Research on Usability Testing and Cognitive Issues of Cartographic Visualizations in the Context of Different Groups of Users

Zbyněk ŠTĚRBA, Čeněk ŠAŠINKA, Milan KONEČNÝ

Keywords: Cartographic Visualization, Usability, User, Cognitive Style

SUMMARY

Maps are commonly considered an effective way for transferring geoinformation to a wide variety of user groups. Most cartographic products are used by people who need to arrive at the target information as quickly as possible and with an appropriate level of accuracy and comprehensibility. Yet, cartographic products have not always been designed strictly according to their primary purpose and the needs of specific groups of users. It is therefore necessary to properly evaluate each new cartographic visualization and obtain feedback on its usability. This process requires the evaluator to consider all potentially relevant cognitive aspects influencing perception of cartographic information in a specific group of users for whom the map is intended. One has to be extremely careful about considering these factors especially when designing and evaluating applications used in emergency services. Cartographic visualizations and tools used in this field should also be designed with the personality of the user in mind. The present paper overviews some of the most relevant aspects that should be taken into account when testing the usability of cartographic products with respect to the user's personality.

Research on Usability Testing and Cognitive Issues of Cartographic Visualizations in the Context of Different Groups of Users

Zbyněk ŠTĚRBA, Čeněk ŠAŠINKA, Milan KONEČNÝ

1. INTRODUCTION

It is not the sole objective of cartography to create cartographic products; it also needs to find out whether these products serve their purpose and whether they are suitable for the intended group of users. Therefore, all cartographic works should be tested and critically evaluated. Each evaluation starts with determining what it is that one wants to evaluate, and what properties the evaluated object (a map, in this case) has. This is because the usability of a map can only be assessed in relation to the user or a specific group of users. Scientific literature cites many methods used for the evaluation of maps and similar products. Some of them (see Krygier & Wood, 2005) place particular emphasis on various aspects of attractiveness, and are therefore relevant mainly when evaluating cartographic products intended for the general user. However, these evaluations are not based on objective characteristics of the products. In maps designed for specialized professional use, the evaluation must focus on different properties: how illustratively the cartographic representation captures the target objects and phenomena, how well the individual features can be distinguished and identified, how clear and transparent are the patterns of different object types, and how effectively and efficiently the map can be read in the conditions in which it is most likely to be used.

Evaluation of cartographic products usually involves (apart from previously used methods of expert evaluation and subjective evaluation of the users themselves) direct testing of various components of usability. While methods used for this kind of evaluation do not usually capture all qualities of the map (e.g. whether the information on the map is correct, up to date and accurate), they are still very helpful in the assessment of different cognitive processes directly involved in reading and interpreting of a given cartographic product. It is usually difficult to assess these processes through different means. The methods of usability evaluation are especially suitable for assessing those visualizations in which users are expected to work efficiently (quickly) as well as effectively (without errors). A good example of such demands is the job of emergency dispatchers, who are frequently required to use available geographic information systems to obtain the necessary information as quickly and accurately as possible. The process of information transmission is in this case influenced by many factors affecting people's perception, including the user's personality. All of these factors, which might be less important in other domains of cartographic applications, need to be considered as key aspects of information transmission between the map and the user when the map is used for dealing with emergency situations. In the present article, besides specific issues of geoinformation processing in emergency dispatch centers, we describe several significant psychological factors and phenomena that can potentially affect the overall usability of cartographic visualizations. We also outline possible ways of testing these factors and their impact on the effectiveness and efficiency of the target group of users, i.e. emergency dispatchers.

2. THEORETICAL BACKGROUND

2.1 Specific characteristics of maps used in emergency centers

The work of emergency dispatchers is very closely associated with spatial and positioning information. Hence, map reading is an essential part of all stages of emergency dispatching: Both dispatchers and emergency/rescue teams use the information obtained from maps to coordinate and adjust their decisions, which largely determine the success of the whole emergency response. Today, the purpose of the main information source of this kind is served namely by the geographic information systems (GIS). Besides promptly acquiring key information and providing control over the emergency response, these tools allow the user to immediately access data stored in databases (Kraak & Ormeling, 2003). However, before one starts to consider how this information can be used in practice, one has to pay special attention to the processes involved in the performance of emergency service workers when working with these kinds of materials.

