CO-201

CARTOGRAPHIC RESEARCH OF MENTAL MAPS AT CHARLES UNIVERSITY IN PRAGUE

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INTRODUCTION

Since 2009, at Charles University in Prague there has been an on-going complex study of mental maps from the point of view of geographers, teachers of geography and cartographers. The goal of the project is firstly to analyze mental maps themselves with a focus on spatial precision and with the use of GIS (a part of the research that is not presented here). It is also to test the methodology for assessing cartographic works with the help of the users' mental maps and the assessment of the learning process by means of teaching maps and the mental maps of students (the interconnection between teaching and mental maps is also not presented). A range of students in education and other fields, as well as several elementary and grammar schools in Czechia are involved in the completion of the project.

Although we could find the idea of "mental maps" in geographical and cartographical literature since the 1960s, the research has until now had a social-geographical character (behaviorism, cultural geography and self-identity, etc.). As far as it was related to GIS, research has offered only a limited number of methodologies for assessing the precision of mental maps. Research in cartography was dedicated mostly to the relationships between the traditional map and the mental map. That is why the authors of this study wanted to expand the spectrum of methodology in the study of mental maps and focus on the connection between geography education and the creation of maps by experts. They also wanted to offer a greater number of relevant methodologies for assessing the precision of mental maps with the use of GIS. Testing the methodology for assessing cartographical works with aid of users' mental maps is also a component of this project. While laying out their goals, the authors were also interested in whether it would also be possible to use mental maps to assess educational processes and school materials (atlases, textbooks). One portion of the project, which is not presented in this contribution because it is not based on cartography, is the interdisciplinary use of mental maps in cultural and social anthropology. The scholarly focus of this scientific team does not involve the psychological or social aspects of the creation of mental maps.

The main subject of this entire study is the *mental map*. The authors of this study see this, like Drbohlav (1991, p. 164), as a "graphic (cartographic or schematic) expression of a person's conception of geographical space, most often of its quality or arrangement." The mental map according to this definition is not merely a picture of reality in the mind of an individual, but should also already be expressed graphically (with the help of a map, scheme or sketch). This corresponds to the theory of Kraak and Ormeling (2003). This idea is associated with the name P. Gould (1986), who investigates the preferences of a map's author with the resulting map being created by a professional. It is also associated with K. Lynch (2004), who deals with the perception of space (form, size, spatial orientation, arrangement of objects, topology, etc.). In opposition to this is the *cognitive map*, which is defined as "the internal (mental) representation of external reality in the mind of a person." (Zelenka et al. 2008, p. 12) A cognitive map is created on the basis of geographic knowledge and knowledge about space and surroundings (Kitchin and Blades 2002). In some sources the concepts of the mental map and the cognitive map are considered synonyms. For mental maps as we consider them here (that is graphic expression), we will use the term "sketch maps" (e.g. Huynh et al. 2004).

ASSESSMENT OF CARTOGRAPHIC WORKS WITH THE HELP OF USERS' MENTAL MAPS I

J. D. Bláha, K. Novotná

The goal of this part of the project is to test the original methodology for the assessment of cartographic works. This methodology rests on several principles:

1. the use of nonexpert, i. e. users' assessment of cartographic works;

2. use of the *aggregated mental maps* method, which focuses on the selection of elements which a respondent incorporates into his/her mental map and compares this selection to the occurrence of specific concrete elements incorporated into the mental maps of all respondents (Kynčlová et al. 2009) – see *Figure 1*;

3. use of findings gleaned in the context of psychological investigations for the purpose of reducing the likelihood that the respondent will artificially alter his/her opinion (e.g. bias in favor of the creator of the cartographic work, etc.)

