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Abstract

According to recent cross-cultural studies there exist culturally based differences between visual perception and the related cognitive processes (attention, memory). According to current research, East Asians and Westerners percieve and think about the world in very different ways. Westerners are inclined to attend to some focal object (a salient object within a perception field that is relatively big in size, fast moving, colourful) focusing on and analyzing its attributes. East Asians on the other hand are more likely to attend to a broad perceptual field, noticing relationships and changes. In this paper we want to describe the recent findings in the field and propose some directions for future research.

Keywords: perception, attention, memory, cross-cultural differences

Introduction

This article asks whether or not people around the globe, observing the same visual scene, perceive the same thing. We will summarize recent research on the topic. Define sensation and perception of a visual scene as two distinctive processes. Further on, we will explain the Gestalt laws of perception, figure-ground organization and perceptual laws of creation of a visual object. In the next part, we will explain the cultural differences in perception – holistic and analytic cognitive styles according to research performed by Richard E. Nisbett and his colleagues. At the end of the article we shift our attention to further directions of research on visual perception – exploration of perception of cartographic material and its cross-cultural variations.

How an object is created in a visual field?

Sensation and perception. The terms "sensation" and "perception" are widely used, but not always understood correctly. In this part of the paper we will define these terms by describing the whole process of visual sensation and perception from the visual stimulus to the mental representation of the stimulus in our brain.

The information about the objects in our physical environment is transferred to the eyes via light. Light is a form of energy – it is electromagnetic radiation that can be characterized by its intensity and its wavelength. The visible light is a narrow part of the electromagnetic radiation spectrum with a wavelength between 370 and 730 nm[41] (Šikl, 2012). The accessory structures in the eyes modify the incoming light rays. First the light passes through the protective layer called the cornea, then through the pupil that adjusts, by its constriction or relaxation, the amount of light entering into the eye. The lens bends light rays so that they are focused as an image on the surface at the back of the eye called the retina. The retina consists of several layers of cells, some of them sensitive to light (photoreceptors), which transfer the light (physical stimulus) into an electrical discharge (neural impulse) (Bernstein, Penner, Clarke-Stewart, & Roy, 2008).

The process of transformation of the physical stimulus into neural impulse is called "transduction". Neural impulses ascend through optic fibers and chiasma opticum into the corpus geniculatum laterale (Silverthorn, 2001). The Corpus geniculatum laterale is a part of the thalamus. From the thalamus the neural stimulus travels to the primary visual cortex in the occipital lobe and about 30 other parts of the brain (Šikl, 2012).

Sensation is the process between the light entering the eyes through the cornea and the neural impulse arriving in aforementioned areas of the brain. The process of perception starts from this point. Perception is a process that organizes various sensations into meaningful patterns, integrating prior knowledge with current sensations (Shiraev, & Levy, 2013).

The central question of cross-cultural research on perception is whether people from various cultures perceive the same set of stimuli the same way and, if not, what factors contribute to the differences in perception across cultures. Marshall H. Segall (Segall, Dasen, Berry, & Poortinga, 1990) distinguishes two main schools of thought in research on perception that differ in their view on the role of experience in the perception process:

1. Nativists: Experience is of minor importance in the perceptual process. Stimuli incorporate all the important characteristics for perception.
2. Empiricists: Human beings are easily misled by prior experience. Perception is not stimulus – determined.

In this paper we will mention theories arising from both of the viewpoints on perception that are both important for further interdisciplinary research:

1. Nativist approach: Gestalt laws of perceptual organization
2. Empiricist approach: Cross-cultural hypotheses on perception of pictorial material (Segall, 1990), field dependence (Witkin, 1977) and analytic and holistic cognitive style theory (Nisbett, 2005).

Gestalt laws of perception. In the year 1912 Max Wertheimer published his study on Phi-phenomenon. This study is considered to be the beginning of Gestalt as a school of psychology (Sekuler, & Bennett, 2001). In this chapter we will try to explain the basic principles of Gestalt and its laws and the experimental methods on visual perception, which arise from Gestalt theory. Gestalt laws of perception

41 Nanometer.

are mostly considered with the principles of organization of visual information and with the relationship of the so called "figure" and "ground".

