Selected Issues of Cartographic Visualization Testing

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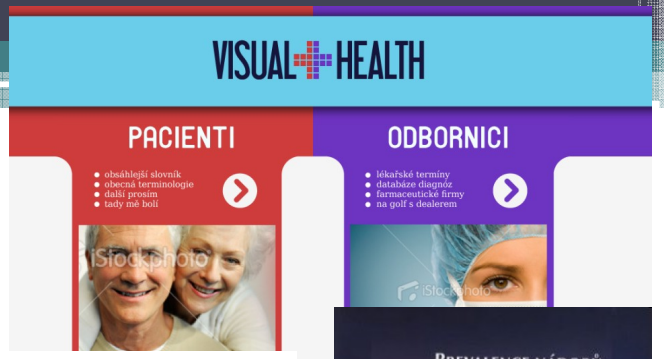
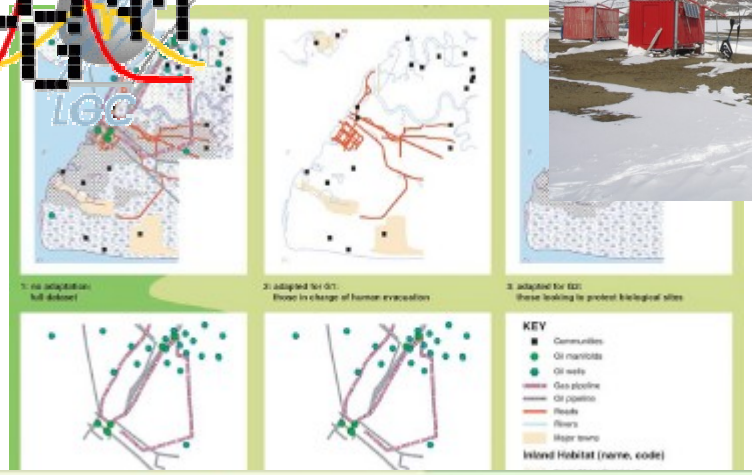
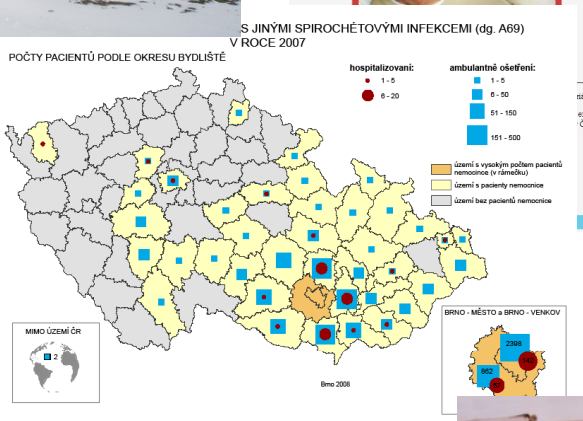
GEOGRAFICKÝ ÚSTAV
PŘÍRODOVĚDECKÁ FAKULTA MU

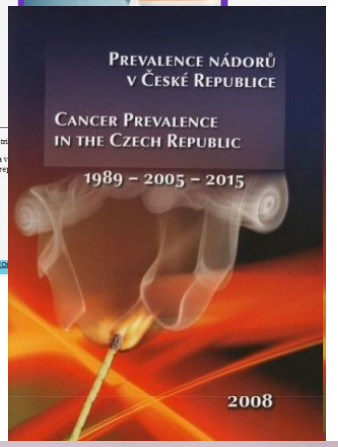
Institute of Geography

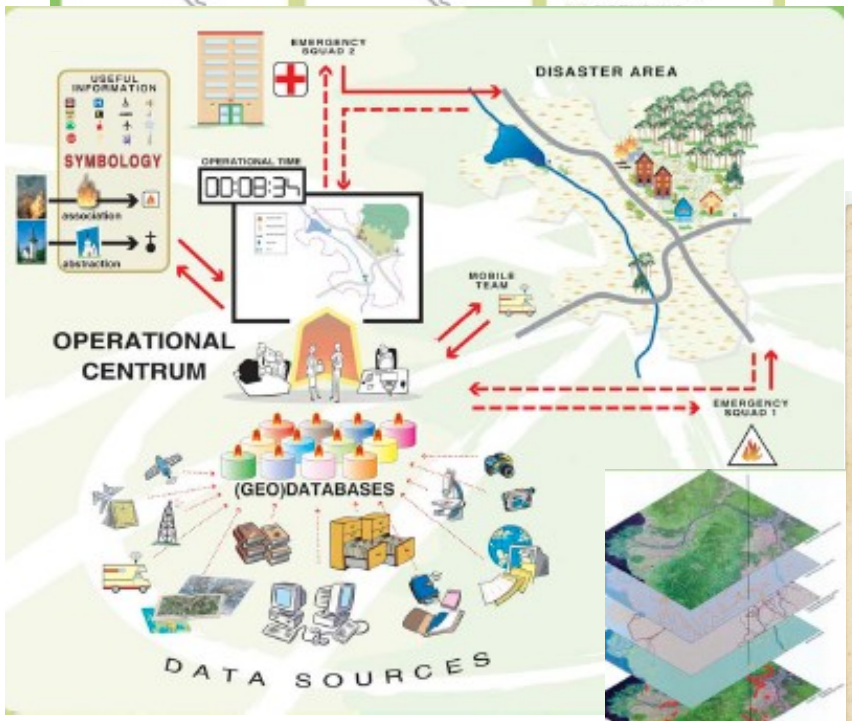
- Faculty of science, Masaryk university
- Masaryk University - second largest university in the Czech Republic
  - 9 faculties and 40,456 students
- Founded in 1919
- Institute of Geography provides within its teaching activities education in bachelor, master and Ph.D. study programmes in geography and cartography.

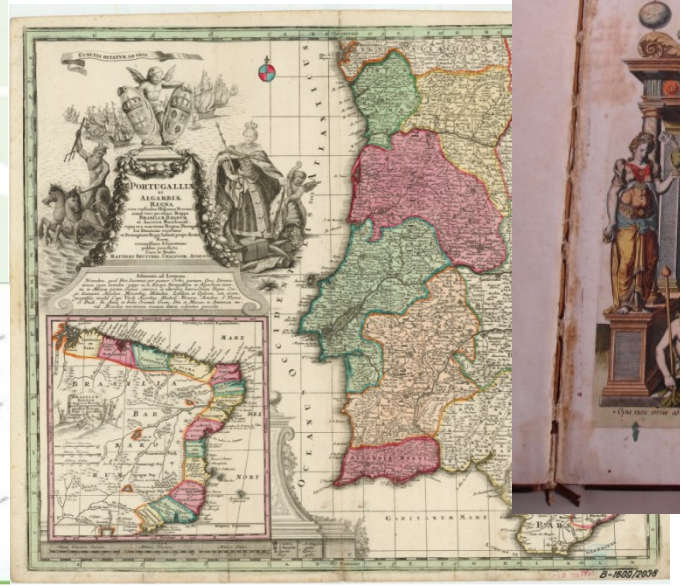

VISUAL HEALTH
PACIENTI
obsáhlejší slovník
obecná terminologie
další prosím
tady mě bolí
ODBORNICI
lékařské termíny
databáze diagnóz
farmaceutické firmy
na golf s dealerem

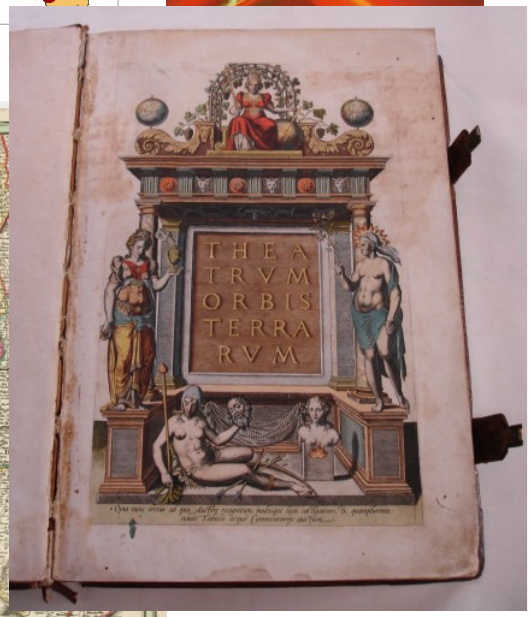

KEY
Communities
Oil manifolds
Oil wells
Gas pipeline
Oil pipeline
Roads
Rivers
Major towns
Inland Habitat (name, code)


S JINÝMI SPIROCHÉTOVÝMI INFEKCEMI (dg. A69)
V ROCE 2007
POČTY PACIENTŮ PODLE OKRESU BYDLIŠTĚ
hospitalizovaní:
1 - 5
6 - 20
ambulantně ošetření:
1 - 5
6 - 50
51 - 150
151 - 500
území s vysokým počtem pacientů nemocnice (v rámečku)
území s pacienty nemocnice
území bez pacientů nemocnice
MIMO ÚZEMÍ ČR
BRNO - MĚSTO a BRNO - VENKOV
2398
852
Brno 2008


PREVALENCE NÁDORŮ
V ČESKÉ REPUBLICE
CANCER PREVALENCE
IN THE CZECH REPUBLIC
1989 – 2005 – 2015
2008


USEFUL INFORMATION
SYMBOLOGY
association
abstraction
EMERGENCY SQUAD 2
DISASTER AREA
OPERATIONAL TIME
00:08:34
MOBILE TEAM
OPERATIONAL CENTRUM
EMERGENCY SQUAD 1
(GEO)DATABASES
DATA SOURCES




THEATRVM ORBIS TERRARVM

Map Adaptation

Which support/map is good?