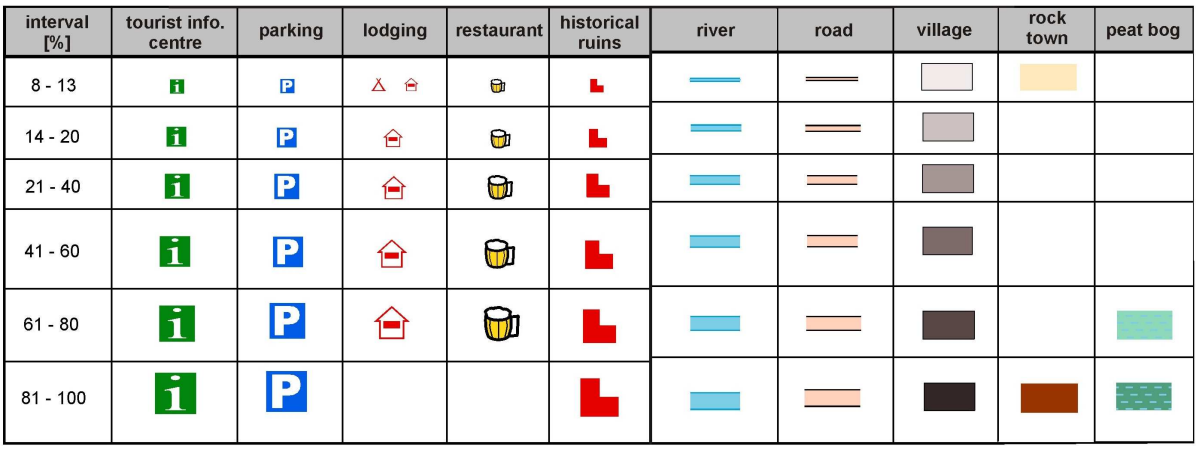


Fig. 1. An example of part of a legend in an aggregated mental map

Each of the rows in the legend shows the differing frequency of a particular drawn element. For example, an interval of 8–13% shows that only that percentage of respondents drew that element into their mental maps.

An *aggregated mental map* is formed from the mental maps of a particular group of respondents/users by noting the depicted area's true layout and then noting in the legend the varying occurrences of particular drawn elements (*Figure 1*). Figural symbols are distinguished by their size (more frequent occurrences are indicated by larger symbols); line symbols either by their structure (in the study of blazed hiking trails, more frequent occurrences are indicated by longer segments of a particular color) or by the width of the line (the more frequent the occurrence, the wider the line); and areal symbols by the intensity of their infill (more intense infill indicates greater occurrence). This study was based on J. Bertin's earlier study Sémiologie graphique [Semiology of Graphics] (Bertin 1967).

The introduction to this part of the study established the following hypotheses concerning a sociological analysis of respondents' mental maps:

Hypothesis 1: The number of drawn elements will depend on the respondent's gender. Males will draw more elements than females. (It is well known that males are better at finding their bearings on maps than females; they should therefore draw more elements.)

Hypothesis 2: The greatest number of elements will be drawn by people in age groups 18-40 and 41-60 and the least elements will be drawn by people less than 18 years old and more than 60 years old. (People in the age groups 18-40 and 41-60 use hiking maps most frequently; they should therefore draw more elements.)

Hypothesis 3: There will be a correlation between number of elements drawn and user's level of education attained. (It is posited that respondents who have attained a higher level of education have better memories; they should therefore draw more elements.)

Hypothesis 4: A beginner will draw the least number of elements and an advanced user will draw the most. (An advanced user will have greater facility with a map and should therefore draw a greater number of elements.)

Hypothesis 5: A user who uses maps infrequently or never will draw the least number of elements, whereas a user who uses maps frequently will draw the most elements. (A user who is not accustomed to using maps is less able to remember a large number of objects on a map.)

The method for assessing cartographic works by means of users' mental maps includes a number of basic phases common to traditional assessment; in certain specific measures, however, it differs significantly from traditional assessment. The preparatory phase entails selection of groups of cartographic products to be assessed, groups of users (respondents) and, above all, questions and tasks related to the assessment of the cartographic works. This involves the testing of various kinds of tasks, including basic spatial orientation (*"Where on the map are we at this moment?", "In what direction is this or that object?", "What is the distance between it and this place?", "Where on this map is north?"*), finding connections between two points on a map (*"Find a way of getting from the church in Svárov to Marek Mill on foot", "Which points of orientation on the map do you use to do this?"*), and various practical questions such as *"Where is the nearest pub from Marek's Mill?", "According to the map, where is the nearest hotel? "*, etc. (Bláha and Hudeček 2010). For more on choosing questions to be asked, see Bláha and Hudeček (2010).

The selection of respondents was to a certain degree random. *A total of 161 people* completed the questionnaire in its final form (83 for the region Český Ráj and 78 for the Krkonoše Mountains). The variants were assigned randomly. It was not possible to interview people on the street due to the questionnaire's length. Initial respondents were selected from the circle of the authors' acquaintances, who themselves brought in more respondents. In order that the sample be representative and taking into consideration the above hypotheses, it included an equal number of men and women, and an effort was made to achieve a similarly even representation of the various age and educational categories. These criteria were not always met successfully (*Table 1*). An incidental finding of the research was a sociological analysis of the created mental maps (examples are provided in *Tables 2* and *3*).