Classical laws of Gestalt – grouping principles. The laws of Gestalt are thoroughly described in a number of publications and research papers (see e. g. Palmer, 2003; Ali, & Peebles, 2013) on perception and cognition. The basic principle is the principle of Prägnanz (Wertheimer, 1923), according to which the perceptual field and the objects that are incorporated in that field, show a tendency to group together into the simplest, most coherent and harmonious units. The individual constituents of the perceptual field create so called "good shapes" – Gestalts. Among more specific laws of perceptual grouping according to Gestalt we count (Wagemans et al., 2012):

1. Proximity: We group together discrete elements that are relatively closer together (Fig. 1 B).
2. Similarity: The most similar elements tend to be grouped together (Fig. 1 C, D, E, F).
3. Common fate: Elements that move the same way tend to be grouped together.
4. Symmetry: Elements that are symmetrical with each other tend to be grouped together (Fig. 1 G).
5. Parallelism: Parallel lines tend to be grouped together (Fig. 1 H).
6. Continuity: We perceive two intersecting lines rather than angles meeting at a certain point (Fig. 1 I).
7. Closure: Elements that form a closed figure tend to be grouped together (Fig. 1 J)

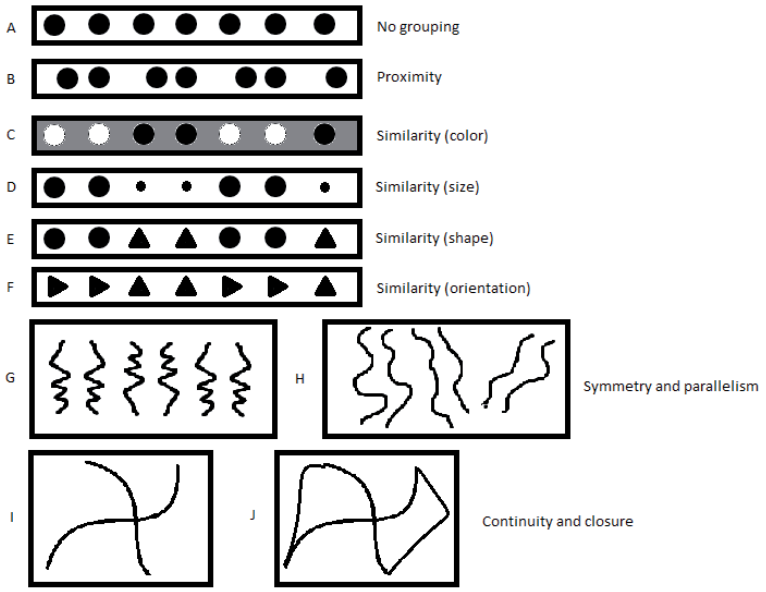


Fig. 1. Classical laws of Gestalt.
Source: Adapted from Palmer, 2002

According to the older approaches to the perceptual grouping processes, perceptual grouping occurs on the basis of primitive perceptual processes that operate with two-dimensional representations of reality. The outcome of these processes is a set of discrete elements, on the basis of these elements so called perceptual constancy is created (see Walsh, & Kulikowski, 1998), and they are further processed by higher cognitive processes (Marr, 1982). More current approaches (Palmer, Brooks, & Nelson, 2003) argue that the results of the grouping processes (the Gestalts) are not influenced just by the structure of the elements passing through the retina, but also by relatively late (in the perceptual process) cognitive operations after the creation of a perceptual constancy.

The new principles of grouping

Generalized common fate (Synchrony). Alisson Sekuler and Paul Benett (2001) expanded Wertheimer's law of a common fate (elements moving in the same direction tend to be grouped together) by the grouping on the basis of common changes in the luminance of objects. On the ground of their experiments, they concluded that if the luminance of the elements of a visual scene changes simultaneously (they get simultaneously brighter or darker), even if they differ in their original brightness, they tend to be grouped together by perceivers. It is de facto an example of the law of similarity - not a similarity of elements themselves, but a similarity of their changes.

Similarly, by its nature an even more general, principle is called a synchrony (Lee, & Blake, 1999; summarized in Wagemans et al., 2012). According to this principle the elements are grouped together on the basis of common visible changes, but these changes do not have to be based on movement in the same direction (common fate) or on the common direction of the change (generalized common fate).

Common region. Common region is a tendency to group together the objects that lie within the same bounded region (Palmer, Brooks, & Nelson, 2003). This principle is shown in the following figure. An example from the real world illustrating this phenomenon often noted are the spots on the leopard's skin, which are grouped by the perceiver within the contour of the beast. This example is used to demonstrate the ecological rationale of this principle. If elements are bounded by a limiting space (blots on the skin, components of a face), it is probable that these elements are located on the surface of the space rather than that their presence within the space is random (Wagemans et al., 2012).

Fig. 2. Common region.
Source: Adapted from Palmer, 2002

Element connectedness. Element connectedness is a tendency to group elements that are mutually connected (Palmer, Brooks, & Nelson, 2003; Palmer, 2002). The ecological rationale of this principle is as follows. It is probable that the components of matter that are mutually connected in the three dimensional space, will be parts of the same object. As an example we can use the door, which consists of a wooden board, hinges, a handle and a lock. These elements will create in our visual field one object – the door, mostly because these elements are interconnected. An illustration of this principle can be seen in the following figure.

Fig. 3. Element Connectedness.
Source: Adapted from Palmer, 2002

Stephen E. Palmer (Palmer, & Rock, 1994) created on the basis of his studies of the processes of perceptual organization an empirical method for studying perceptual processes: repetition discrimination task (RDT).