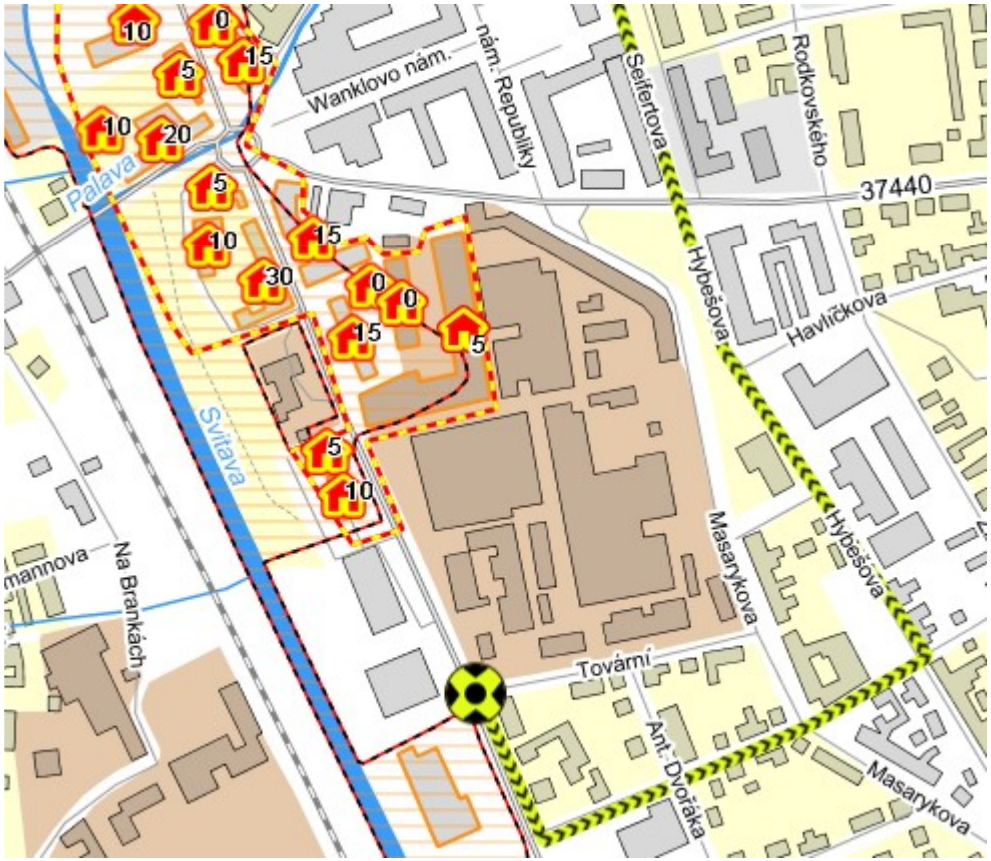
- A map which fits:
  - **USER SITUATION**
  - **USER ROLE**
  - **DISPLAY DEVICE**
  - …
- A map which fits **CONTEXT**

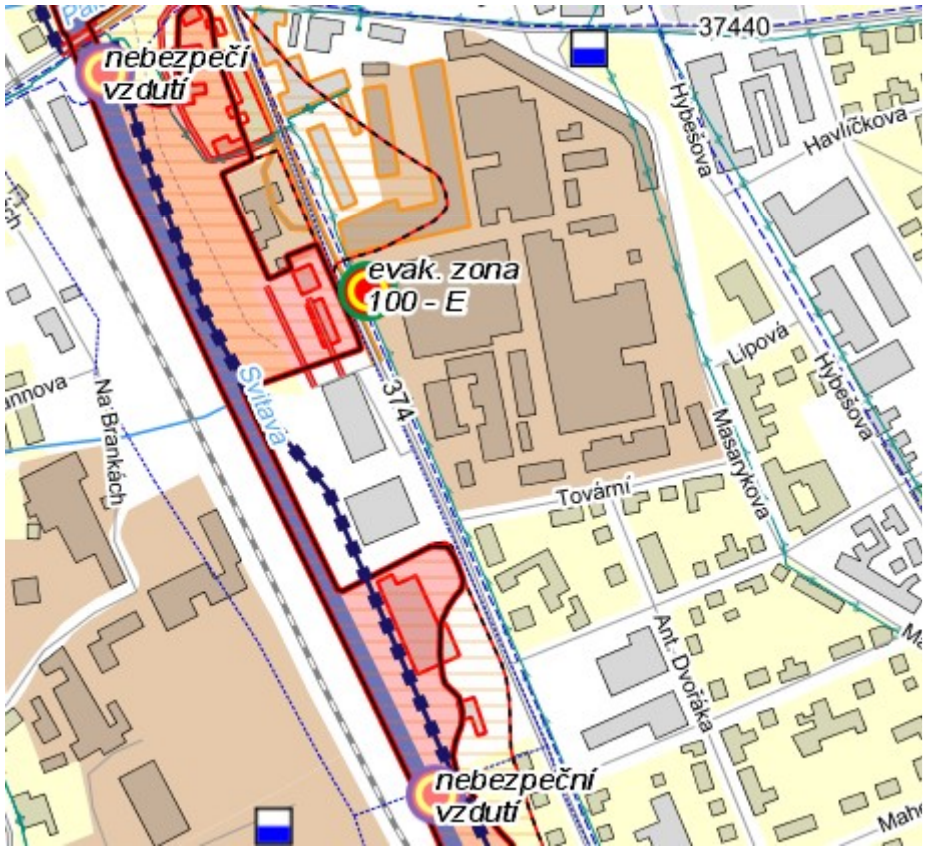
- **Adaptive Mapping**

How to adapt a map?

- Centre, scale, and orientation
- Map symbols
- Generalization
- Cartographic visualization methods

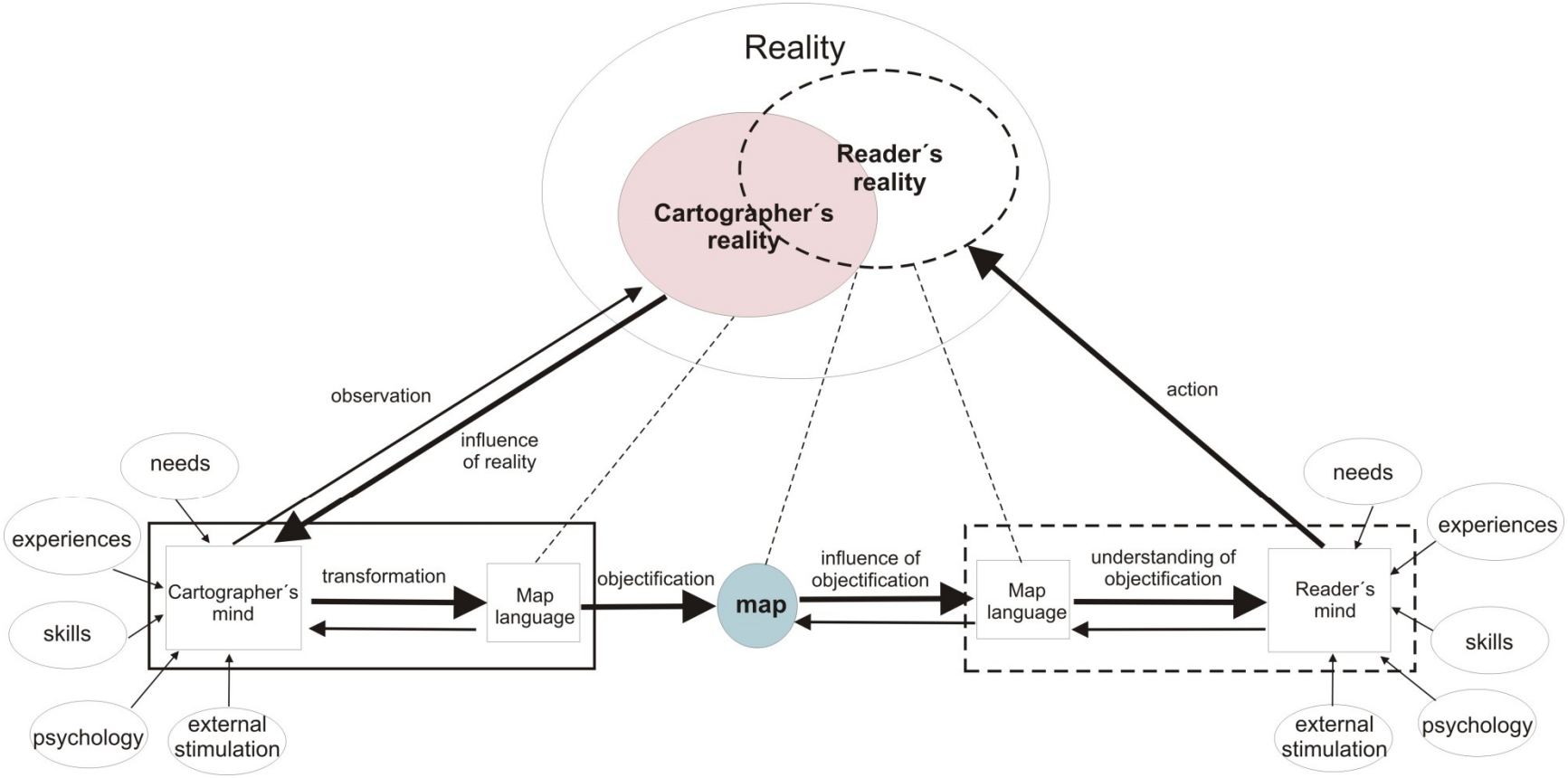
Adaptive Mapping (Cartography)