Table 1. Respondents according to age and highest level of education attained

age / gender	male	female	total	age / gender	male	female	total
under 18 years	**18**	**26**	**44**	**over 60 years**	**6**	**6**	**12**
BE	18	26	44	BE	0	0	0
SS	0	0	0	SS	0	0	0
SS+G	0	0	0	SS+G	4	6	10
P-SE	0	0	0	P-SE	2	0	2
18 - 40 years	**27**	**28**	**55**	**TOTAL**	**74**	**87**	**161**
BE	6	3	9	BE	24	30	54
SS	1	2	3	SS	2	9	11
SS+G	12	16	28	SS+G	24	34	58
P-SE	8	7	15	P-SE	24	14	38
41 - 60 years	**23**	**27**	**50**				
BE	0	1	1				
SS	1	7	8				
SS+G	8	12	20				
P-SE	14	7	21				

BE = basic education, SS = secondary school without graduation, SS+G = secondary school with graduation, P-SE = post-secondary education

Table 2. Average number of drawn elements according to gender

study area	gender	number of respondent	number of elements in m.m. TOTAL	average number of elements in mental map
Český Ráj	male	39	2 330	**59,74**
	female	44	2 448	**55,64**
	TOTAL	83	4 778	**57,57**
Krkonoše	male	36	2 148	**59,67**
	female	42	2 353	**56,02**
	TOTAL	78	4 501	**57,71**

Table 3. Average number of drawn elements according to highest level of education attained

study area	education	number of respondent	number of elements in m.m. TOTAL	average number of elements in mental map
Český Ráj	BE	31	1 741	**56,16**
	SS	5	234	**46,80**
	SS+G	30	1 751	**58,37**
	P-SE	17	1 052	**61,88**
	TOTAL	83	4 778	**57,57**
Krkonoše	BE	23	1 282	**55,74**
	SS	6	288	**48,00**
	SS+G	28	1 699	**60,68**
	P-SE	21	1 232	**58,67**
	TOTAL	78	4 501	**57,71**

Sociological analysis of the mental maps produced by respondents confirmed hypotheses 1 (see *Table 1*) and 2, but the differences in the number of drawn elements were not in any way significant. Hypothesis 3 was not confirmed by the study, but this is due to a poor sample of respondents (see *Table 3*). Hypotheses 4 and 5 were unambiguously confirmed by the study (the difference in number of drawn elements relative to experience with hiking maps was on average 20 drawn objects on a mental map for each hiking map). The results varied depending on the depicted area itself as well (Krkonoše Monutains, a well-known but geographically complicated region, versus Český Ráj, less well-known but geographically simpler). The sociological analysis of the mental maps was conducted only with regard to quantitative criteria (i.e. how many objects were depicted), and not with regard to which objects were depicted.

The ability to read a map, basic knowledge about a map's language, understanding of a map's contents, etc. all play a role in a user's assessment. It is also necessary to take into account individual respondents' ability to express themselves using the language of the map. Such information is determined at the beginning of a given experiment. Particular questions and tasks are given to respondents with respect to specific products to be assessed; however, respondents are asked to commit to memory as much information (e.g. topography, basic sites on the map) as possible for use in the event that the map in question is not available for consultation.

For this method, the specific answers to questions are not particularly relevant, a detail the respondent should not be made aware of. The researcher records the respondent's replies only for the purpose of comparison and in order to demonstrate interest. After this, respondents are asked to form their own mental maps on the basis of information gleaned from the maps they have seen. The study presumes that a subject will commit to memory (subjectively) important elements of the map's contents for later use. The elimination of subjectivity is achieved by the high number of respondents and by the aggregation of their responses; more frequent replies appear more often on the resulting aggregated map than less frequent replies. Moreover, the object of research is not the mental maps themselves (although they may well serve as a basis for further studies) but the cartographic works. The result is the aforementioned *aggregated mental maps*, which are compared both to the assessed products and to each other. Most importantly, it is determined whether the contents of the aggregated mental maps correspond to the requirements placed on the respective type and purpose of the cartographic work.

This methodology has been tested by K. Novotná (2010) using Czech hiking maps, which are a type of cartographic product employed by a wide segment of users; moreover, in Czechia there has been a good deal of similar research that provides an opportunity for comparison of results. In this case, *three Czech hiking maps* from *two geographically diverse regions* were assessed in order to demonstrate that the method's findings hold true irrespective of geographic idiosyncrasies. With respect to each map, subjects were asked to respond to *three variants of questions and tasks*. Because over time the respondent worked with all the maps, s/he gradually "learned" the maps and usually achieved the best results with the third and final map. In order to eliminate this problem, the following research scheme was devised, in which individual maps were presented to users in varying sequences (see *Table 4*). Moreover, three variants of the assigned task were always offered (variants I–III). Every respondent thus drew a total of three mental maps, each for a different evaluated map and always on the basis of differing tasks.

Table 4. Scheme for a method of assessment (according to Víšek 2009)

respondent	variant I	variant II	variant III
1st	map A	map B	map C
2nd	map B	map C	map A
3rd	map C	map A	map B
4th	map A	map C	map B
5th	map B	map A	map C
6th	map C	map B	map A
etc. (as 1st)	map A	map B	map C

A questionnaire determined the subject's age, sex, education and area of expertise, as well as which if any of the maps in question the subject already knows, which s/he uses, etc. For the purposes of comparison, an expert assessment employing multiple criteria was undertaken before the research was conducted (Bláha 2009). After the initial investigation, questions and tasks were organized (especially for the purpose of eliminating similar or redundant questions and tasks); after this they were categorized and aligned for easier work with the maps. Psychologists were consulted in regard to the questionnaire. In spite of our efforts, the average time of completion of the questionnaire is no less than 45 minutes.