Cross-cultural differences in visual perception

The influence of an environment on perception. In the previous part we discussed some cross-cultural universals in the field of perception arising from the nativist approaches, in this part we will focus on the cross-cultural differences that follow the empiricist line of thought. There is a notable shift in focus in the field of cognitive psychology (number of papers) from the individual to cultural differences. Extensive research covers cultural differences in various cognitive domains such as attention, categorization and causal attribution (Choi, Koo, & Choi, 2007), or more specifically perception of pictures, perception of color, perception of depth, susceptibility to visual illusions and perception of faces (Berry, Poortinga, Breugelmans, Chasiotis, & Sam, 2012).

William Halse Rivers is considered to be the pioneer of cross-cultural psychology. His main work is based on the data gathered with Torres Strait Islanders on various cognitive phenomena such as visual acuity, color vision, visual afterimages and illusions, etc. (Berry, Poortinga, Breugelmans, Chasiotis, & Sam, 2012). This line of research is characterized by the exploration of differences in perception (acuity, speed of processing, etc.) of basic patterns, pictures, visual illusions, depth and color. The emphasis is put on a comparison of the cultural differences in the basic perceptual mechanisms. The following table summarizes the areas of research, specific topics and methods of research according to Jan B. Deregowski (1980).

Tab. 1. The areas of cross-cultural research on perception.

Area	Specific topic	Methods
Perception of patterns	Symmetry	Patco test, Discrimination learning
	Spatial orientation	Mental rotations, comparison of figures, recognition of figures
Pictorial perception	Depth perception	Epitomic and eidolic pictures, Hudson test, Jahoda and McGurk test
	Size and shape constancies	Drawing tests, horizontal-vertical illusion, Müller-Lyer illusion, Sander parallelogram
	Object recognition	Incomplete figures, pictures of real-world objects

As mentioned above, the empiricist approach to visual perception states that human beings differ in their visual inference systems based on their previous experience. Since the individual experience is determined by the surrounding environment, the differences in environment shape our perception by creating perceptual expectations. These expectations, known as a perceptual set (Shiraev, & Levy, 2013), make particular interpretations likely to occur and increase both the speed and efficiency of the perceptual process. Perceptual sets common in people of a particular culture – and most relevant to their experience – are not necessarily developed in individuals from other cultures. Strong evidence for this statement was provided by Colin Blakemore and Gregory Cooper (1970). Researchers reared kittens in total darkness except for a few hours each day. During that period of time, the kittens were put in a cylinder and exposed only to horizontal or vertical lines. After several months, the cats raised in a horizontal environment were unable to perceive vertical lines and vice-versa. Their brains lacked the detectors for horizontal/vertical lines; the specific neural pathways had no opportunity to develop.

Starting from this position A. Segall and her colleagues (Segall, Dasen, Berry, & Poortinga, 1990; Berry, Poortinga, Breugelmans, Chasiotis, & Sam, 2012; Shiraev & Levy, 2013) derived three hypotheses of how people from industrialized and developing societies differ in their perceptions.

The carpentered world hypothesis. The carpentered world hypothesis postulates that those, who were raised in highly carpentered environments (rectangular furniture, houses, streets), will interpret non-rectangular figures as representations of rectangular objects seen in perspective. According to this hypothesis, the tendency to interpret non-rectangular retinal images as rectangular objects is reinforced in carpentered environment, thus becoming automatic and unconscious. This hypothesis had been tested by visual illusions such as the Müller-Lyer illusion or the Sander parallelogram.

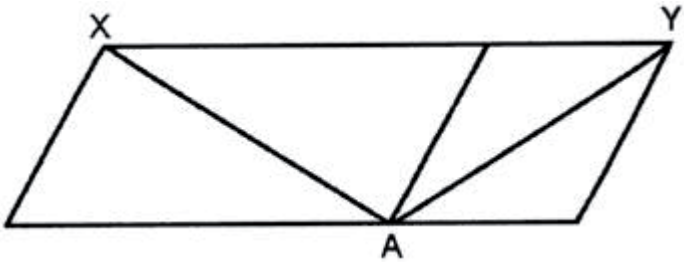


Fig. 4. Sander Parallelogram.
Source: Adapted from Deregowski, 1980

The viewer judges (Fig. 4) the left diagonal (XA) significantly longer than the right diagonal (AY). The people living in an environment, where straight lines and precise right angles are a rarity, are not as susceptible to this illusion as people coming from carpentered environment.

The foreshortening hypothesis. Lines in the horizontal plane that extend away from the observer appear to be horizontal; a short vertical line in a drawing may be represented as relatively long horizontal line. For people living in wide, flat planes with open landscapes, there would be a great ecological validity to interpret vertical lines in the retina as long horizontal lines. On the other hand, people living in relatively closed environments such as a rain forest or valley dwellers should be less susceptible to horizontal-vertical illusions.