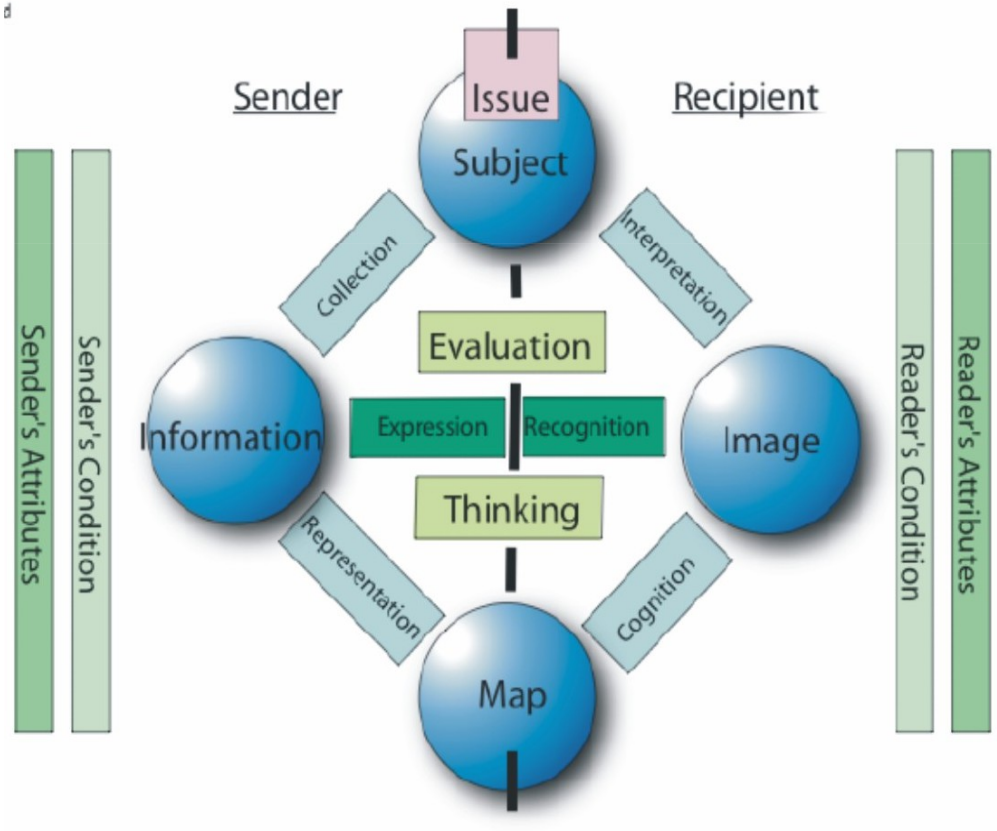


Cartographic Information Processing

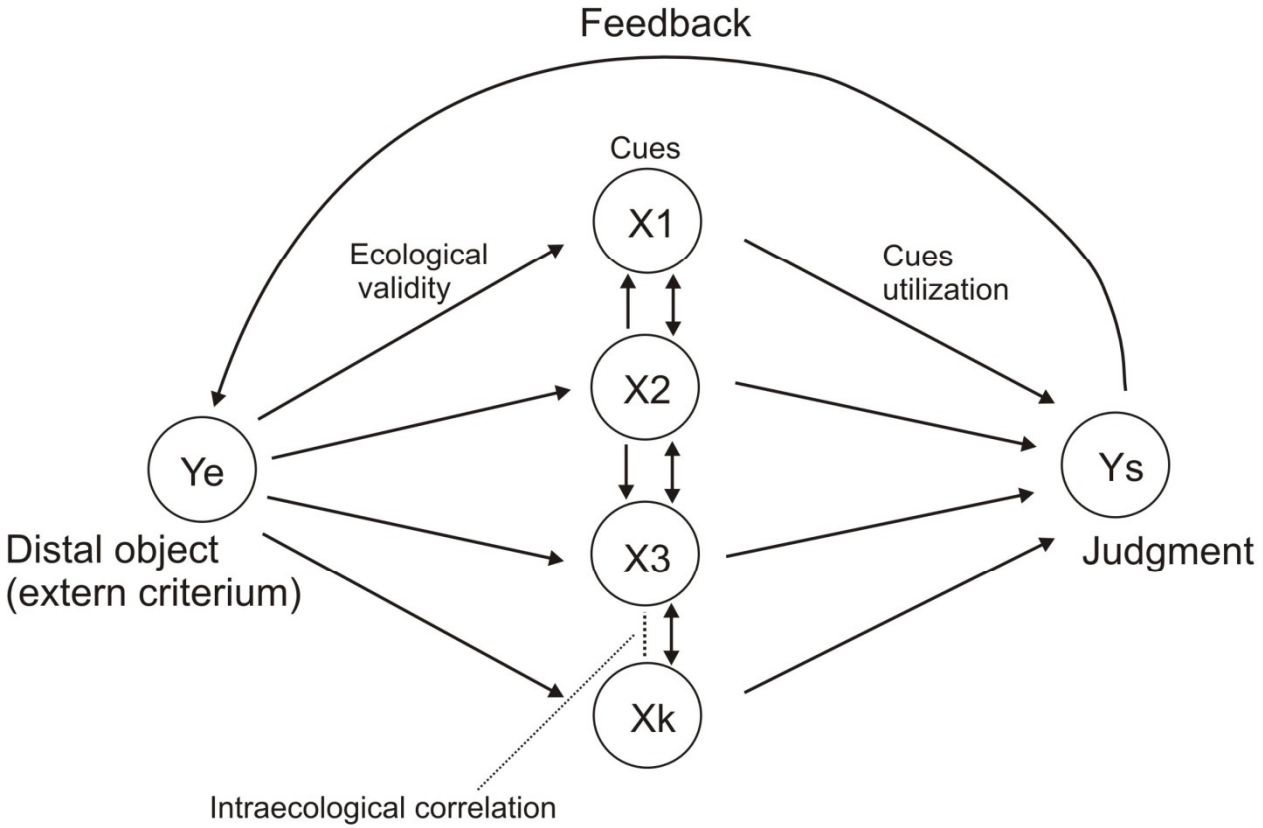
Map commucation - Cartography – Koláčný (1968)



Map communication - Cartography – Morita (2004)



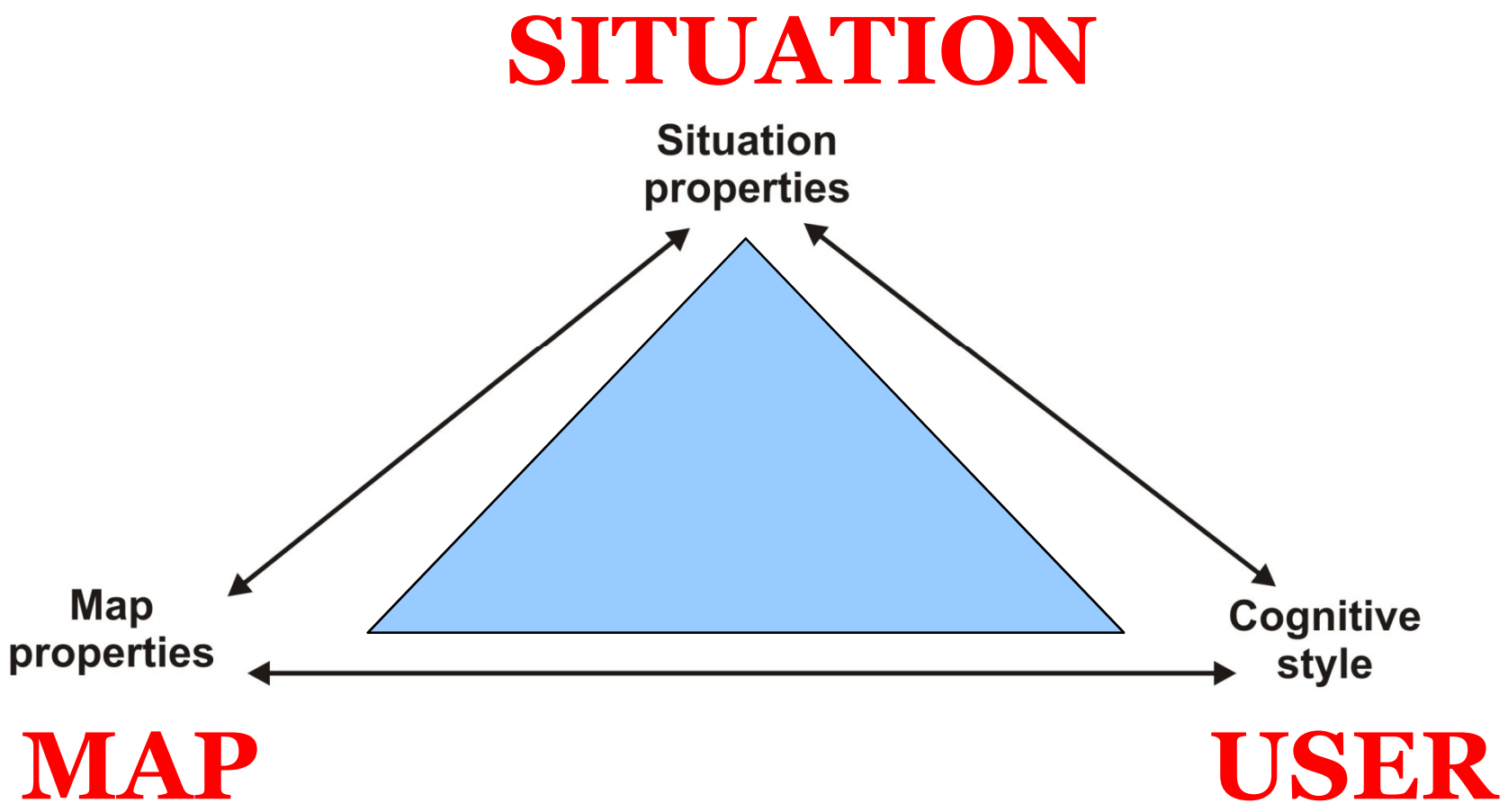
(Map) **communication** - Psychology – Brunswick´s lens model