The mental maps that were obtained (483 maps in all) illustrate which objects and features represented on a map are best registered and remembered by users and which are not (*Figure 2*). It is clear that the tasks concerning the hiking maps significantly influenced the type of objects respondents chose to draw into their mental maps. Objects connected to task results dominated the maps. The following types of objects were drawn most frequently:

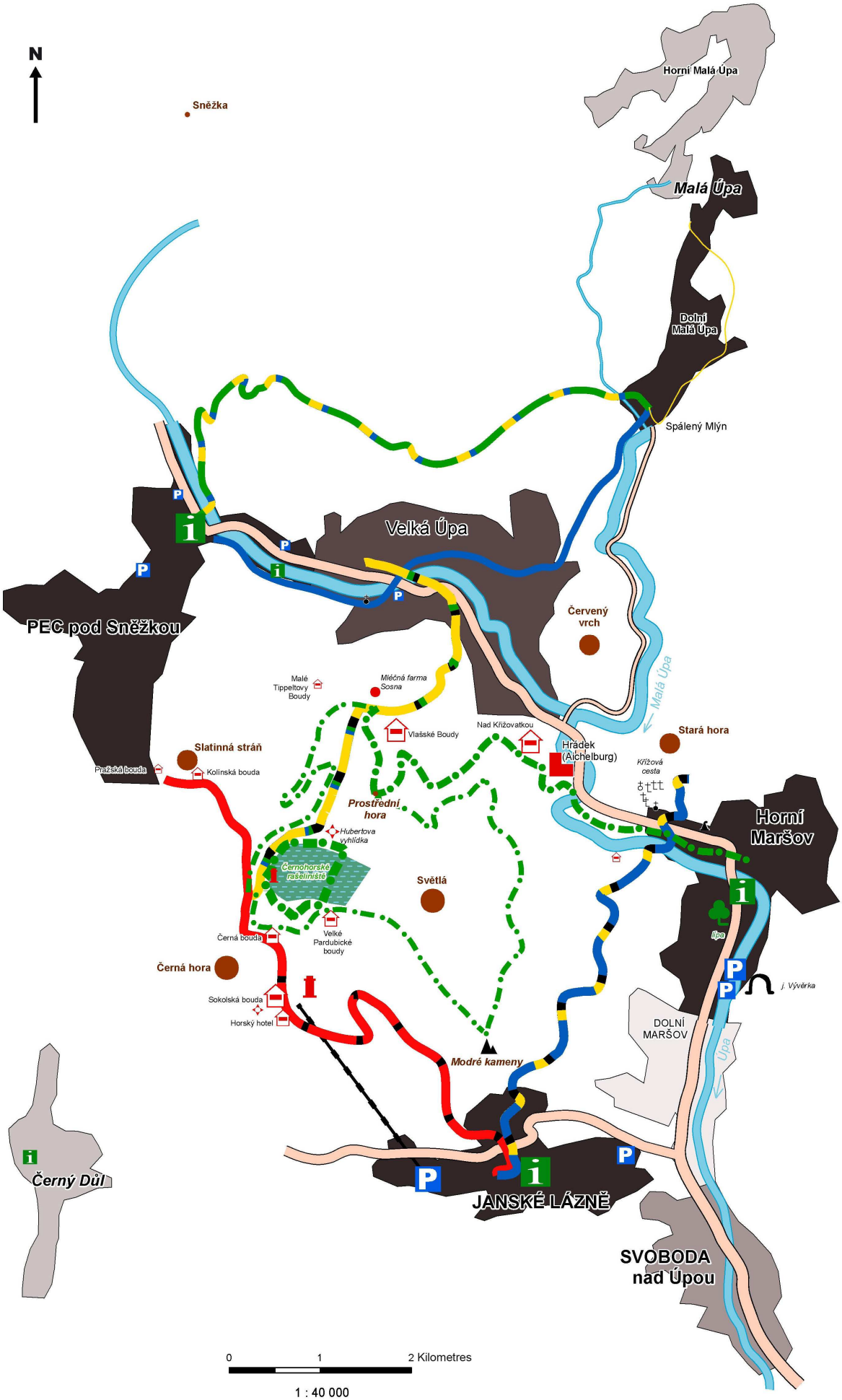
a) *blazed hiking trails* (a network of color-coded trails serving hikers and tourists, the Czech trail system is the most comprehensive in the world) in four basic colors (red, blue, green and yellow); these colors appear in the aggregated maps as well (alternating colored sections of lines); the lines or sections of line are represented in black when no color has been specified;

