatery (2009) and his team studied the possibility to influence regeneration of hair cells of the inner ear by activating a gene, which activated regeneration of (feathered) bird's cells. Sophia Gaboyard and her team (2003) proved that a change in gravitation causes a change in hair cells of the inner ear and alterations in development of retinal cones of rats. Thus it seems that the presence of an individual in a certain influencing environment (and many other factors), eventually results in the appearance or non–appearance of certain genes and their expressions leading to formation and modification of sensory receptors.

5.2 How to study the sensory world of other beings?

Owing to the fact that we inhabit a sensory stimulating environment, our sensors are adjusted to conditions, in which relevant information is present and is being mediated to us. Although other species live in similar conditions, we can't say that they possess similar sensory apparatus. The structure of individual sensors is not and does not have to be identical in identical conditions. Evolutionary biologists proved that the eye, for example, has already developed 50 to100 times and often completely while not further developing phylogeneticaly older types of the organ. The insect eye is different from the eye of a bird or a man. That's why it is difficult to say what this or that animal can see, as its sensory apparatus is diametrically different and can be a descendant of other developmental lines of a specific receptor.

Apart from limited analogy which can't be used on other phylogenetic developmental lines of a certain receptor, there is another problem of comparing the sensory world of other species and that is the holistic aspect of perception. We have shown that other cognitive functions (learning and prior experience) take part in processing sensory information and thus it is difficult to evaluate perception only through analysis of a receptor itself and through possibilities this receptor offers or doesn't offer.

The third problem is the issue of the privacy of quale. As Thomas Nagel (1974) showed by the analysis of the cognitive apparatus of a different individual, we can arrive at just an image of what it might be like to perceive the world through its eyes and not what it means to it. To be able to understand what another being can see, we must forget our own way of seeing the world and thus stop being human. And that is principally impossible.

Based on prior reasons, it is impossible to know what the sensory world of a bat, monkey or a bee is like, but despite this, we can analyze which elements might be present in their world and what their function might be. We can ascertain this by analyzing their receptors and mainly by the analysis of their behavior, which presumes reaction to the perception of given stimuli.

5.3 What is the subject of the world of other species?

A good example of the analysis of a receptor's functional abilities is Darwin's presentation of the evolutionary development of the eye, starting from shellfish all the way to humans (Pitman, 2011). It doesn't enable us to see what the bearer of a certain type of eye can see, only what we might be able to see through it. However, it is

not essential. What's important is to monitor what this particular eye could see.

One of the best charted fields of perception is the perception of colors. We know that the existence of certain photosensitive pigments is directly responsible for processing of various wave lengths of light radiation. Accordingly, we can presume that a bearer of photosensitive cells containing these pigments is able to differentiate between specific light stimuli and perceive colors of his color world. In his work, Ewan Thompson (1995), pointed out that there are several color sensitive visual systems, monochromatic, dichromatic, trichromatic (including humans), but also tetrachromatic systems including, for example, pig or carp or even pentachromatic systems (turtle). Each of these systems divides the visible part of the spectrum individually and comparing them is only illusionary. It may seem that possessing a larger number, or a bigger variety of specific types of photosensitive receptors might offer to its bearer better discriminating conditions and a fuller color world (Goldsmith, 1990). This is the very thing that is the basis of Ewan Thompson's evolutionary argument which ascribes an evolutionary advantage to the apes of the Old World over the apes of the New World, which are dichromatic. The Old World apes gradually developed photosensitive sensors sensitive to shortwave light — red color, which gave them an advantage to discriminate the ripeness of fruits based on their color, while eliminating the risk to get unnecessarily exposed to potential predator attack when testing fruits for ripeness. In this context we can, therefore, agree with Goldsmith (1990, 300) that perhaps birds and turtles are the future of further evolutionary development of perception. This claim, however, applies only with limits, because a greater number of photosensitive receptors enables its bearer only faster and more precise identification of visual stimuli features, which can, however, be partially attained from other visual stimuli and structures, for example texture, brightness etc. At the same time, it applies that with a lower number of photosensitive pigments we can also “read” the whole composition of the visible spectrum, although in a more rudimentary way, through fine shades of the same color.