Cognitive processes in Cartography

- Evaluation of alternative methods of cartographic visualization
- Research of basic principles of cognitive processes
- Influence of user personality to map use abilities
- Influence of situation properties on map use

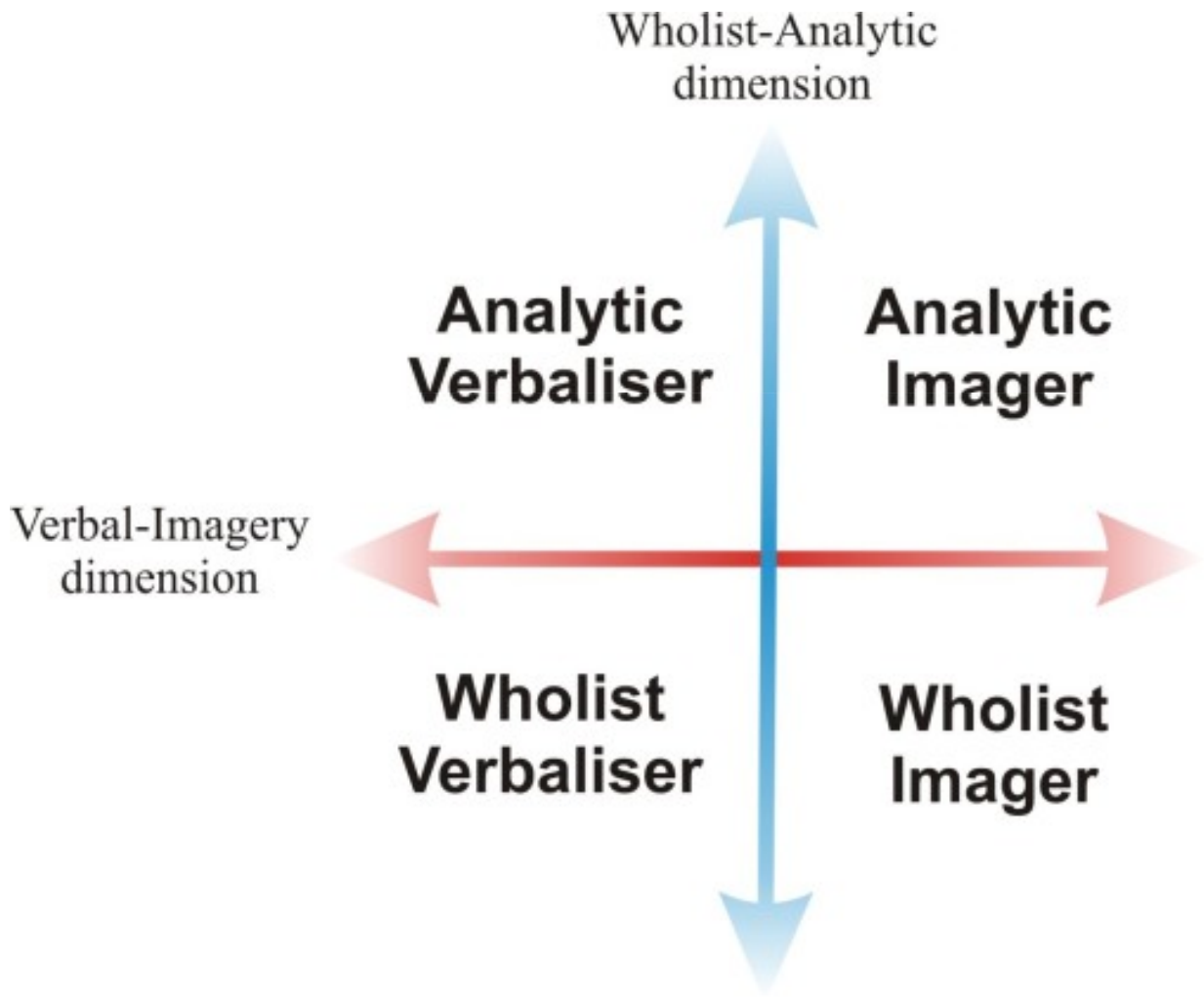
Basic aspects



Map User Personality - Cognitive style

- Interindividual differences in information perceiving and processing
- **Cognitive style** or "thinking style" is a term used in cognitive psychology to describe the way individuals think, perceive and remember information, or their preferred approach to using such information to solve problems.

Cognitive style – basic dimensions



Models of cognitive style

Wholistic	-	Analystic
Verbal	-	Imagery
Field dependence	-	Field independence
Spatial visualisation	-	Object visualization

(wikipedia)

Cognitive continuum theory

(Hammond)

- Cognition oscillates between two extremes in accordance with a nature of perceived problem. Pure intuitive or pure analytic judgement are two extremes how we can deal the problems…
- if we use in a certain situation an adequate form of judgment we can expect better results.

- low grade of information processing
- high grade awareness of this process
- high grade of knowledge about the situation

- high grade of information processing
- low grade awareness of this process
- low grade of knowledge about the situation

The Cognitive Continuum Theory of Judgment

- How task properties influence judgment form (task continuum index)

Task properties	Situation that provokes intuition	Situation that provokes analysis
1. number of cues	High	Low
2. measurement of cues	Perceptual	Objective, reliable
3. redundancy of cues	High	Low
4. task decomposition	Low	High
5. availability of organizining principles	Not available	Available
...		

(Hammond, 2000)

Possibilities of empirical research

- Observation
- Questioning
- Experimental testing

Methodology

- Differencies between psychological and geographical terminology
- Comparability of map representations
- External and ecological validity
- Definition of experimental variable
  - characteristic of map
    - Memorability
    - Readability
    - Associativeness

Vizualization Testing

Technological solution vs. users‘ satisfaction - map usability testing

Map’s effectiveness can be generally addressed by map usability research (Wachovicz et al., Van Elzaker et al.).