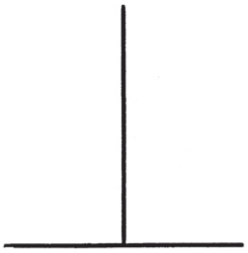


Fig. 5. The horizontal--vertical illusion.
Source: Adapted from Deregowski, 1980

For observers susceptible to this illusion the vertical line appears to be longer than the horizontal one.

The sophistication hypothesis. The sophistication hypothesis is related to the experience with pictorial material. People in developed countries are used to the pictorial two dimensional (2D) representation of three dimensional (3D) reality. They acquire the skills to see 2D pictures as 3D objects, which makes them more susceptible to some illusions designed to mislead the observers by confusing depth cues.

The influence of social orientation on perception

A similar line of research on differences between urban industrialized populations and traditional cultures was followed by Herman A. Witkin and John W. Berry. In this case, some traditional populations are more similar to industrialized populations than to other traditional cultures (Kitayama, & Cohen, Handbook of cultural psychology, 2010). H. A. Witkin discovered substantial individual differences in a way people differentiate an object from the field in which it appears. On the basis of his experiments H. A. Witkin defined two distinctive cognitive

styles – field dependent (FD) and field independent (FI) cognitive style (Shiraev, & Levy, 2013). The original method of field dependency testing was the Embedded figure test (EFT) (Berry, Poortinga, Breugelmans, Chasiotis, & Sam, 2012). In this method a simple figure has to be found embedded in a complex background. The speed with which a person can differentiate the target figure from the background is an indicator of field dependency. People who can do it readily are field independent and people who do it with difficulties are field dependent.

The concept of field dependency is in part a result of social orientation of a person toward other people (Kitayama, & Cohen, 2010). Various cross-cultural differences were studied in their relation to the concept of field dependency/independency (FDI). They are summarized in the following table.

Tab. 2. The factors influencing FDI.

Factor	Field dependent	Field independent
Way of obtaining food	Farmers	Hunters, gatherers
Type of society	Modern, industrialized	Traditional
Geographic region	Non-Western	Western
Sex	Women	Men
Goal-oriented behavior	Cooperation	Competition

Farmers that need to coordinate their activities with others, in order to obtain their living, tend to be more field dependent than hunters-gatherers, who do not need such a level of coordination (Van de Vijver, & Leung, 2000). Women tend to be more field dependent than men (Haaken, 1988). People from modern societies characteristic with lower levels of mutual interdependence (family, community, etc.) are less field dependent compared to people from traditional societies with strong bonds and high levels of interdependence (Weitz, 1971). In summary, the field dependent people are characterized as having strong bonds to other members of the society, while acting, they have to consider the impact of their actions on the people around them, to achieve their goals they have to cooperate and coordinate their actions more than field independent people. Yoshitaka Yamazaki (2005) mentions an effect of western-type schooling on the development of the field independent cognitive style.

Holistic and analytic cognitive style

R. E. Nisbett and his colleagues pursued a similar line of research to H. A. Witkin, but they assumed that the differences in cognition and perception may exist not just between industrialized and traditional populations but also between two industrialized cultural areas: the West (Western Europe, North America) and East Asia (Japan, South Korea, and China) (Kitayama, & Cohen, Handbook of cultural psychology, 2010).

On the basis of his research R. E. Nisbett and his colleagues proposed a theory of holistic and analytic reasoning. The central idea of his theory is that eastern and western cultures differ in their philosophical traditions to such an extent, that

it influences their reasoning (categorization, causal attribution) and perceptual processes (perception, attention) (Nisbett, & Masuda, 2003). Western thinking emerged from ancient Greek philosophical tradition, whereas East Asian thinking is rooted in the tradition of ancient Chinese philosophy. The main differences between these two philosophical traditions are summarized in the following table (Nisbett, & Miyamoto, 2005; Nisbett, & Masuda, 2003).

Tab. 3. The differences in ancient Greek and Chinese philosophy.

Area	**Greece**	**China**
Formalized logic	Yes	No
Composition of a matter	Discrete objects (atoms)	Continuous substances
Focus of attention on	Salient objects and properties of these objects; objects and their properties categorized	Field in which salient objects are located; relationships between the objects and events in the field
Thinking	Analytic	Holistic
Tendency to	Find the truth	Find the harmony

The above-mentioned differences in ancient philosophies are explained by the different social practices of the two societies. Due to the complex social relations (e. g. harvesting rice needed coordinated effort of whole village), trying to minimize social friction, the Chinese adopted interdependent social relations. The Greeks, on the other hand, were relatively independent, having fewer and less social relations, they also highly valued independence and autonomy (Nisbett, & Masuda, 2003).