Emergency response management uses various information sources, which is why all forms of information behaviour must be taken into account and studied in detail. This is the only way to establish which of the information is truly required by emergency dispatchers responding to emergency situations (Šašinka et al., 2010). Zbořil (2010) also emphasizes the role of cognitive load which tends to increase in critical situations proportionally to the experienced stress. Cartographic visualizations should deal with this issue by depicting relevant features on the map in a way that keeps the cognitive load in the user to a minimum.

2.2 Optimization of tools used in emergency centers

An analysis of the communication between different units of emergency services (Stachoň & Šašinka, 2009) have revealed that emergency service workers need access to as many relevant input information as possible, so that they can later decide on the appropriate measures to be taken (e.g., which units will be dispatched, in what numbers, etc.). This underlines the importance of ensuring that the information is of high quality, as it largely determines the degree of success for the final solution. Keeping these issues in mind, Stachoň et al. (2010) explored potential ways of optimizing geoinformation tools for emergency services in detail. Weak points of these tools could be found especially in their functionality, data management options and updating possibilities. Another major variable influencing the usability of these tools are the forms of cartographic visualization of available data, which are not the same in all products. Based on these findings, several key areas for further research have been identified.

In the first place, it is necessary to concentrate on the improvement of the user interface, which is one of the most important aspects of usability in the GISs and has a strong impact on the effectiveness of decisional processes. An observation of the work of emergency dispatchers responding to emergencies indicated that improved user interface in the employed GIS applications would enable the dispatchers to use the tool more intuitively and discourage

them from searching through other, unofficial sources of information. This could help to increase the overall performance of the end users working with the GIS tools.
Another domain which provides room for improvement is effective data utilization. Optimization of existing data sets especially involves strengthening the interconnection between various databases and allowing regular updates. In case of emergency response management there are no obstacles in legislation or other that would prevent free utilization of these functions. It is therefore mostly a matter of integrating different databases with various geographic and non-geographic data so that all units involved in the process have free access to these data (which also regards databases originally created and owned by individual telecommunication centers). Most recently, it is increasingly possible to also include data from sensor networks which can be a very powerful source of information when dealing with emergencies (see Hřebíček & Konečný, 2007).

An emergency response may require immediate communication between several parties situated at different locations (typically the communication of a dispatcher with several remote emergency or rescue units). In these situations, it is necessary to have access to high-quality geocollaboration tools, which are very efficient mediators when dealing with unstable situations. MacEachren et al. (2006) describe geocollaboration as the collaboration of two or more subjects who use geographic information and geoinformation technologies to work on the same spatially defined problem simultaneously or in an immediate sequence. Through the optimization of geoinformation tools it is possible to make the intervention much more efficient and solve the problem more quickly. Suggestions for how this can be achieved have been provided, for example, by Štěrba & Březinová (2009).

The last major source of shortcomings in geovisualization tools used by dispatchers is the cartographic data processing itself. Improvement in currently used visualizations may increase the efficiency and accuracy of the performance of emergency dispatchers, who often cited apparent lack of conceptual justification in cartographic depiction of various phenomena (improper symbolic representations, poor readability of the map, etc.) as one of the limitations. A possible solution would be visualization directly based on user requirements, which falls under the domain of adaptive cartography (Konečný et al., 2007; Friedmannová et al., 2006). The adaptive approach in cartography attempts to meet all of the demands of emergency operators by responding to their individual needs. In the following sections, we look more closely at the evaluation of usability and the effect of cartographic visualizations on cognitive load in the users from the perspective of individual differences.

3. MONITORING OF THE ASPECTS OF MAP USABILITY

With the evolution of various technologies, the demand increased for designing specialized base maps (which also applies to emergency response management, e.g. in the form of context visualization). This development can be observed even today, and it is obvious that maps are still in use and will be used in the future as well. However, technologies keep changing rapidly, which means that the means of transmitting spatial information are constantly changing as well (e.g. internet map portals, navigations, etc.).

Sliviaková et al. (2009) points out that the rapid progress in the field of information technologies at the end of the past century has strongly affected a wide range of areas of human activity, and cartography was no exception. Today, the most typical cartographic outcome is the representation of geographic data in a digital form on the computer screen or a display of a portable device. Substantial decrease in the technical as well as financial demands of creating cartographic outcomes also produced profound changes the approaches to map design. Traditional maps were static and commonly used in many different tasks, which is why they were supposed to contain as much information as possible to serve their function as an analytical tool. The only limitation was the maximum tolerable graphic density of features on the map so that the map was still readable. Thus, overall usability of a map does not only depend on the amount and quality of the represented content, but also on the map's graphic qualities, which determine its readability.