Significantly more important in this regard is covering the spectrum of light rays. Some species can see beyond the boundary of UV rays, or in other words perceive also shorter infrared rays. For example, a bee is similarly trichromatic as humans, but can also perceive UV rays. It means that its “mixing” of colors covers different parts of the spectrum, which gives us reason to suppose that there isn’t any specific conversion allowing us to decode the color world of species with a higher number of color dimensionalities or with shifted spectrum (Thompson, 1995, Démuth, 2005). Hilbert (1992), therefore, thinks we should talk about colors exclusively in with the context of human perception and the question of what is the “color” world of other species made of and how it is made is an incorrectly postulated question — or in other words it is a purely academic question.

Another example of exploring the difference in visual worlds of humans and other species is a study of the sensitivity to visual stimuli, mainly illusions. Joel Fagot and Isabel Barbet (2009) proved that some primates are unable to perceive the global structure of hierarchic objects and instead perceive the details (contrary to humans). Baboons, for example don’t possess the ability to perceive the depth of a depicted object, if the background of the picture, from which they would have been able to read such information, is covered. At the same time, if the background of the picture is visible, they are able to perceive optical illusions, for example an illusion of a corridor.

Kazuo Fujita (2009) showed that besides humans, other primates and birds also perceive visual illusions. Observation of reactions of pigeons, macaques, chimps and humans to a Ponzo illusion served as an example. It turned out that linear representation of this illusion brings out a perception of an illusion in all species, but that pigeons are more sensitive to it than primates. Differences can be seen when the illusion is illustrated by using points. Humans

turned out to be the most sensitive to this type of representation while chimps and apes didn’t demonstrate any difference between linear and point representation. Photographic representation of a Ponzo illusion demonstrated a difference between perceptions of macaques and chimps, but proved human dominance.

A completely different type of stimuli evaluation was revealed in amodal completion. Pigeons are the only species, which were unable to perceive objects sticking out of an overlapped background (Kanizsa Triangle). Fujita and Vallortigara (2009) think that this is a result of a specific type of food, which disallows perception of details against the background. Chickens, on the other hand, which feed also on worms, possess this ability, as worms have a tendency to hide behind other objects. This would indicate the influence of the environment and experience on illusion perception. However, it is quite interesting that pigeons have experience with the overlapping of relevant stimuli. While studying their behavior, it turned out that the head of a female partner is an important stimulus for courtship. When it is covered, a male pigeon limits its courting, but covering of the lower part of the female’s body has no influence on a male’s behavior. The pigeon thus “knows” that the head can see and therefore “he” wants the female to see “him”. When studying the ability to identify partially covered stimuli in humans and chimps, no relevant differences were observed, neither in the nature of successfully identified stimuli nor in the time needed for their identification.

Vallortigara’s research showed (2009) that chickens, too, manage similar tasks (identification of partially covered objects, determination of the overlap direction, perception of completely covered objects). Pigeons use identification of features, not global perception. Their world is more mosaic–like without the percept of a total picture. This enables them to differentiate grain from stones, but they don’t practice picture completion. That’s why they lose interest in food which they can’t see entirely. The reasons for these differences lie in different functional organization of the brain and the left hemisphere of chickens and pigeons resulting from the different environment they live in (Vallortigara 2009).