b) other lined elements include *important water ways* and *borders of nature and culture preserves,* of which there is a rather dense network and within which figural elements are situated;

c) figural elements include *castle ruins* (toward which questions and tasks were naturally often directed), *high elevation landmarks, parking lots, information centers, restaurants* and *hotels and other accommodation*. Mental maps rarely included *protected trees, isolated cliff formations* or *caves*;

d) the most prominent areal elements were *residential areas* (Czechia's residential organization is especially dense); *bodies of water* (of which there are relatively few in the regions in question), *moorland* and *extensive cliff formations* are rarely depicted.

In the framework of a comparison of the resulting aggregated mental maps (*Figure 2*) with the assessment of three hiking maps (according to the respective purposes of the hiking maps), a list of recommendations for individual map producers was created.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Sněžka
Horní Malá Úpa
Malá Úpa
Dolní Malá Úpa
Spálený Mlýn
Velká Úpa
PEC pod Sněžkou
Červený vrch
Malé Tippeltovy Boudy
Mléčná farma Sosna
Vlašské Boudy
Nad Křižovatkou
Malá Úpa
Stará hora
Hrádek (Aichelburg)
Křížová cesta
Slatinná stráň
Pražská bouda
Kolínská bouda
Prostřední hora
Hubertova vyhlídka
Černohorské rašeliniště
Horní Maršov
Světlá
Velké Pardubické boudy
Černá bouda
Černá hora
Sokolská bouda
Horský hotel
lípa
j. Vývěrka
DOLNÍ MARŠOV
Úpa
Modré kameny
Černý Důl
JANSKÉ LÁZNĚ
SVOBODA nad Úpou
0
1
2 Kilometres
1 : 40 000

Fig. 2. Aggregated mental map of a hiking map depicting the Krkonoše region and published by Kartografie Praha

They are recommendations as to which means of expression would be appropriate to highlight, which to tone down, which elements to expand, which to remove, etc. A summary of these recommendations is presented in *Table 5*:

Table 5. Recommendations for hiking maps on the basis of the executed evaluation

Hiking map	Recommendation
Klub českých turistů (Czech hikers' club)	The problem with the hiking maps of this group was the large number of elements on the maps. This map is clearly appropriate for an advanced user. But as can be seen from the results, it does not suit the wider public. It might be suitable to publish two kinds of maps: in the current form for advanced users and a more general form for the wider public. It would also be good to render some of the symbols for certain points of interest (lodge, restaurant) more vividly and to increase the size of all the symbols for points of interest
Kartografie Praha Cartography Prague	In the case of maps by *Kartografie Praha*, it would be useful to darken the topographical background, while taking care that the thematic content does not disappear and thus decrease the legibility of the map. Darkening the topographic background would also bring out the hiking trails and the respondents would not have so much trouble remembering their colors. It would also be useful to highlight the labels on the map, especially for the towns.
SHOCart	In the case of maps by *SHOCart*, we recommend changing the structure of the lines used for bicycle trails because respondents confuse them with the hiking trails. It would also be advisable to avoid covering the waterways for a considerable distance with an adjacent line symbol. The color of waterway symbols should also be better differentiated from the blue hiking trails, so one is not mistaken for the other (which happened in the case of the map of the Krkonoše, for example). Another recommendation is to use white edging around the cartographic symbols (which are written in black) in order to increase the legibility of the maps.

In terms of the comparison of corresponding aggregated mental maps, no significant differences in content occurred with regard to the number of elements. Professional assessment differed in some degree from that of users, but these differences can be explained. The most problematic aspect of the testing methodology was the amount of time it demanded.

AN ASSESSMENT OF THE DEVELOPMENT OF STUDENTS' PERCEPTION OF THE SPATIAL LAYOUT OF THE LAND IN WHICH THEY LIVE, WITH THE HELP OF THEIR MENTAL MAPS | *T. Pastuchová-Nováková, J. D. Bláha*

This part of the study involved the participation of students from four schools. The research took place in two schools in Prague (as the capital of Czechia, Prague is markedly socially distinct from the rest of the country) and two outside of Prague in Southern Bohemia. In each location one elementary school and one grammar school were chosen. The research done with the students had the following goals: a general analysis of mental maps of Czechia, analysis of the precision of localization of Prague in a mental map, and analysis of preferences for permanent residence – mental maps of preferences.

In the established hypotheses, the focus was on ascertaining differences in mental maps according to the age of the students (1st hypothesis: older students will draw in more elements and with greater precision) and above all according to where the students live and attend school (2nd hypothesis: the area of the student's residence will be drawn in more detail; 3rd hypothesis: in view of the locations in which the research was carried out, there will be more elements drawn in Bohemia than in Moravia, which is farther away; 4th hypothesis: in comparison with this, the precision of localization of Prague in mental maps will not depend on the location of residence or school; 5th hypothesis: students from Prague will most often prefer living in Prague).