Sliviaková et al. (2009) points out that cartographers today strive to make maps more customized, i.e. design different cartographic outputs for different tasks and user groups. A modern map should only contain minimum (adequately displayed) information which is necessary to interpret the message quickly and, most of all, correctly. Whereas traditional maps relied largely on the user's expertise, complex analytical operations are today conducted (completely or partly) automatically, so that the users obtain the information in a form that corresponds to their individual levels of knowledge and skill. In this place, it is probably good to stop for a moment and notice the differences in how the issue of map usability is addressed by different fields. While cartographers might tend to view the users as a mere aspect of a particular context and "reduce" their role to the level of available hardware, psychologists will always see them as active subjects who transcend the context in which the map is used through intentional and purposeful action. The primary concern is always the general intention of the individual, which goes beyond map reading.

Usability as a relevant criterion for the evaluation of maps in emergency response management was already briefly introduced in the introduction section. Let us now look at how exactly this concept should be understood and how it can be used in map evaluation. Rubin (2008) defines usability as the quality of a product which might or might not be present to a satisfactory degree. Usability can especially be described in products with a user interface, which also includes maps. The quality can be further divided into several attributes. Rubin (2008) argues that a "usable" product (or service) should meet certain standards of usefulness, effectiveness, learnability, satisfaction, and accessibility. All of these attributes actually define the general goal the user has in mind for a usable product, which is the ability to use the product freely for its intended purpose without encountering obscurities and confusion. This perspective is well applicable to the evaluation of maps, which should also meet these requirements (the issue is discussed in more detail by Štěrba et al., 2014). Thus, it can be concluded that, depending on a given situation, usability can be defined as a set of one up to all of the abovementioned attributes. However, quantification of these attributes can be extremely problematic, and some of the aspects can only be evaluated through comparisons with other objects or products.

Lately, usability of cartographic visualizations has been widely tested using objective methods of both qualitative and quantitative nature (e.g. Stachoň et al., 2013; Brychtová et al., 2012; Çöltekin et al., 2010). These methods, which employ modern computer technologies for assessing users' performance, enable objective quantification of some of the usability attributes. Moreover, when these methods and testing procedures are combined (e.g. through a mixed research design combining quantitative assessment of user effectiveness/efficiency with the analysis of users' cognitive strategies by means of eye-tracking systems), the data can be compared with the results of simultaneous psychological testing capturing individual differences between the users (respondents) – see Štěrba et al., 2014; Kubíček et al., 2014; and Stachoň et al., 2013. Different options for the assessment of personality characteristics in users of cartographic visualizations are described in the following chapter.

4. COGNITIVE PROFILE OF A MAP USER

Research in cartography in the past few years has been increasingly focused on the study of cognitive processes involved in map reading. Maps should be designed not only with a particular purpose in mind, but they should also be compatible with the user and her cognitive abilities. In fact, to be thorough, one should also consider the environment and the broad context in which the end user works (Perkins, 2008). In this part, we will therefore try to outline the effect of the user's personality on their perception of the map. This knowledge could – particularly in connection with the knowledge on other, external factors – yield substantive conclusions for the application of cartography, especially in the field of emergency response management.

The issue of individual (or group) differences which could have a relatively strong impact on map reading has already been discussed by a number of authors. From the wide range of psychological disciplines, inter-individual variability is not only addressed by personality psychologists but also by other sub-fields where differences (in terms of skill, cultural background, gender, age, or limits of vision) play an important role in explaining general principles of human experience, cognition or behaviour (see, for example, Cole, 2003; Kitayama et al., 2003).

4.1 Cognitive style

One of possible ways to address the issue of individual differences in perception is the concept of cognitive styles. The concept of cognitive (or thinking) styles explains the differences between the ways different people process information and between people's preferences for particular forms of information representation. Hence, the theory of cognitive styles presents a typology describing typical strategies of coordinating and engaging cognitive functions in different groups of individuals. This typology has a potential use also in cartography, especially in the sense of customizing alternative methods of visualization for users employing different cognitive styles (see Štěrba et al., 2011).

Analyses of existing conceptions of cognitive styles provided by Kozhevnikov (2007) and Riding & Cheema (1991) suggest that the concepts generally involve two broad dimensions. The first one is the Verbal-Imagery dimension, which describes the preference of an individual to primarily process information in terms of either a verbal code or mental images. The second group of approaches differentiates between individuals on the basis of a Wholist-Analytic dimension. This dimension regards the focus of an individual either on detail or on the global context of the visual field (for more information, see e.g. Allison & Hayes, 1996). The concept of cognitive styles can surely find an application in the domain of emergency response management. Namely, individual tendencies related to the first dimension may influence, for example, people's performance on (self-)localizing tasks, while the second, Wholist-Analytic dimension could be more instrumental in determining the dependence of the individual's cognitive style on map reading. Especially when applying the principles of contextual cartographic visualization, one has to consider different consequences of changes in the visualized spatial data on the user's perception.