R. E. Nisbett defined two distinctive cognitive styles: holistic and analytic (e. g. Nisbett, & Miyamoto, 2005; Kitayama, Duffy, Kawamura, & Larsen, 2003). People with the analytic style focus their attention primarily on so called focal objects (the object dominating the visual field; the object that is bigger, colorful, fast moving, etc.) and its characteristics. Holistic style, on the other hand, typically maintains its primary focus of attention on the context or background that is surrounding the focal objects, the relationships between the units of the background and the relationships between the background and the focal objects.

The tendency to perceive analytically or holistically develops in early childhood, during the process of socialization of an individual (Duffy, Toriyama, Itakura, & Kitayama, 2009) as a consequence of different social relations that are typical for a certain culture (see Geert Hofstede's dimensions of culture, e. g. Hofstede, 1983).

As mentioned above, most of the research based on the theory of holistic and analytic cognitive style was comparing North American and East Asian cultures, or cultures in developing countries (e. g. Boduroglu, Shah, & Nisbett, 2009; Uskul, Kitayama, & Nisbett, 2008). The Central and East European region was so far largely neglected. Most of the research used university students as experimental subjects.

Among the other variables that have been studied so far, we can mention the effects of a host culture and education on an individual's holistic or analytic perception (Kitayama, Duffy, Kawamura, & Larsen, 2003; Ventura et al., 2008).

Experimental methods used within holistic/analytic cognitive style paradigm

Framed-Line Test. The Framed-line test (FLT) is a widely used method for the exploration of cross-cultural differences in perception (see Uskul, Kitayama, & Nisbett, 2008; Ventura, Pattamadilok, Fernandes, Klein, Morais, & Kolinsky, 2008). FLT was developed by Kitayama and his colleagues (Kitayama, Duffy, Kawamura, & Larsen, 2003) and was first used for testing Japanese and American experimental subjects. The task consists of a series of presentations of a geometrical figure that is composed of a square frame and vertical rod (see Fig. 6). In the next phase only the frame is presented, which is either the same size as the original frame or it is enlarged or reduced. The participants are asked to draw a line identical to the first one in either absolute length (absolute task) or in proportion to the height of the surrounding frame (relative task), the deviation is measured in millimeters. The absolute task is facilitated by the ability to decontextualize (analytic cognition), whereas the relative task is facilitated by a contextualized mode of processing (holistic cognition) (Kitayama, & Cohen, 2010). Most Westerners perform better in the absolute task, whereas most East Asians perform better in the relative task.

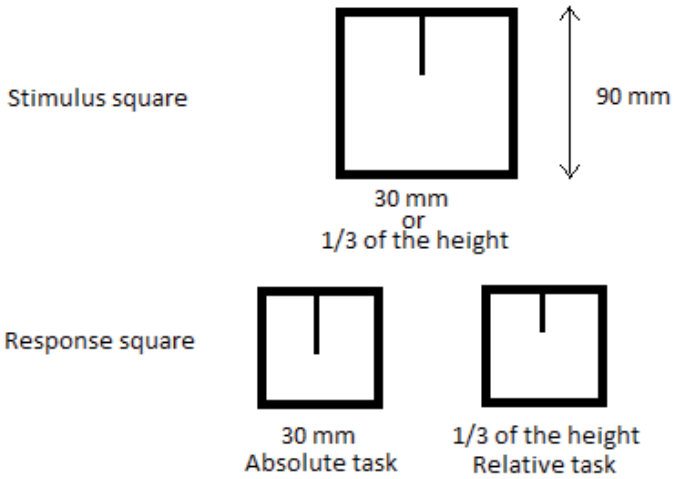


Fig. 6. Framed-line test.
Source: Adapted from Kitayama, & Cohen, 2010

Animated underwater scenes. Takahiko Masuda and R. E. Nisbett (2001) performed a different experiment on a sample of Japanese and American respondents. A series of 10 second long animated underwater scenes was presented to the respondents. Every scene was presented twice and after the presentation of each scene the respondents were asked, what they had seen in the scene. They

were given only 2 minutes for their responses. Their responses were divided into the smallest possible segments (words). The segments were in both languages coded into the following categories:

1. Focal fish (distinctive, big, in the foreground, in motion)
2. Background fish (blurred, dull, in background, slowly moving)
3. Active animals (frogs, salamanders, etc.)
4. Inert animals (shells, etc.)
5. Plants
6. Bubbles (moving horizontally or vertically)
7. Bed
8. Water (color, streams)
9. Environment (sea, lake, river, etc.)

These categories were grouped into superordinate categories:

- Focal objects (1)
- Active objects (2+3)
- Inert objects (4+5)
- Background (6-9)

Each of the segments was described according to its features (plain description, amount, attribute, feeling, behavior, location, time, in relation to the active objects, in relation to the passive objects). The first sentences were analyzed, the focal and the active objects grouped into the category "salient objects", while the inert objects and the background grouped into the category "background". The statements about the scenes were analyzed in terms of whether they were related to the salient objects or to the background. Japanese subjects mentioned relatively more objects from the background than American subjects.