The most significant feature of this research is the finding that despite many differences in perception, some principles of perception field organization (like Petter's rule) can be found in other forms of perception, too. Similarly, the research of auditory perception of perfect pitch suggest that although in Nature we can encounter different sensitivity abilities, if individuals possess the same type of sensory apparatus (camera eye, inner ear) their perception can differ in the degree but not in the type of perception (Weisman, et al, 2009). This enables us to explain the possibilities of comparative and analogous approaches in the study of perception and find surprising homogeneity and analogy of mechanisms as well as of the contents of perception and of the total cognition of related species (monkeys weighing stones for breaking nuts, Visalberthi, 2011, but unable to identify a missing object, Liszkowski, 2009).

On the other hand, development of specific sensory apparatuses is not represented by an direct line of sensory receptors development, but rather by an intricate track of numerous trials and errors leading to a wide palette of the most diverse sensory systems. Many organisms possess totally different mechanisms of acquiring information and of their processing dependent on the environment they move in. This enables them to be relatively successful in their environment and to use strategies which couldn't be used in different environments. Diversity in this area is greater than we could imagine.

The principal aim of this chapter was to show how rich and diverse perception processes can be (even if talking about the same types of sensory receptors) and that in addition to our way of perceiving there is a plethora of fundamentally different ways and preferences of mechanical–chemical–physical detectors, depending on a specific environment. The human way of perceiving is just one of many evolutionarily formed systems striving for the most successful detection and interpretation of data in a given environment. If the system manages to do so, the species survive. This raises questions whether certain perception convictions are true or pragmatic as well as about possibilities and direction of certain sensory systems development.

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6. Perception and artificial inteligence

Key words: *extensification, intensification, substitution*

Interspecial comparisons highlight the limits of this or that type of perception. Our cognitive apparatus, for example, is not adapted to perception of the level of radioactivity in our environment, because evolutionarily we weren't present in an environment in which this type of information would be necessary. Similarly, we don't possess receptors for determining the pH of the environment or any sonars enabling us to identify objects in darkness or under water, because we were given eye sight, which enables us to see as a result of light. Despite this, the existence of radioactivity, of invisible entities or of the level of environmental pH is important to us, as not detecting them can have dire consequences. The question of improving and expending an individual's sensory possibilities is thus a question of survival.

We saw that many organisms are much better equipped in the area of their abilities to detect relevant stimuli and not only in sensitivity (shark, dog — smell, eagle — sharpness of eye sight, dog — hearing, bee — UV radiation), but also in the type of receptors (bacteria — pH; dolphin, bat — sonar). Therefore, the question whether we can extend and improve the palette of our perception is a relevant one. We can assume that the more information we have and the more precise it is, the more successful we might be (provided we can use and process it correctly) in our integration with the world.

To study perception might be, therefore, useful for at least three reasons: 1) it enables us to discover and understand the nature and boundaries of our knowledge and thus approach it accordingly, 2) based on our knowledge of specific determinants and mechanisms of perception, to intervene and make corrections in places where specific percepts are failing, 3) consider possibilities of improving existing forms and ranges of perception through application of already existing forms of perception, which are, however, present in other places, as well as through development of completely new elements and mechanisms of perception.

6.1 Why improve the possibilities of perception?

An effort to improve possibilities of perception is not new at all. People have been searching for ways of overcoming the limits of their own receptors for a long time. Glasses, telescopes and many other gadgets are examples of such improvements. The telescope lens works on the same principle as the natural lens of the eye and thus when using a telescope or a microscope, we are talking about multiplying our optical abilities. Thanks to these instruments, we can see things that are not normally accessible to our vision or, in other words, we are increasing the efficiency of existing abilities.

One of the main reasons for developing artificial receptivity is thus an effort to obtain information in places where our receptors are unable to provide such information. Therefore, we are looking for ways of expanding the *extension* — range of our own perception as well as *intensity* — quality of perception. Artificial instruments should thus serve as our receptors in places where our own receptors can't reach or where a receptor is missing altogether.