4.2 Possibilities for testing individual differences between users

In psychology, there are many methods for establishing cognitive styles in relation to specific individual characteristics. Some of these methods could also be used for assessing performance on map-reading tasks. The traditionally accepted Verbal-Imagery dimension is further elaborated by certain authors to differentiate between "object imagery" and "spatial imagery" (Blazhenkova & Kozhevnikov, 2009). Object Imagers (exemplified by painters) are able to form lively, concrete and detailed images of individual objects. In contrast, Spatial Imagers are more analytical and prefer rather schematic representations which emphasize especially spatial relations between objects. Accordingly, they are more likely to employ more complex spatial transformations in their cognitive processing. These two preferences are measured by the widely used Object-Spatial Imagery Questionnaire (OSIQ), which is a standardized questionnaire consisting of 30 carefully formulated items asking about respondents' preferences within a defined range of object or spatial orientation (Kozhevnikov et al., 2006).

In cartography, the questionnaire can be used to test the associativeness of symbols sets in relation to cognitive style. If the map symbols differ in their degree of iconicity, schematic nature or colour scheme, it can be expected that established cognitive styles will correlate with the users' performance with a particular symbol set. An example of a study exploring these relationships has been reported by Štěrba et al. (2011), who found that Spatial Imagers needed more time when completing perceptual tasks (i.e. search and recognition of symbols) involving colourful and highly iconic map symbols. This suggests that symbol sets of this kind might actually undermine the performance of schematically oriented users, which might be because such elements may attract more of their attention, interfering with the otherwise smooth processing of visual information.

One of the most theoretically elaborated cognitive styles is field dependence. The author of the concept H. A. Witkin argues that field dependence or independence is an individual ability

to perceive objects within a visual representation as separate elements (Cassidy, 2004). In this perspective, Witkin et al. (1962) distinguish between people who are capable of freeing themselves from the context of a perceived image (spatially independent individuals) and those who perceive things in a more global manner, with various elements indivisibly merging with the field (spatially dependent individuals). This idea can be directly applied to the study of map reading. It can be assumed that field-independent map users will be able to switch their attention between figure and ground elements more smoothly and therefore will also perform better on complex tasks that involve searching for several pieces of information at the same time. Similarly, it can be hypothesized that field independence will correlate with the ability to adjust to changes in visualization which may occur when switching between different cartographic contexts or map scales. Field dependence can be measured, for example, by the FLT test (framed-line test; Kitayama et al., 2003). The entire test involves repeated presentation of stimuli which always contain a line whose length varies across different tasks. The line is a part of different geometric figures, which represents the background of the entire visual field. After viewing the figure for a certain period of time, the respondent is asked to draw a similar line into another figure of the same shape but of different size. The drawing should follow one of two rules: either the line should be of the same absolute length as the line in the original figure, or it should be of the same proportional length with respect to the background elements. Hence, the test involves alternation between two types of tasks – absolute and relative estimation of the length of a line. Results obtained in the test can be interpreted by the concept field dependence. Namely, the number of errors in both types of tasks will be taken into consideration: If errors in the absolute estimation tasks prevail, it is an indication that the individual is field-dependent. Conversely, more errors in the relative estimation tasks suggest that the individual is probably field-independent. As discussed above, the latter group of respondents will be expected to perform better on more complex map-reading tasks which require the user to frequently switch attention between figure and ground elements on the map.

All of these methods of cognitive style assessment can be seen as another potential aspect of the evaluation of cartographic visualizations in terms of their usability. In particular, they may provide a more detailed perspective on the way a map (or cartographic symbology) is perceived and help to identify problems that may arise in specific groups of users.

5. CONCLUSIONS

All of the above information illustrates that evaluation of the usability of cartographic products is a complex issue which requires an analysis of potential groups of future users. This fact becomes even more relevant in the domain of emergency response management in which the user's personality is a crucial element in successful interventions which cannot be neglected. Emergency service workers (e.g. members of rescue parties) often work under considerable time pressure while bearing great responsibility, as wrong decisions on their part may lead to fatal and irreversible consequences or may even make the whole emergency situation even worse. Acute stress reactions can change the way people perceive their surroundings and process information, including spatial information. This is why cartographic

visualizations and GIS applications used in emergency services must be adjusted not only to the individual characteristics of the user but also to the demands of specific situations (time pressure, etc.). Inappropriate tools might have a strong negative impact on users' performance and increase their stress even further, which could be dangerous when responding to emergency situations.