159 students took part in this research (80 in elementary schools and 79 in high schools; of these, 73 were in Prague and 86 were outside of Prague). *Table 6* shows that the first part of the first hypothesis was proven true: high school students in reality drew more elements, because their cognitive map begins to

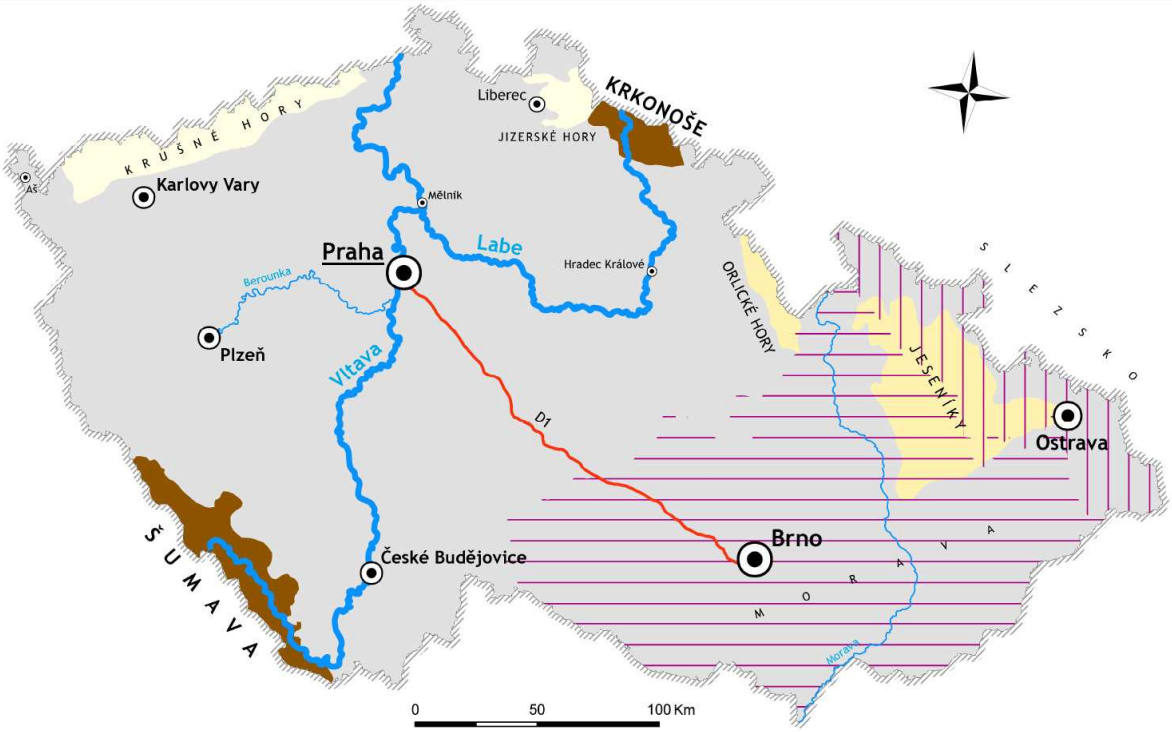
acquire more complex and numerous features. Differences between the schools in Prague (the worst results being in the grammar schools) and outside Prague can be seen in the fact that the younger children in Prague do not "keep track of" anything very far from Prague (everything is provided for them in the city, making it unnecessary to leave their home town), so they know only the basic geographical objects in Czechia. Regional patriotism is evident among those from Southern Bohemia, who have maps richer in content thanks to the added elements of their locale. It is not without interest that the average number of elements drawn by high school students is practically identical (23).

Table 6. Average number of elements in one mental map

school in research	ES Planá	ES Prague	GS Tábor	GS Prague	Total
number of tested students	37	43	49	30	159
number of drawing elements	531	379	1127	677	2714
average number of drawing elements in one map	**14,4**	**8,8**	**23,0**	**22,6**	**17,1**

ES = elementary school, GS = grammar school

In the first part of the analysis of mental maps, it was necessary to aggregate these maps into the above-mentioned *aggregated mental maps*, which reflect the number of individual elements that were drawn (an example of a legend of an aggregated mental map is presented in *Figure 1* and *3*, an example of one of these maps is presented in *Figure 3*). A map of Czechia is provided for comparison (*Figure 4*).



frequency in ment.m.	town	peak	river	highway	mountain r.	region
29 - 39 %	⊙	●	~		▭	||||
40 - 49 %	◉	●	~	—	▭	
50 - 69 %	◉		~		▭	
70 - 89 %	◉		~		▭	
90 - 100 %	◉		~		▭	