Another incentive can be the fact that we are conscious of the risks and issues connected with the availability of data. In a dangerous environment we welcome the possibility to avoid exposing our receptors and ourselves to danger, but rather collect important information from the environment through technical instruments which, in case of problems, can be sacrificed. Therefore, it is not surprising that development of artificial sensory instruments is booming as it enables us to observe entities and occurrences which are very important and at the same time to eliminate dangers stemming from learning by trial and error.

The third important reason for thinking about creating artificial sensory instruments is a need for permanent long–term collection of information. An existence of a large amount of data is quite rare. Its observation presumes long–term, targeted scrutiny and some sort of instruments are more suitable for this than a living human being that is unable to remain concentrated for a long time or to satisfactorily distinguish stimuli during a relatively long time. Moreover, other capacities of this being would remain unused during this time.

Another reason for creation of artificial sensory instruments is the effort to eliminate data deformation caused by our own presence. Physicians, judges and psychologists know that a person behaves differently when he knows he is being watched and that his behavior might be evaluated. Therefore, if we want to learn the real mechanisms and causes, we must eliminate negative consequences of our own observation by studying objects while they behave naturally. This applies not only to humans but also to animals (the need to study them in their natural habitats) and also, surprisingly, to most other entities. Based on the findings of quantum physics, we know that a part of our observations can be influenced by the presence of the observer even at the level of elementary particles. Our temperature, energy, gentle vibrations or our presence itself can have negative effects on observed occurrences and thus it might be necessary to eliminate the observer's presence (but at the same time to facilitate data collection) if we want to achieve accurate and non–deformed data.

From highly sophisticated reasons we can move to more prosaic ones. Yearning for a higher quality of percepts and for better entertainment might be some of those reasons. A big part of perception research is carried out by the consumer industry, starting

with the cosmetic industry all the way to the most sophisticated electronic equipment and applications. An effort to achieve the highest potential quality and complexity of perceptions, either in the area of communication technologies or in entertainment, are the driving forces behind this development. This uncovers another reason why we study perception and strive for its improvement via artificial technologies.

One of the most significant areas is the improvement or total substitution of failing or damaged sensory abilities. People lacking certain sensory abilities are burdened with a limited number and insufficient quality of sensory inputs. The use of artificial applications enables them to return to normal life and live it more or less to the fullest, or to at least increase the capacity of existing abilities. This effect can be also observed in the use of other technologies enabling improvement of other cognitive abilities such as memory, counting etc., exactly in the spirit of Chalmers' and Clarck's thesis about extended mind (1998).

6.2 How to improve perception possibilities?

It would be a mistake to think that AI is the only way to improve sensory possibilities. Another mistake would be to think that the effort to improve one's own receptors is purely a domain of humans. Animals, too, utilize the potential of receptors of other individuals to cover their own needs. That is one of the main reasons why insects, rodents or mammals live in groups, which presumes division of labor (some watch so that others can work), often with a high degree of specialization based on individual abilities. However, utilizing perception of another individual can be often seen in inter–species behavior as well, when individuals belonging to certain species react to the behavior of other species either by escaping or other mob reaction.

Since time immemorial, humans have been using guard dogs, because they know their exceptional sense of hearing and smell and as a result use them to search for people or objects. Pigs can also serve as experts for drug search and the symbiosis of people and cats is based mainly on their sociability and other benefits stemming from their agility and good sense of observation. A guide dog to a certain extent substitutes a blind person's missing eyesight. Humans, however, may improve their own perception possibilities not only via symbiosis with other species, but also by applying their mechanisms of perception.

Another possible way of extending our sensitive abilities is a transformation of (originally non–sensory) physical stimuli to stimuli, which can be perceived by senses. An example of this type of procedure can be detection of pH or of the degree of radioactivity by using the dosimeter. A fundamental feature of this process is the fact that the detection of entities, qualities or occurrences is being carried out based on physical principles, which are not detectable by our senses, but the total outcomes (litmus paper changes color, digital or acoustic instrument shows data) can be perceived by senses. A large number of precise measurements connected to almost all observation procedures (detection of an object, of qualities, spontaneous observation, controlled observation, measuring, scaling as well as experiments) use precisely this mechanism since the detection of many entities, occurrences and qualities is not possible via our senses alone as well as because our receptors possess no objective scale for scaling and measuring of saturation levels of given indicators. When detecting a certain occurrence, we thus rely on creation of artificial entities or mechanisms and this is precisely the area for finding symbiosis between our natural abilities and artificial intelligence.