The objective of the present article was to describe potential consequences of cognitive differences between the users of cartographic products. On several examples, we attempted to demonstrate how objective methods of usability testing could be combined with detailed examination of cognitive abilities in map users. This way, we also tried to emphasize the role of the user in the overall transmission of information communicated by the map, as well as the necessity to focus more deeply on user aspects in map design.

This work was supported by the project „Employment of Best Young Scientists for International Cooperation Empowerment" (CZ.1.07/2.3.00/30.0037) co-financed from European Social Fund and the state budget of the Czech Republic.

REFERENCES

Allinson, J., Hayes, C. (1996). The Cognitive Style Index, a measure of intuition-analysis for organizational research. In *Journal of Management Studies,* vol. 33, p. 119-135.

Blazhenkova, O., Kozhevnikov, M. (2009). The new object-spatial-verbal cognitive style model: Theory and measurement. In *Applied cognitive psychology*, vol. 23(5), p. 638-663.

Brychtová, A., Popelka, S., Dobesova Z. (2012). Eye-tracking methods for investigation of cartographic principles. *SGEM 2012 Conference Proceedings Volume II*, Technology Ltd., Sofia, Bulgaria, p 1041-1048.

Březinová, Š., Šašinka, Č. (2011). Interindividuální rozdíly ve způsobu sebelokalizace v neznámém prostředí: terénní výzkum. In K. Bartošová et al. (Eds.) *Sociální procesy a osobnost: Člověk na cestě životem: Křižovatky a mosty*, Proceedings (p. 45-50). Brno: Tribun EU.

Cassidy, S. (2004). Learning Styles: An Overview of Theories, models and measures. In *Educational Psychology*, vol. 24(4), p. 419-444.

Cole, M. (2003). *Cultural Psychology: A Once and Future Discipline*, Cambridge, Belk-nap Press: Harvard University Press, 401 p.

Çöltekin, A., Fabrikant, S.I. Lacayo, M. (2010). Exploring the efficiency of users' visual analytics strategies based on sequence analysis of eye movement recordings. In *International Journal of Geographical Information Science*, vol. 24(10), p. 1559-1575.

Friedmannová, L., Konečný, M., Staněk, K. (2006). An Adaptive Cartographic Visualisation for Support of the crisis management. In *AutoCarto*, CaGIS, Vancouver, Canada, p. 100-105.

Hřebíček, V., Konečný, M. (2007). Introduction to Ubiquitous Cartography and Dynamic Geovisualisation with Implications for Disaster and Crisis Management. In *The Geospatial Web: How Geobrowsers, Social Software and the Web 2.0 are Shaping the Network Society*, Londýn: Springer-Verlag, p. 209-214.