After the presentation of all the scenes a sequence of 90 objects was presented, while one half of the objects were presented in animated scenes, the other half of the objects were not presented so (Nisbett, & Masuda, 2003). Some of these objects were presented on their original background, some on a different background and some with no background. Respondents were to decide whether they had previously seen the object or not and indicate the level of certainty.

The authors assumed that if the Japanese participants focus more on the background and its elements, their ability to recognize previously seen objects on the new or non-existent background would be relatively more hindered than American subjects. This assumption proved to be correct. While American respondents showed no significant differences in the recognition of the 3 variants, Japanese subjects had the biggest difficulties with identification of objects on the different background (Nisbett, & Miyamoto, 2005).

Static scenes. The following experiment had a similar design, but with static pictures of animals on various backgrounds (Masuda, & Nisbett, 2001). In the first phase of the experiment 24 pictures of animals were presented, each for 5 seconds. The respondents were instructed to rate the level of sympathy they have for each animal (on a scale from 1 to 9). In the second phase the respondents were presented another set of pictures, and they had to identify whether or not they had previously seen the animals. Two variables were manipulated: the animal and the

background (they could be previously seen or new). The reaction time and the precision of the answers were measured. As assumed the reaction time of Americans was faster, and the error rate was lower, when the previously seen animal was presented on a novel background.

New directions in a visual perception research

The linkage between psychological and cartographic research areas. Psychology as a scientific discipline evolved during its existence research methods and tools that find their application outside their original field of study. One of the areas, where theoretical concepts and methods of psychology can contribute to the development of the field, is cartography. Rapid development can be observed in recent years in the areas of cognitive cartography and geographic information systems (GIS). This trend can be observed, besides other things, on the ground of the level of activity of particular committees within the International Cartographic Association (ICA) that is worldwide the most important cartographic association. "Commission on Cognitive Issues in Geographic Information Visualization" (see references) and "Commission on Use and User Issues" (see references) do show particularly substantial activity.

The emphasis that is put on the activity of the user of cartographic material, and cognitive aspects connected with it, brings along the need for a close interdisciplinary cooperation with cognitive psychology. One of the most important figures in Czech psychology, who was one of the first to establish cooperation between psychologists and cartographers, is Josef Švancara (see Švancara, 2006; 2007; 2009; Konečný, & Švancara, 1996). Together with former president of ICA M. Konečný they realized a multidisciplinary project „Dynamic Geovisualization in crisis management" (Kubíček et al. 2013; Konečný et al., 2011), where the psychological matter had its own section. Thanks to the cooperation an interdisciplinary work group was created within the purview of Masaryk University in Brno focusing on cognitive cartography. One of its outputs was a dissertation thesis of the coauthor of this paper, in which cartographic problems from a psychological point of view is elaborated (see below: Šašinka, 2013).

Cartography from a psychological point of view. A map represents primarily an objectivized human representation of space – of phenomena, objects, and relationships among them. A map as a symbolic representation is a product of human ability to think abstractly. The main purpose of a map is to communicate information. Those with knowledge of a certain phenomenon try to communicate the information using cartographic tools in such a way, that the receiver can interpret the information according to the intentions of the sender. Cartographers have various tools to code communicated data. The same phenomenon, the same information can be coded in multiple ways, and our purpose is to monitor, how the form of information influences its perception and interpretation. Konečný et al. (n.d.) proposes a definition of a map according to ICA: "A map is a reduced generalized depiction of the surface of the Earth, of other heavenly bodies or heavenly spheres, constructed according to the laws of mathematics on a plane, depicting the position and charac-

teristics of objects tied to the surfaces by pre-agreed symbols. " The space-time data depicted in maps have 3 main components: localization (where), time (when), and objects (what) (Peuquet, 1994). Lynn S. Liben and Roger M. Downs (1989) point out that both children and adults have limited notions of capabilities and functions of maps. Maps are mostly presented just as archives of information or data warehouses, in a sense "how vast a certain area is" or "where is what placed", etc. According to this limited perspective we would not need maps, but the information could be presented in a form of text. Maps are in reality a creative depiction of a world, they are its reflection and projection of our experience.

According to Milan V. Drápela (1983), one of the basic characteristics of a map is its communicability – capability of a transfer and communication of information. Among the other characteristics M. V. Drápela counts its illustrative nature (an ability for a quick and effective production of stimuli for further cognitive processing), interpretability (the perceiver can interpret the information), and compressibility (an ability for an increase in density of received information). One of the first authors that pointed out the importance of design and structure of a map considering the user of a map was Arthur H. Robinson (Robinson, & Petchenik, 1976; Robinson, 1952), who was also one of the first cartographers to define a map as a medium for communication of information. His inspiration most probably comes from the information theory by Claude Elwood Shannon (1948). One of the basic suppositions for decoding information from a map by the user is a corresponding level of user knowledge of map language. The ability to communicate the message between a cartographer and a map user is thereby conditioned by a sharing of the same code – of the same symbolic system (see Kalverkämper, 2008).