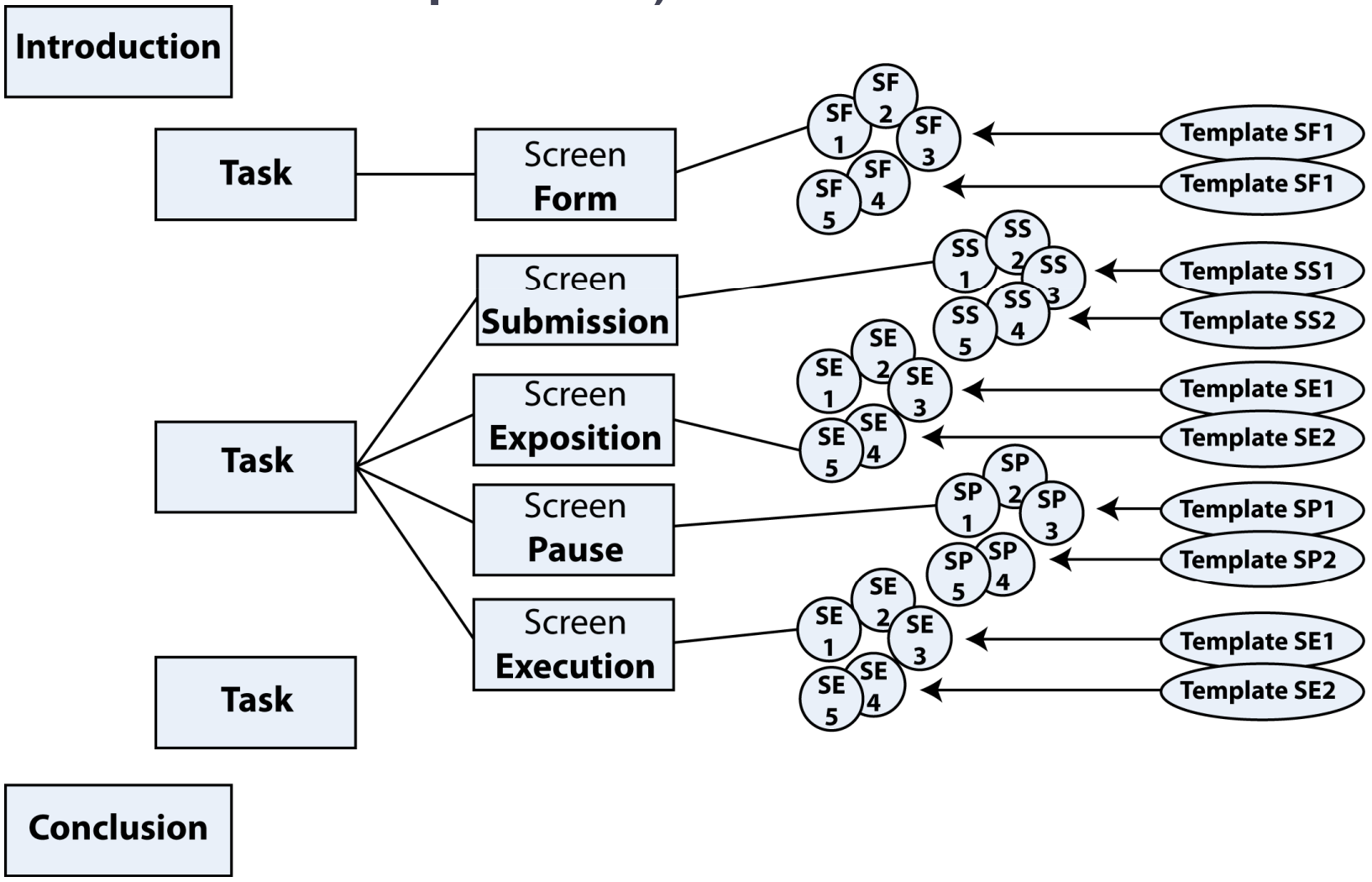
- **The key role in usability testing plays evaluation by the map users.**

Goal –to establish the set of adaptation principles based on cartographic experiences and create cartographic alternatives which are then subjects of usability testing.

MuTeP – Tool for Experimental Testing

- MuTeP – **Mu**ltivariate **Te**sting **P**rogram
  - interactive web based testing tool was designed and an prototype developed.
- Ready to test a wide variety of inputs from isolated cartographic symbols or symbol sets to complex map composition both static and interactive.
  - Technologically based on Google Web Toolkit
  - Cartographic part relies on Open Layers libraries.

General schema of usability testing (GP Test templates)



Experiment I - Evaluation of different base maps

Aim of experiment - Evaluation of different base maps

X

Design of experiment

Basic design

	undifferentiated population
Map visualization A	
Map visualization B	

Matrix design

	Cognitive style 1	Cognitive style 2
Map visualization A		
Map visualization B		

Expectations

- A) Lower time consumption for tasks on topographic map to orthophoto
- B) Lower time consumption for cartographers to non-cartographers

Tasks

- 1. Simple map symbol identification
  - Term is revealed
  - Participant have to identified designated sign
  - Speed of search is measured.
- 2. Multiple map symbol identification.
- 3. Described route identification
  - Participant can call up legend
  - Route is described in the headings

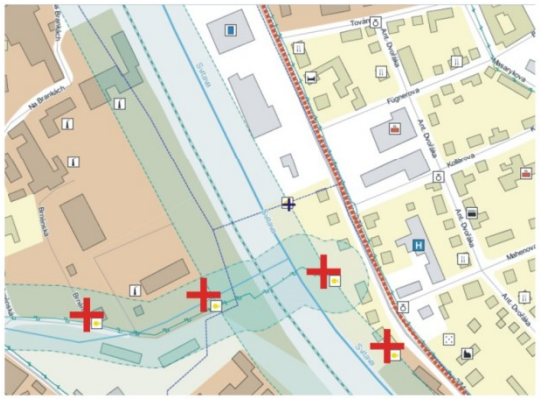
Task 1,2

Point out **all**:

Water hydrants

NEXT

Point out **all:** **Water hydrants**

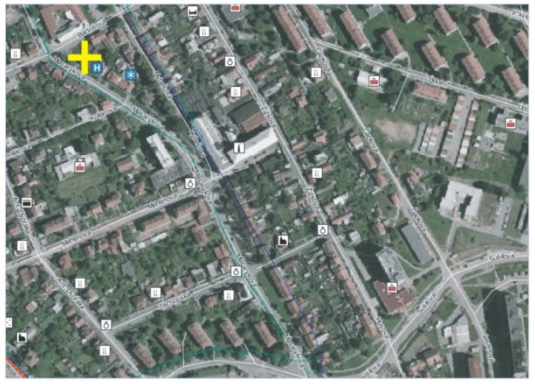


Point out:

Hospital

NEXT

Point out: **Hospital**



Task 3 - example

Choose the decriben path:

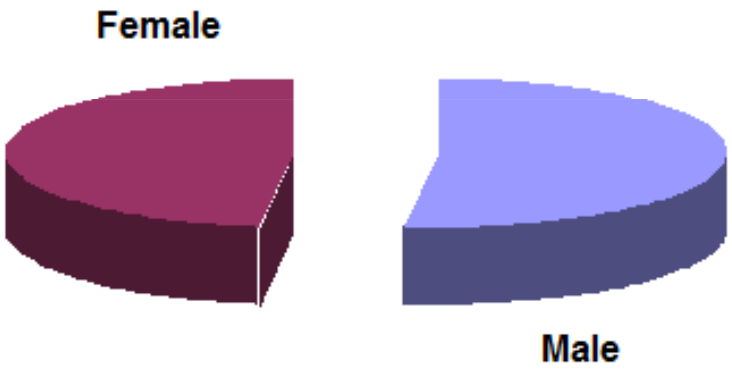
Path description....

NEXT

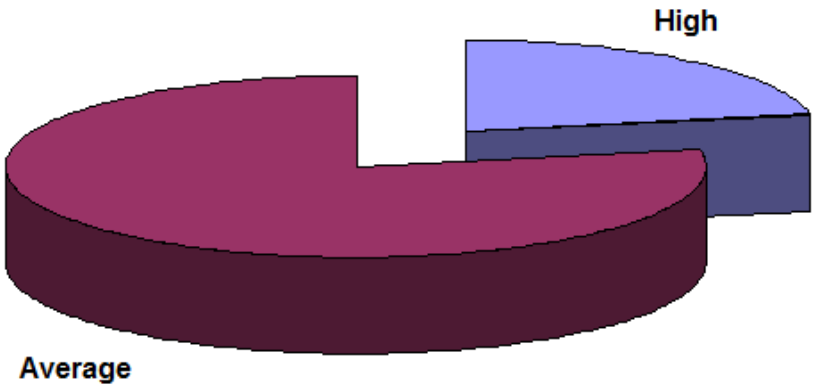
Path description....

Participants

- Gender



Map skills



Results

	Average time			
	Orthophoto	Topographic	T	Significance level
Simple symbol identif.	5,664	4,966	1,514357	0,132256
Multiple symbol identif.	13,87111	11,51286	1,076920	0,293732
Route	41,20111	33,39857	0,984553	0,336052

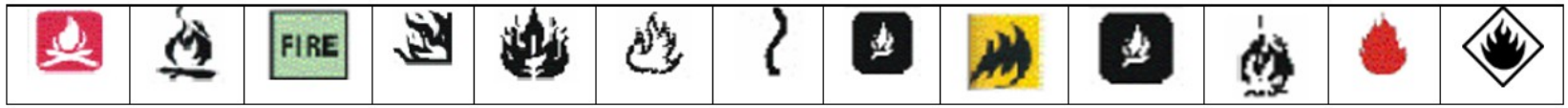
Significance of the results - t-test

	Map use skills			
	Average	High	T	Significance level
Simple symbol identif.	5,352	4,272	2,000327	0,048775
Multiple symbol identif.	11,76889	11,05200	0,246506	0,809457
Route	37,12333	26,69400	0,972881	0,349816

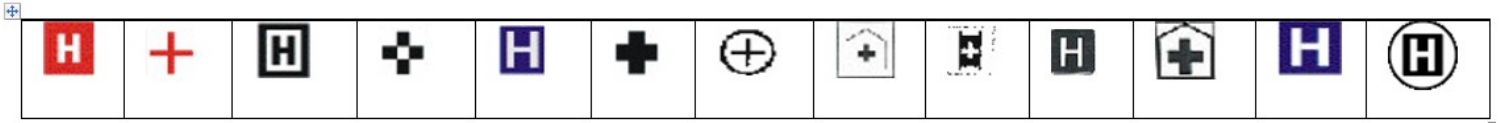
Experiment II - Evaluation of Different Map Symbol Sets