Kitayama, S., Duffy, S., Kawamura, T., Larsen, J. T. (2003). Perceiving an object and its context in different cultures: A cultural look at new look. In *Psychological Science*, vol. 14(3), p. 201–206.
Konečný, M., Staněk, K., Friedmannová, L. (2007). Adaptabilní mapy pro krizový management. In *Kartografické listy*, Bratislava: Kartografická apolečnosť Slovenskej republiky, p. 41-50.
Kozhevnikov, M. (2007). Cognitive Styles in the Context of Modern Psychology: Toward an Integrated Framework, In *Psychological Bulletin* vol. 133, p. 464-481.
Kozhevnikov, M., Blazhenkova, O., Motes, A. M. (2006). Object-Spatial Imagery: A New Self-Report Imagery Questionnaire, In *Applied Cognitive Psychology* vol. 20, p. 239-263,
Krygier, J., Wood, D. (2005). *Making Maps: A Visual Guide to Map Design for GIS*. New York, Guilford Press, 303 p.
Kubíček, P., Šašinka, Č., Stachoň, Z. (2014). Vybrané kognitivní aspekty vizualizace polohové nejistoty v geografických datech. In *Geografie - Sborník České geografické společnosti*, Česká geografická společnost, vol. 119(1), p. 67-90.
MacEachren, M. A., Cai, G., Brewer, I., Chen, J. (2006). Supporting Map-based Geocollaboration through Natural Interfaces to Large-screen Displays, In *Cartographic Perspectives*, vol. 54, p. 16-34.
Perkins, C. (2008). Cultures Of Map Use. In *The Cartographic Journal*, The British Cartographic Society, Londýn, vol. 45(2), p. 150–158.
Riding, R., Cheema, I. (1991). Cognitive Styles - an overview and integration. In *Educational Psychology*, vol. 11(3), p. 193-215.
Rubin, J. (2008). *Handbook of usability testing: How to Plan, Design and Conduct Effective Tests*, Indianapolis: Wiley Publishing Inc., 348 p., ISBN 978-0471594031.
Sedlák, P. (2010). Nový přístup k testování a hodnocení kvality map.In *Geodetický a kartografický obzor*, vol 56/98(9), p. 182-188.
Sliviaková, A., Stachoň, Z., Šašinka, Č., Zbořil, J. (2009). Posuzování uživatelských charakteristik kartografických produktů: interakce člověk a GIS. In *Kognice a umělý život IX*, Opava: Slezská univerzita v Opavě**,** p. 297-304.
Stachoň, Z., Šašinka, Č., Štěrba, Z., Zbořil, J., Březinová, Š., Švancara, J. (2013). Influence of Graphic Design of Cartographic Symbols on Perception Structure. In *Kartographische Nachrichten*, 63(4), p. 216-220.
Stachoň, Z., Šašinka, Č. (2009). Perception of Various Cartographic Representations Under Specific Condition. In *Cartography and geoinformatics for early warning and emergency management: Towards better solutions*, Brno, Czech republic, 2009, 9 p.
Stachoň, Z., Šašinka, Č., Zbořil, J., Březinová, Š. (2010). Utilization of Spatial Data in Emergency Response: System Optimization Based on Analysis of Working Practices. In *Proceedings Digital earth in the service of society: sharing information, building knowledge*, 12 p.
Šašinka, Č., Březinová, Š., Zbořil, J., Stachoň, Z. (2010). Analýza činnosti operátorů HZS v krajských operačních střediscích v perspektivě teorie informačního chování: empirický výzkum. In *Kognice a umělý život X*, Opava: Slezská univerzita v Opavě, p. 367-370.
Štěrba, Z., Šašinka, Č., Stachoň, Z., Štampach, R., Morong, K. (2015). *Selected Issues of Experimental Testing in Cartography*, Masaryk University, Brno, in press.

Štěrba, Z., Šašinka, Č., Stachoň, Z., Kuníček, P., Tamm, S. (2014). Mixed Research Design in Cartography: A Combination of Qualitative and Quantitative Approaches. In *Kartographische Nachrichten*, vol. 64(5).

Štěrba, Z., Šašinka, Č., Stachoň, Z. (2014). Usability testing of cartographic visualizations: principles and research methods. In Bandrova, Konečný: *5th International Conference on Cartography and GIS Proceedings Vol. 1 and Vol. 2.*, Riviera (Bulgaria): Bulgarian Cartographic Association, 2014. p. 333-340.

Štěrba, Z., Březinová, Š. (2009). Možnosti využití geokolaborace v krizovém řízení. In *Geoinformační infrastruktury pro praxi*, Brno: MSD spol. s.r.o., 9 p.

Štěrba, Z., Stachoň, Z., Šašinka, Č., Zbořil, J., Březinová, Š., Talhofer, V. (2011). Evaluace kartografických znakových sad v kontextu osobnosti uživatele. In *Geodetický a kartografický obzor*, 2011(8), 10 p.

Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., Karp, S. A. (1962). *Psychological Differentiation*, New York: John Wiley and Sons, INC, 430 p.

Zbořil, J. (2010). *Kontextová kartografická vizualizace a její využití v krizovém managementu*, dissertation thesis, Masaryk University, Brno, 160 p.

CONTACTS

Zbyněk Štěrba, Ph.D.
Department of Geography
Masaryk University
Kotlářská 2, 611 37
Brno, Czech Republic
Tel. +420 549 49 7621
Email: zbynek.ste@mail.muni.cz

Čeněk Šašinka, Ph.D.
Department of Psychology
Masaryk University
Kotlářská 2, 611 37
Brno, Czech Republic
Tel. +420 549 49 7111
Email: 44276@mail.muni.cz

Prof. Milan Konečný
Department of Geography
Masaryk University
Kotlářská 2, 611 37
Brno, Czech Republic
Tel. +420 549 49 5135
Email: zbynek.ste@mail.muni.cz