Maps most commonly code information by graphical means and they can thus serve as objects for research in the field of psychology of visual perception and cognition. At this point it should be clear that a map represents a graphical entity, which always carries a meaning, so the research in the field of visual perception of cartographic material should always take into consideration all crucial characteristics of maps. In addition, a map represents a complex phenomenon in which the particular components are always in mutual interaction. Thus we cannot investigate partial graphical primitives without considering their context (e.g. investigation of the effect of the size of a cartographic symbol on the speed of its processing without considering its color, texture, etc.).

Adaptive cartography. One of the most recent directions of research in cartography is the so called contextual adaptive visualization (see Konečný, & Staněk, 2010; Konečný et al., 2007). Andrea Sliviaková et al. (2009) states that by application of the contextual adaptive paradigm, the selection of depicted elements and the selection of the mode of their depiction in a map runs automatically on the basis their context. Among the typical constituents of the context we count: the information about the user (experience, preferences), the situation (time, location), the type of employed device (size of a display, etc.), and the purpose of the activity that we want to perform on the basis of decoded information. This information can be acquired either automatically (by various sensors), or they can be inserted by a user.

The main characteristic of the adaptive cartography is, that it allows GIS to adjust the form of depicted information effectively according to a specific situation and certain user or group of users. The contextual adaptive cartography represents by any means an area of importance for psychological research. We can ask such questions as: "Which types of depictions of cartographic material are preferred by certain populations? (women vs. men, people from various cultural groups, people of various personalities, cognitive styles, etc.)"

For the purpose of this type of research we developed a new web application MuTeP.

Research tool – Multivariant Testing Program (MuTeP). The goal of the development of MuTeP testing software was to obtain a tool for examination of cognitive processes involved with the work with digital cartographic material such as visual perception, decision making, planning, etc. Because in every research we need to use different stimulus material, both cartographic material and psychological tests, we have laid a maximum emphasis on variability of the software. That means that a researcher is able to effectively change its contentand permit and combine its functions in order to investigate various cognitive processes.

MuTeP is online software, so both the preparation of research batteries and the administration of tests is online. It allows a flexible adaptation of performance tests (EFT, FLT). The typical research design is an experiment combined with a correlational study (Fig. 7). We compare two and more cartographic methods of visualization in combination with psychological testing. Due to this research design we are able to investigate not just differences in speed and efficiency of cognitive processing of cartographic material, but also relate them to the results of psychological tests and psychological concepts in general (intelligence, cognitive style, etc.).

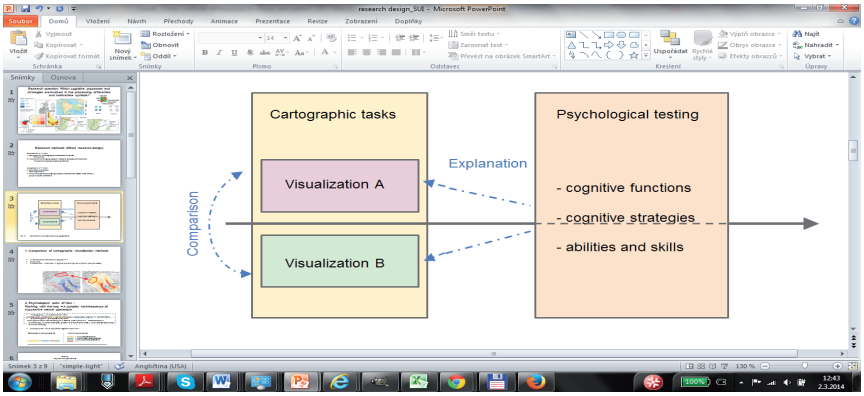
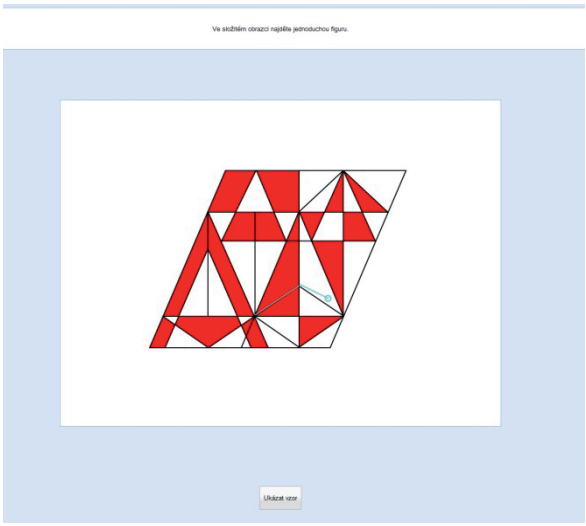


Fig. 7. Experiment combined with correlation study.