The use of different devices for improving the possibilities of perception can be organized based on their functional similarity or dis–similarity of mechanisms or of sensory outcomes they are offering. Many AI researchers are thus trying to use the metaphor about similarity of the human brain and sensory apparatus to a computer in order to create a "humanoid" variant of an artificial

intelligent device according to organization of human cognitive apparatus. Balkenius' work *Natural Intelligence in Artificial Creatures* (1995), Beer's *Periplaneta computatrix* (Beer, 1990) as well as the creation of haptic hands (LUCS) or of many other various forms of artificial organisms and androids are just a few examples of such an approach.

Elimination of anthropomorphic features and the mechanism and creation of artificial devices collecting information from the environment independently of the functional as well as formal similarity to humans or other living organism are different routes to perception possibilities improvement. Aerospace devices or various detectors serve as just a few examples. The fundamental feature of these entities is that although the contents of their "information world" is not directly accessible to human receptors, the machines eventually modify them to human form. Otherwise they would be useless to us. What we are after is to use their abilities and to apply them in our own cognitive processes.

6.3 Possible applications

A variant connecting both previous approaches is the creation of a system (half alive and half mechanical human) synergizing the positives of cognitive abilities of both humans and artificial devices. The core of this system lies in the extension or improvement of our own cognitive abilities through implantation or application of new, originally non–human elements or applications and systems. The final product can be something which we call a cybernetic organism (cyborg) as well as the everyday symbiosis of humans and their common sensory and communication tools. In the case of cyborgs, we tend to imagine various technological implants reshaping the essence of a human itself, but in reality these are just instruments and tools such as cardio stimulator, cochlear implant or even an endo–prosthesis. Cochlear implants enable us to have percepts in places where they would be normally impossible or insufficient. By artificial stimulation of the ear nerve (bypassing the damaged parts of the cochlea) using sound from the external environment, we can substitute a natural sound channel and theoretically enable detection of such auditory stimuli which were normally undetectable. Likewise, we can imagine a different stimulation of other parts of the sensory cortex which might lead to a different type of (for example osmatic or visual) stimuli. With respect to technological challenges connected with trans–humanism and neuro–ethics, the research in this filed is still relatively young.

It is substantially more interesting in the area of creating sensory symbiosis between humans and various devices. We can consider a diary or a book as a form of external memory. We can approach various devices in a similar way and consider them as forms of externalization or of shifting the boundaries between a human and its surroundings. Clark's and Chalmers' example with "alarm clocks" in the cockpit of a plane is a good demonstration of the creation of common boundaries of a machine and a person, substituting our sensors by devices and instrument platforms. Same as with internet communication between distant on/off line users, when signing into the network (for example Skype) can be immediately detected by another computer and announced to the other user. The computer "knows" when another desired user "appears" online and announces this occurrence. It can, at the same time, perform many processes fully automatically even without our presence (sending messages about availability, intelligent home systems regulating temperature, reporting disruption of the system etc.), which leads many philosophers to thoughts about the shape and content of the world of artificial intelligence devices.