Various symbols used for fire (A) and hospital (B)

A)



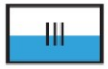
B)



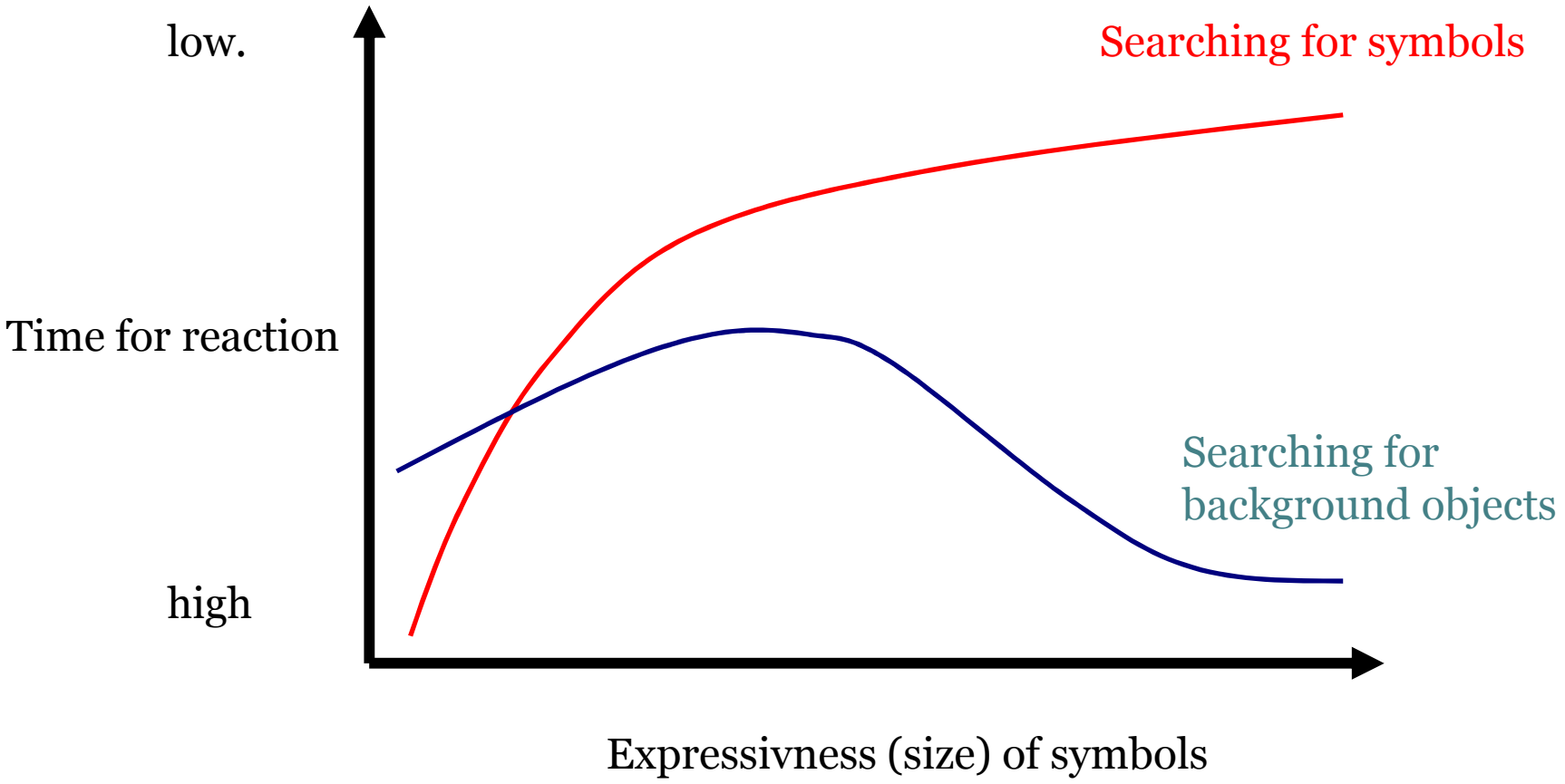
(Bodnárová, 2009)

Study

- Two map symbol sets designed for purposes of flood situation
- DGCM

Sada A	Sada B	Význam znaku
		vodní dílo III. kategorie
		čistírna odpadních vod
		místo shromažďování

Expectations



Description

- 3 phases of the test
  - Perception testing
  - Motivation testing
  - Psychological testing OSIQ – cognitive style

- Participants
  - 68 students (Institute of Geography)
  - Randomly into 2 groups,

1. Perception testing

- Searching for selected map symbol. Influenced by:
  - a) Symbol graphic construction (map symbol has to atract the user)
  - b) Base map graphic construction (map symbol has to allow find objects of base maps – act as distraktion)
- Time and correctnes was recorded


set B
Husovice
Božské srdce Páně
Dukelská třída
Gargulákova
Dačického
Svitavská
Tésná
Markéty Kuncové
Podsední
42
Skopalíkova
Čejkova
Svitavská strouha
set B
Zábrdovice
Trávníčkova
Vranovská
Jana Svobody
Lazaretní
Nanebevzetí Panny Marie
Zábrdovická
Francouzská
Přadlácká
Cejl
Svitavské nábřeží
Svitava
Svitavská strouha
Bubeníčkova
Koperníkova
Stará osada
Svatoplukova
Zábrdovice
Myslbekova
Václavkova
Gebauerova
Filipínského
Vaškova
Vojanova
Velehradská
Pastrnkova
Šámalova
Kuldova
Krokova
Tomáškova
Vaníčkova
Tkalcovská
Plynárenská
Husův sbor
E3
Zábrdovice
Trávníčkova
Vranovská
Jana Svobody
Lazaretní
Nanebevzetí Panny Marie
Zábrdovická
Francouzská
Přadlácká
Cejl
Svitavské nábřeží
Svitava
Svitavská strouha
Bubeníčkova
Zábrdovice
Myslbekova
Václavkova
Gebauerova
Filipínského
Vaškova
Vojanova
Pastrnkova
Šámalova
Kuldova
Krokova
Tomáškova
Vaníčkova
Tkalcovská
Plynárenská
Husův sbor
set A
Gargulákova
Markéty Kuncové
Podsední
42
Skopalíkova
Čejkova
Svitavská strouha
set A

1. Perception testing

- Better results: set A (in 19 pairs was time significantly lower – t-test)

ID	Average time [s]		ID	Average time [s]	
	Set A	Set B		Set A	Set B
1	*3,5	4,2	19	*2,6	4,5
2	3,5	3,9	20	*3,0	6,5
3	*4,0	9,0	21	2,7	3,0
4	3,3	3,1	22	2,6	3,1
5	2,3	2,6	23	*2,3	2,9
6	*4,0	10,7	24	*2,5	3,1
7	2,8	2,6	25	*2,3	3,3
8	*2,5	3,1	26	3,0	3,3
9	3,7	4,1	27	3,5	3,7
10	2,3	2,4	28	*5,2	7,5
11	4,2	*2,5	29	*2,5	3,4
12	2,7	3,0	30	*3,2	4,1
13	*5,7	14,0	31	2,7	2,4
14	*2,9	3,7	32	*2,0	2,4
15	*2,6	3,8	33	2,6	3,0
16	*2,4	5,2	34	*2,8	4,5
17	2,9	2,7	35	2,5	2,7
18	2,2	2,4	36	*2,3	3,8

2. Motivatin testing

- Motivation – Shape of the map symbol matches to the real object (people do not have to use legend)
- For each symbol was designed 5 possibilities of meaning.
  - Correct
  - Sematicaly close
  - Shape close
  - Neutral but relevant to the symbol set
  - Totally wrong
- 2 variants:
  - Isolated map symbols
  - Map symbols in the map field

  - 15 map symbols from each symbol set

2. Motivatin testing

Choose the meaning of symbol

A) shopping mall
B) theater
C) cinema
D) muzeum
E) pottery shop
F) other

Choose the meaning of symbol

A) shopping mall
B) theater
C) cinema
D) muzeum
E) pottery shop
F) other

2. Motivatin testing

- Correctness of meaning specification - Pearson's chi-squared test
- Time consuption - t-test
  - Significance level 5 %

2. Motivatin testing

Number	Set A		Set B	
	Correctness[%]	Time [s]	Correcness [%]	Time [s]
1	9,4	16,9	*28,6	19,4
2	87,5	12,8	71,4	14,7
3	34,4	16,6	34,3	14,9
4	68,8	11,8	74,3	*9,0
5	90,6	10,0	74,3	9,2
6	100,0	*5,3	91,4	7,7
7	56,3	9,6	68,6	11,6
8	81,3	9,0	77,1	7,6
9	65,6	16,6	65,7	14,5
10	56,3	9,3	*100,0	*6,2
11	*100,0	*6,1	34,3	8,2
12	71,9	10,3	77,1	9,5
13	78,1	*7,5	60,0	9,7
14	81,3	11,4	88,6	*7,9
15	90,6	8,6	97,1	6,7

Results

- Set A was significantly better in Percetion testing
- Statistically significant difference discovered on single map symbol level in Motivation testing
  - There are no significant difference beetween set A and B on Motivation level
- There was no significant difference on level of cognitive style, gender, age etc.