Fig. 3. Aggregated mental map of students of the Prague grammar school, with legend

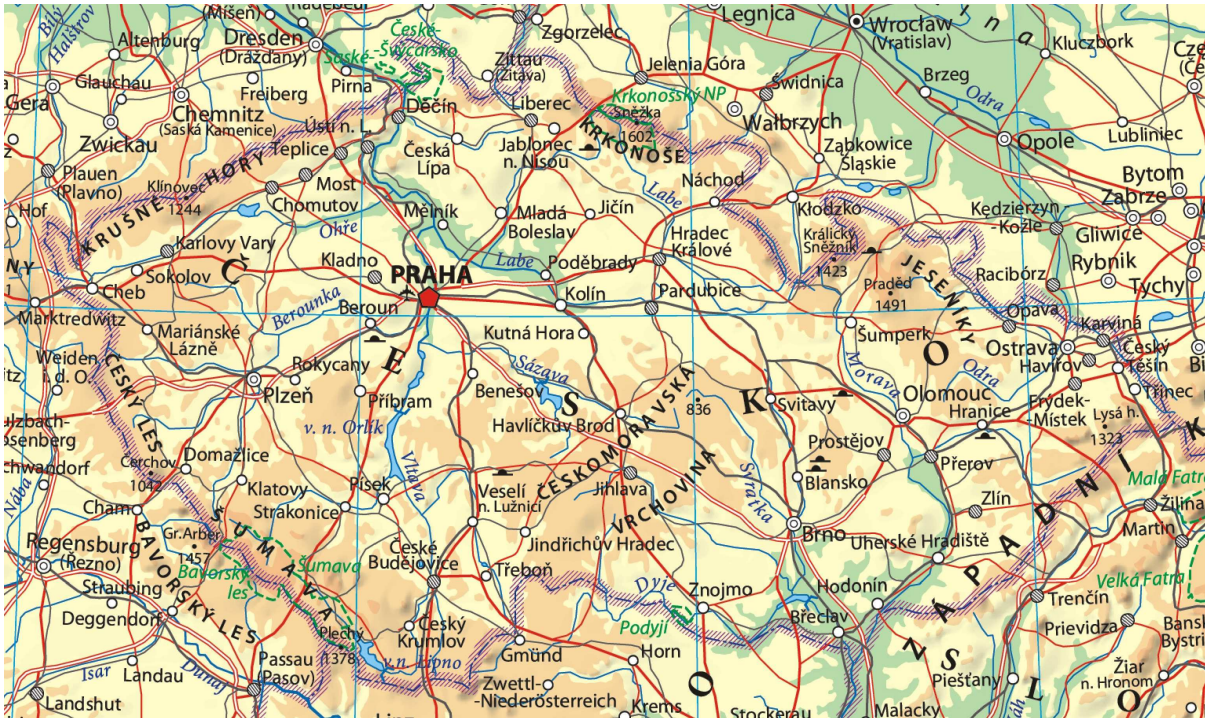


Fig. 4. General geographic map of Czechia (source: Kartografie Praha)

By comparison of four of the resulting aggregated mental maps of the students (one from each participating school), hypotheses were either confirmed or contradicted. The results indicated that some maps were in agreement with the second hypothesis, but it was not confirmed as an overall trend. Authors of some of the mental maps chose geographic objects according to their importance more or less objectively, without showing special preference for the area of their own homes. The third hypothesis was clearly confirmed. Authors of these maps drew relatively more objects in Bohemia. This is not necessarily only influenced by where an author lives. For example, it could also be due to the fact that there are more important regional or touristic centers there than in Moravia. The basic skeleton created by the geographic objects drawn in all of the aggregated mental maps is ostensibly similar, but they differ in which elements they each highlight. While respondents living outside of Prague placed more emphasis on social-geographic elements (regionalization, communication), respondents from Prague concentrated on representation of natural objects (waterways, mountain ranges). The individual mental maps of the students were digitalized and geo-referenced with the program ArcGIS. Following this, a point shapefile was created of localization in Prague of each of the students for each school and compared with its real localization (on the basis of a point shapefile of sites in Czechia). Deviations were also analyzed in the ArcGIS program. The results gained from this comparison confirmed the second part of the first hypothesis. Older students really drew Prague more accurately. It would be possible to measure deviations of any given geographical object (including line or area symbols), or in some cases a large number of objects at once in a similar fashion. Concerning the fourth hypothesis, the students living outside of Prague

paradoxically carried out a better localization of Prague. Nevertheless, the differences were not great enough to be able to discuss ruling out the fourth hypothesis. That hypothesis was consequently true.