Taking no account of whether the sensory world of such devices actually exists and what it might look like (Turing's test, Chinese room, thermostat etc.) it is clear that many devices can not only find, identify and actively search for required objects or sensory inputs but thoroughly process and evaluate them as well. One of the possible examples is a software platform Picasa which enables users to

find a particular face among thousands of other faces via identification of basic facial features. The platform collects these features from a single specified picture and subsequently searches for them in a given combination among various stimuli. Analysis of features and patterns is the fundamental principle of a search engines' function. They can find a desired text or object among millions of digital entities. To find and recognize an object among many similar objects is actually one of the most complex perception operations. Based on precisely set algorithms, it is possible to "teach" for example an optical recording system to watch, find and record (mainly) moving objects. This becomes a suitable condition for building fully automated intelligent traffic or security systems. They might be able to not only record an occurrence of a given object, but monitor (sharpen, activate other suitable instruments, sending signals which change behavior of a monitored object) as well. Application of these systems (making our lives more comfortable) has almost no limits — it is in fact limited only by our imagination.

Another area for application of these systems is the already mentioned reconstructive medicine (for example prosthetics), which attempts to replace insufficient or non–functioning receptors by artificial substitution. Understanding the rules and mechanisms of our perception behavior allows for correction or intervention in situations when individuals lose certain sensory abilities. This understanding also enables us to protect our receptors and prevent future damage. In this point we are coming to problems connected to ergonomics and design optimization.

A relatively large part of perception research concentrates on the analysis of information systems, on the search for criteria for the most precise and most effective discrimination of information needed in the process of communication and in creation of communication flows and channels. It seems that some characteristics of sensory stimuli are being detected (by a given system) first (such as movement, shape, contrast) and others subsequently (such as color versus text — Stroop's test). That's why it is important to identify mainly those elements of the sensory field, which we identify most quickly and most precisely and connect these with the communication signal. This is the reason why we need to study the way in which it is possible to secure stability and accuracy of discrimination of the above mentioned elements and factors for example in traffic or in a common game of two soccer robots (RoboCup — the problem of color stability — Balkenius, 2003). The knowledge of perception can be also applied in many areas of industry and the arts dealing with spatial organization, ergonomics of functional products (for example communication and operating instruments) and with design itself, which shifts the issue of perception to the level of functional and cognitive aesthetics.

Last but not least we should mention the use of AI in an attempt to achieve the best possible and the most realistic mapping of external stimuli. In this context it is important to transform and process sensory outcomes into a form most natural to our perception. An improvement of imaging technologies based on 3D projection or the synchronization of more sensory stimuli (home theater, professional multimedia projections) for achievement of the most realistic experience serve as a few examples. Building of systems which: a) offer precise, realistic and complex sensory input most natural for the given sensory apparatus and b) are able to adequately substitute people in specific perception operations are just a few challenges of AI in this area.

Successful creation of artificial sensory systems ultimately requires transformation of sensory processes and operations into a form adjusted for perception by human cognitive apparatus. Although technical and computing solutions enable creation of artificial sensory systems, they can't substitute for the study of human sensory and cognitive apparatus. (However, they can make it easier for us to understand.) In fact the opposite is true. To be able to design and discover more ingenious technical sensory devices, we have to learn about the workings of our own perception at least to an extent of being able to obtain the most information in the most accessible form.

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Conclusion

This text, with respect to its extent as well as its focus on philosophically oriented aspects of the problem, doesn't claim to be a comprehensive study of perception. A thorough understanding of perception (of its origins, determinants and expressions) assumes deep and widespread study from many areas of scientific and philosophical exploration, which is impossible in this type of text. This work is a sort of *vade mecum* — an introduction into the problem of perception, an attempt to problematize the subject. For this reason you will find no specific analysis of technical or functional details describing the process of perception, which would enable deeper understanding of problems and functional connections of perception. I suppose a reader interested in such knowledge may find more specific studies. Recommended literature at the end of each chapter encourages such search. In this sense *The Perception Theories* (as most theories usually are) are an invitation to further research rather than an answer to various questions. It is an invitation indicating areas we should (or shouldn't) study in more detail. Because *to look* and *to see* is not the same just as *to see* and *to know (why and) how I see* what I see are two completely different types of understanding.

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