- Results used for optimization of set A
  - Further testing needed

Experiment II - Uncertainty visualization testing

Uncertainty visualization

•A prevalent shortcoming in the scientific and information visualization communities where data are visualized without any indication of their associated uncertainties.

(Pang 2008)

•**INSPIRE directive** – new data with quality components

Cartographic methods for uncertainty visualization

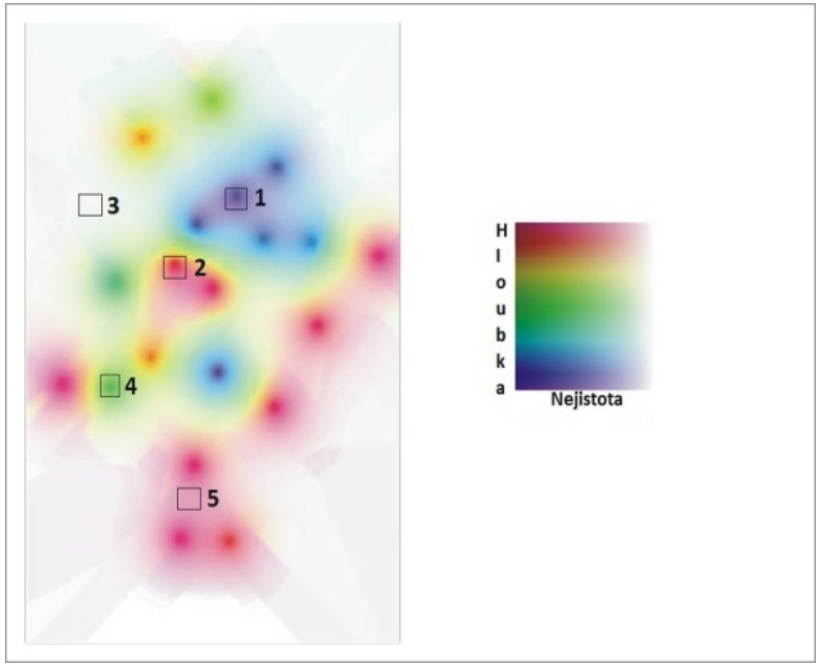
- **Maps compared** – combination of 2 maps both for the mapped attribute and its uncertainty.
- **Maps combined** – both variables are visualized within 1 map using an appropriate graphic variable.
- **Interactive exploratory tool** – varying visualization of both attribute and uncertainty.

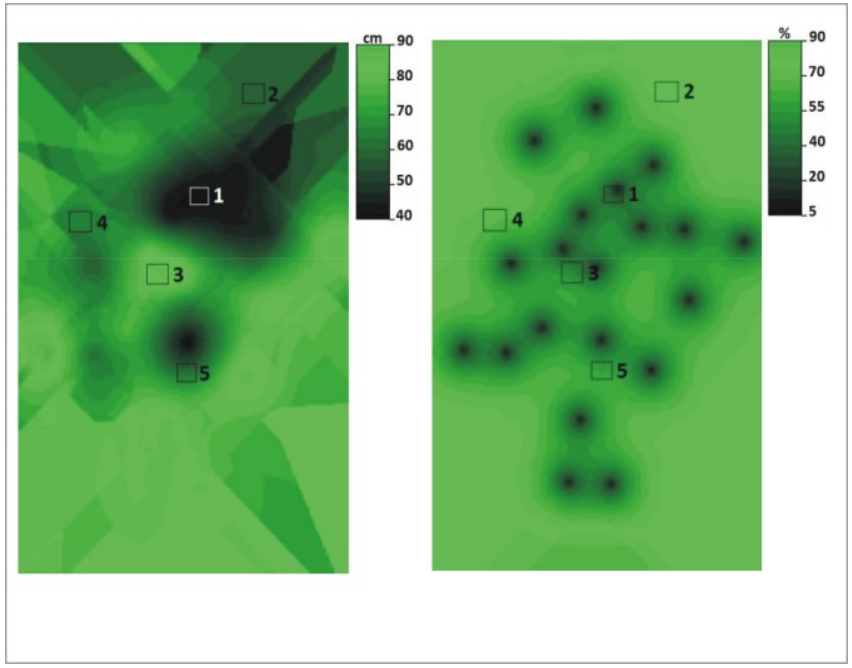
- Static vs. dynamic.

MacEachren (1992)

I. Thematic Uncertainty Visualization

- A combination of regular kriging interpolation method and interpolation uncertainty values is used for maps compared.





- Whitening visualization method is applied for **maps combined** based on the hue-saturation-intensity (HSI) colour model.

Expectations

- Tasks on the maps performed in our study will evoke differences in the way of information processing:
  - **serial processing** of information is expected for maps compared, where map user is forced to decode the predicted value, maintain this information within memory and consequently identify uncertainty level at the corresponding spatial location of second map.
  - **parallel processing** of information - for the second method (maps combined, whitening) both variables are presented on the same map and the user has all information available at the same moment.

Test structure

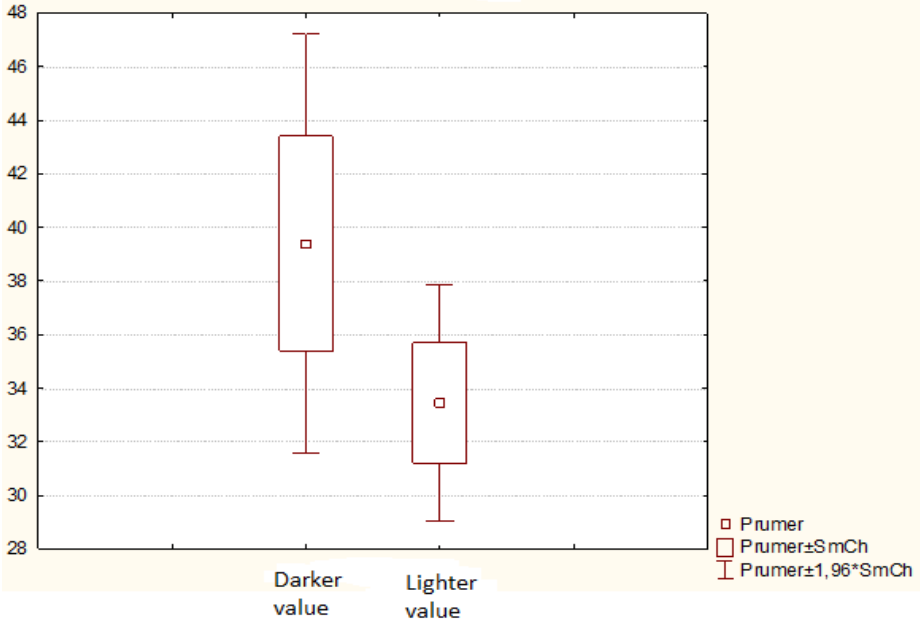
- Visualization methods were tested on two different levels:
  - On the first level **the intuitiveness of whitening method** was questioned visualized as map combined.
  - On the second level **both methods were compared** for:
    - uncertainty level decoding (soil depth uncertainty);
    - simple decoding of predicted value (soil depth interpolation results);
    - comparison of combined values (both soil depth and uncertainty)
  - While the tested level of soil depth and uncertainty was identical for both visualization types, the placement of testing polygons was different both for tasks and visualization methods.
  - Correctness and processing time was recorded in order to enable further statistical processing.

Participants

- 3 different groups:
  - students of University of defence (aged 19 – 23) – 15 participants,
  - geography and geoinformatics students (aged 19 – 23) with intermediate skills in the field of spatial information – 39,
  - the “open door day” participants - heterogeneous - 50.
  - Gender : 63 M / 41 F.

Results

- Tests results were processed and statistically tested. T-test for independent samples was used for the first level, while paired Student's t-test or Wilcoxon signed-rank test were used for the second level of samples.
- Intuitivness - confirmed, that more participants (63 %) acknowledged the lighter value to be more uncertain. Those preferring this result were also quicker and were able to decide within more condensed time variability



Test results

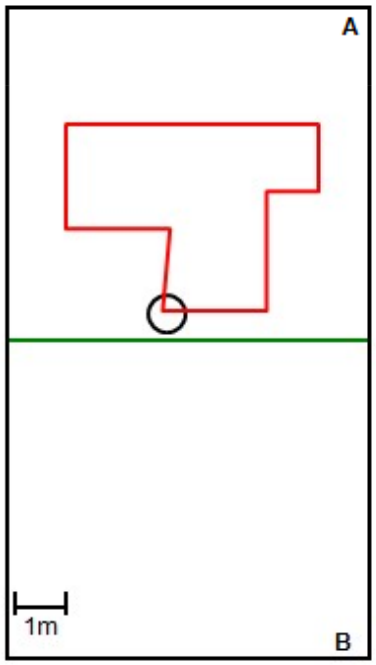
- Second level - only correct answers were taken into account, thus a pair comparison for both methods (maps combined and maps compared) is always available :
  - **Uncertainty level decoding** - significantly better results for maps combined (whitening) than for maps compared for both groups.
  - **Decoding of predicted value** - slightly better results for maps combined (whitening) but without statistical significance (carry over effect??)
  - **Comparison of combined values** - controversial as far as the correct answers are concerned. Only 43% were correct for both methods at the same time. 64% correct answers were valid for maps compared and 56% for maps combined . Significantly better results were achieved by whitening methods – quicker, more confident.