In the last part of the research done with the students, preferences were analyzed for places of permanent residence in Czechia (*Figure 5*). Besides confirming the fifth hypothesis, it proved the long-standing assumption that industrial regions are not favorite destinations. People prefer the place where they are born and which they know best. Mountainous regions or larger cities without much industrialization are also among the favorite destinations in which to live. Respondents from Prague gave a negative preference to towns in Moravia; the students from the grammar school in Plané had the same attitude toward Prague. The findings more or less confirmed the 20-year old studies of D. Drbohlav (1991) and T. Siwek (1988).

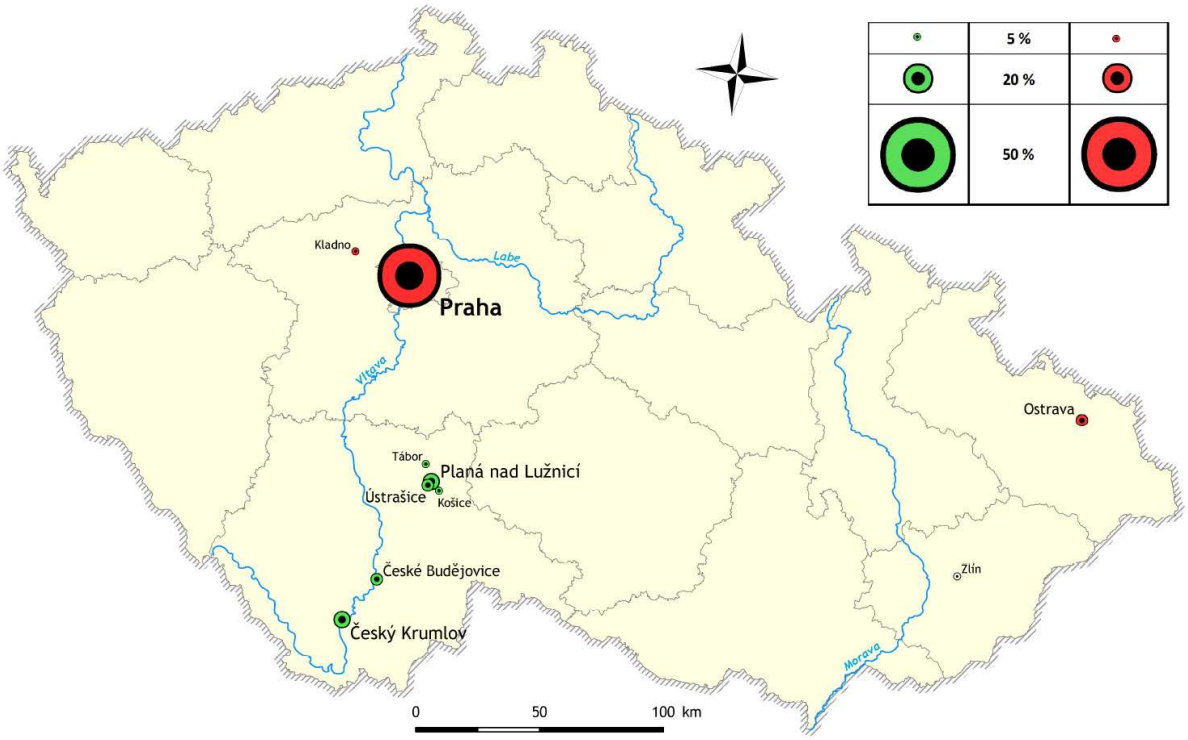


Fig. 5. Sample Map of preferences for where to live, with legend

Green marks indicate a positive balance of preferring votes; red marks indicate a negative balance. White marks indicate an area that was mentioned, but votes have cancelled each other out.

The greatest contribution of this part of the research is the high degree of clarity in the presentation of findings from all three types of analysis: of the mental maps themselves, of the localization of Prague (the capital of Czechia) and the preferences of students for where to live.

CONCLUSION

The project *Mental Maps: Subject and Means of Assessment*, of which two parts have been introduced in this contribution aspires to complex cartographical research on mental maps with a focus on the assessment of cartographic works and the assessment of the educational process. We apologize to those who would like to have gained more detailed knowledge of this project. The team's goal is the gradual completion of scientific articles describing each part of the study in more detail, and possibly a comprehensive monograph.

More testing of methodology for assessing cartographic works by means of mental maps is planned for other cartographic works (e. g. school atlases, through which individual parts of the project could be joined). In the framework of assessing educational processes, we expect to assess other learning materials and to cross over into the field of cultural anthropology in the framework of cross-culture research.

The main goal of the project is fundamental: it concerns the appropriate and purposeful involvement of users in the assessment of cartographical works and the process of creating school materials for teaching regional geography. Collaboration between users and creators of any given geo-informational systems is considered essential. The vision of "user-participate cartography" is no mere fiction. More information about the project can be accessed at *www.jackdaniel.cz/mentmap*.

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