The MuTeP platform allows us to create experimental batteries for online testing. The battery itself is composed of individual slides defined by their content and functionality. This means that every single slide can contain a different content and a different type of task. All the users actions (except the cursor move-

ments) and related times are recorded and saved. See an example below (Embedded figure test).

A)



B)

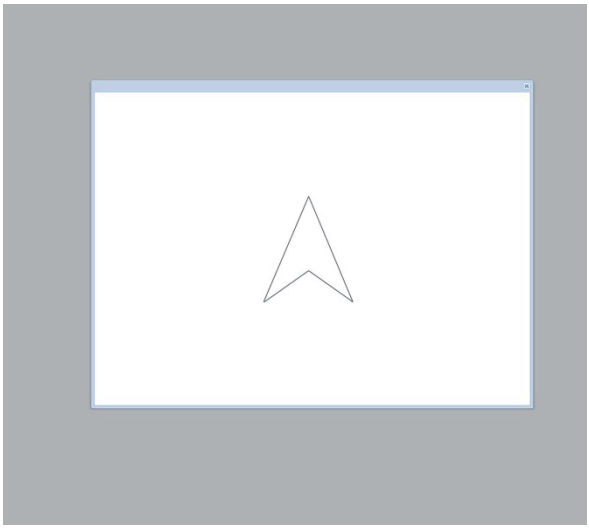


Fig. 8. A) Selection of a simple figure in more complex figure. B) Production of a simple figure and blockading of a complex figure.

Even though the MuTeP software is primarily assigned for research purposes, it has its potential for psychological diagnostics. It offers an opportunity for an effective adaptation of original psychological tests. Some of the tests can be, accor-

ding to our point of view, administered even more effectively than in their original form. In the following figure we show an example of FLT (mentioned above). The version of the test adapted in MuTeP allows us not only a group administration of the test, but it also records the precise results of the test (time, accuracy), and automatic evaluation.

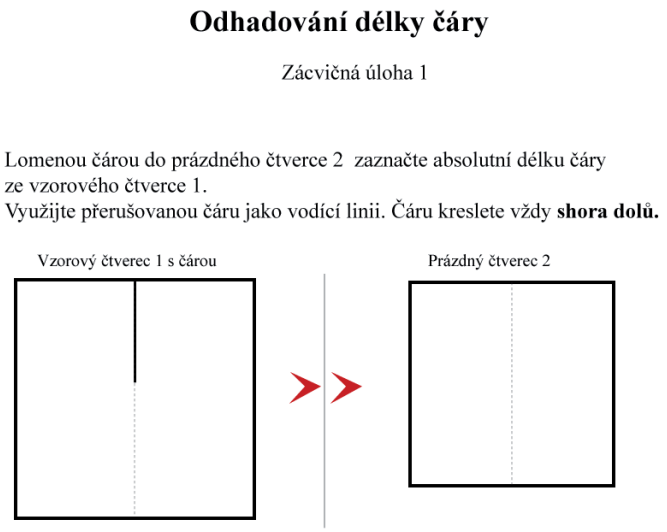


Fig. 9. Practice phase of Absolute-relative test, adapted version of FLT. [The evaluation of the Length of the Line]

Several master, dissertation and habilitation theses have been already realized on the MuTeP platform and the research outcomes have been published in scientific journals (e. g. Kubíček et al., 2014; Stachoň et. al, 2013). SW MuTeP is closely described in Šašinka and Morong (2012) or Šašinka and Stachoň (2013). Currently we have launched a beta-version of a new platform (Hypothesis) that is conceptually connected with MuTeP, but that even more widens the possibilities of the usage of the software (e. g. computer adaptive testing principle, eye-tracking).

Summary

In the first part of this article we tried to explain the process of visual perception to the potential reader and to identify the role of experience as a possible source of changes in the perceptual process. We also described two approaches to the role of experience in the process. The nativist approach states that a perceptual stimulus incorporates all the important characteristics for perception. On contrary, the empiricist approach states that perception is not stimulus-determined and that experience plays an important role in the perceptual process. The nativist approach is represented by Gestalt and its laws of perception – grouping

principles of perceptual organization, and it demonstrates some universal laws of human perceptual process. The empiricist approach is represented by the experiment by C. Blakemore and G. Cooper that was one of the first laboratory demonstrations of the role of experience on perception; the Segall's hypotheses on the role of the environment in the development of perception; Witkin's theory of field dependence and Nisbett's theory of holistic and analytic cognitive style.

In the second part we tried to link the psychological research on perception with the area of cognitive cartography, highlighted some principles common to both ares. Finally, we introduced the MuTep system and outlined the possibilities of a combination of cartographic and psychological experimental research in multidisciplinary research design.

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