Positional Uncertainty Testing II

- INSPIRE directive data specification contain demand on quality of cadastral data.
- Experimental verificaion of two ways of cadastral data uncertainty visualization.
  - Scale
  - Graduated limits
    - Based on work Hope and Hunter, (2007)

Experiment II

- Visualization of uncertainty of cadastral data



Selected corner is situated:

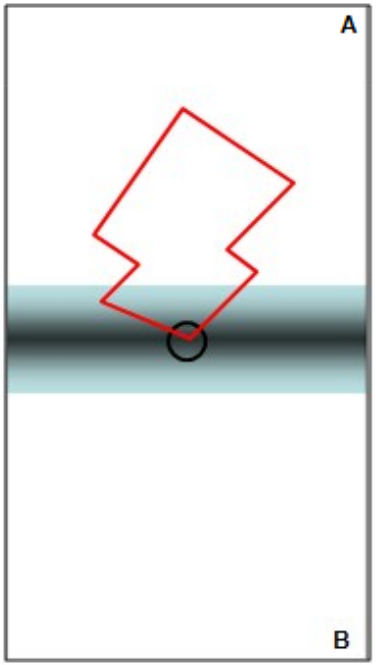
A. Definitely in cadastral parcel A

B. Probably in parcel A

C. Equal chance of being in either parcel

D. Probably in parcel B

E. Definitely in cadastral parcel B



Selected corner is situated:

A. Definitely in cadastral parcel A

B. Probably in parcel A

C. Equal chance of being in either parcel

D. Probably in parcel B

E. Definitely in cadastral parcel B

Expectations

- Efficiency (speed)
- Efectiveness (correctness)

(Garladini and Fabricant, 2009)

- Scale method will be faster
- Graduate limit method will be more accurate

Participants

- 2 groups
- A) students of cartography - specialists
- B) students of different specialization – non specialists

- Gender and age balanced groups

- Both groups had no or only very limited experience with uncertainty visualization. Thus, we can consider them as groups with different spatial education and evaluate the influence of a geographic education on decision-making under uncertain conditions.

I. Step - results

- Correctness – 92 % - user are able to understand used methods
- Time consumption – more time needed to decide in Graduate limit method

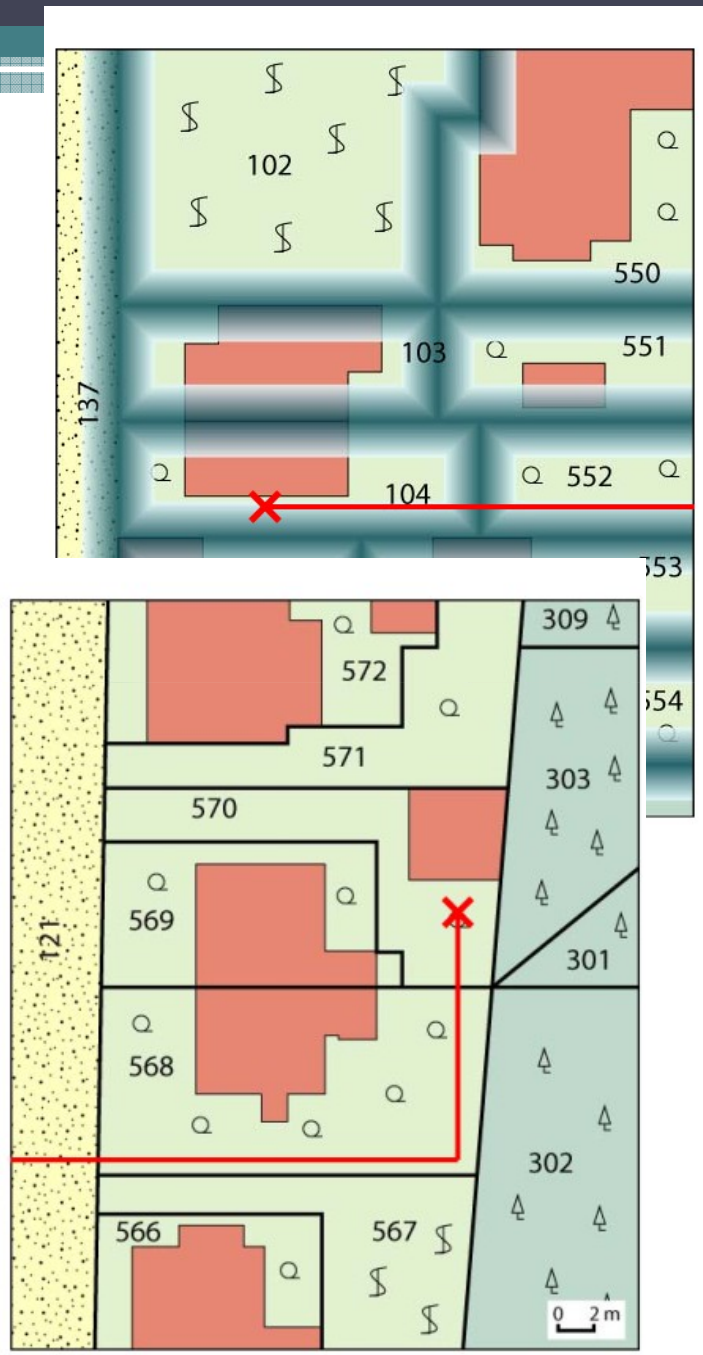
- Specialists has slightly better results – not significantly

Step II - dynamic

- Aim – e.g. draw the line from Parcel 570 to 121 which Will end:

A)On 100% in parcel 121

… etc.



Expectations

- both representations are informationally equivalent,
- there will be differences between the static and dynamic tests because of the different information processing components.
  - static test only search and recognition are performed,
  - inference is the main component of the dynamic test.
- Different visual information processing is required for each type of representation.

Participants

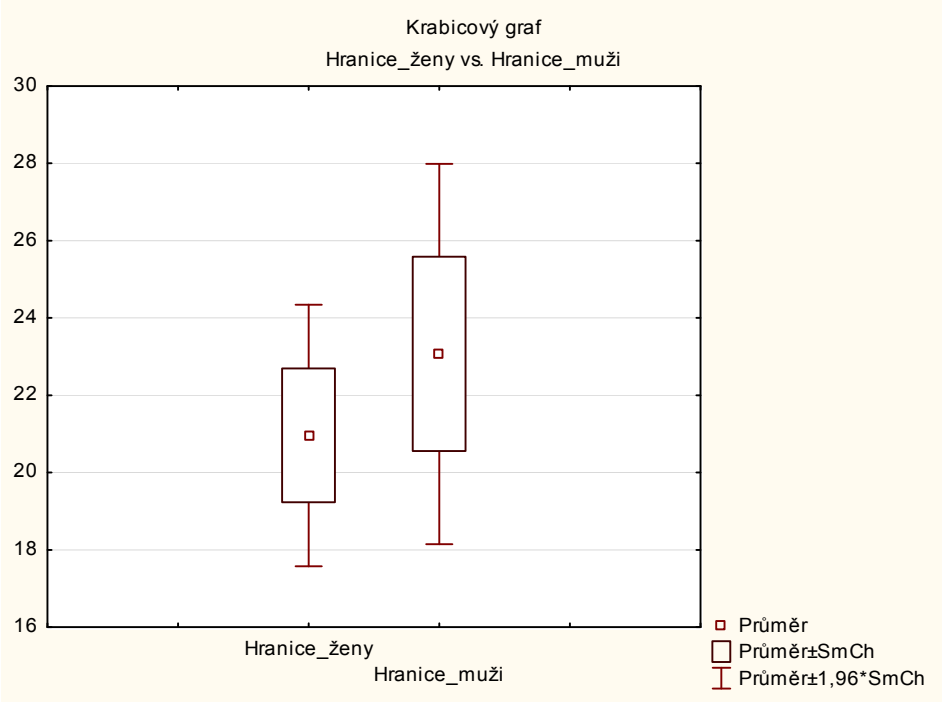
- totally 68 participants.
- Volunteers – Open doors
  - Finally 46 samples
- balanced from a gender point of view

Results

- Equal chance of being in either parcel (50:50) task – no significant differences between representations, slightly better completion times in the case of Graduated limits;
- Definitely in parcel A and Definitely in parcel B (100% A and 100% B) - no significant differences between representations. Respondents tended to finish the line closer to the border in the case of Graduated limit;
- Probably A and Probably B (>50% A and >50% B) – significant difference for both Probably A (p=0,0225) and Probably B“ (p=0,0241). **Respondents had a tendency to finish the line closer to the border in the case of the Border representation.**

Results

- Gender comparison revealed **longer completion times for males**.
- This result generally supports the belief of Loyd and Bunch (2005) that males are less effective in complex spatial tasks (above the level of simple perception) than females.



Future research

- Further MuTeP development
- Multidimensional line symbols testing
- Intercultural differences in spatial information processing
- J. Piaget theory verification

Thank you for your attention!!!

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