Digital maps and their users

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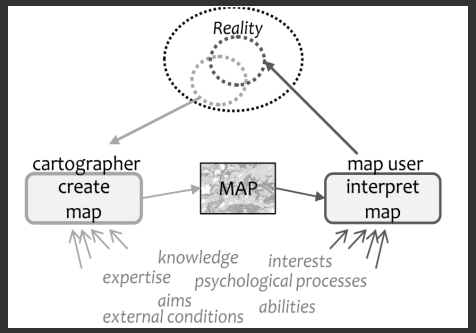
PhD (2012): 'Maps, how do users see them?'

Research Objectives

Improve the effectiveness of (screen) map designs based on the users' characteristics.

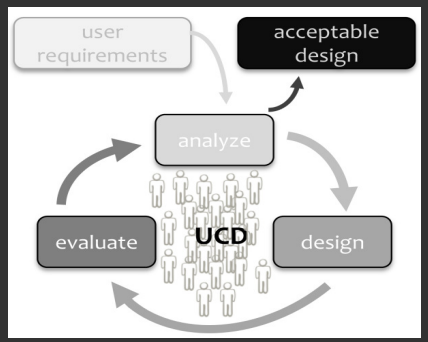


After Kolácný (1969)

Purpose of maps
→ Communication

Research Objectives

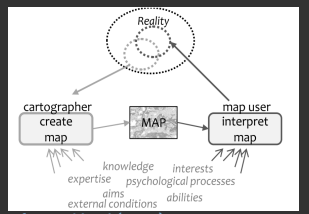
Contribute to the understanding of how map users read, interpret, store, and use the presented visual information on screen maps.



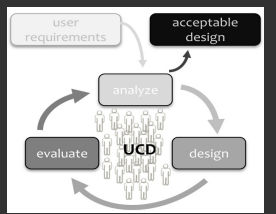
After van Elzakker and Wealands (2007)

Research Objectives

Investigate the influence of (cartographic) expertise on the map users' cognitive processes and their limitations while processing the visual information presented on screen maps.



After Kolácný (1969)

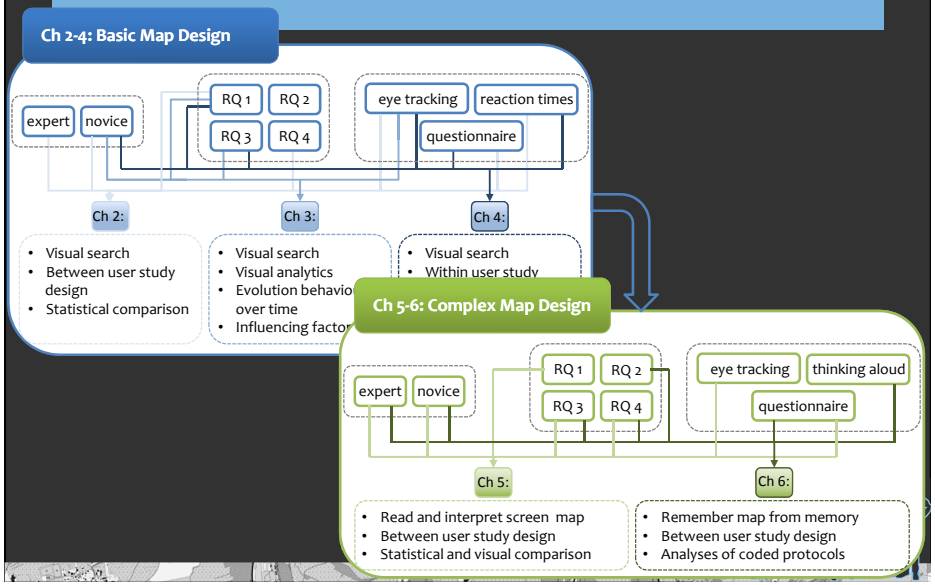


After van Elzakker and Wealands (2007)

Research Questions

1. *How do map users read and interpret the visual information presented on screen maps?*
2. *How do map users store and retrieve (use) the information that was previously gathered from screen maps?*
3. *How are the map users' cognitive processes influenced by deviations in the map image?*
4. *How does (cartographic) expertise influences the cognitive processes investigated in the previous research questions?*

Overview

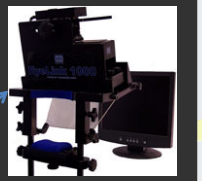


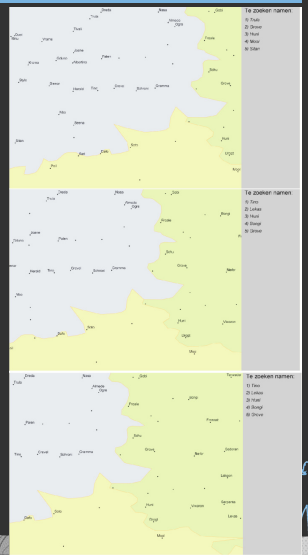
Eye Tracking Questions

1. When can / may / should eye tracking be applied in the geodomain?
2. Why should eye tracking be applied?
3. How should eye tracking be applied?
4. What are the main issues / obstacles in eye tracking at the moment (both technical and in the analysis)?
5. What are the advantages of using eye tracking as opposed to other user research techniques?
6. What are the main disadvantages of eye tracking?

Part I - Basic Map Design

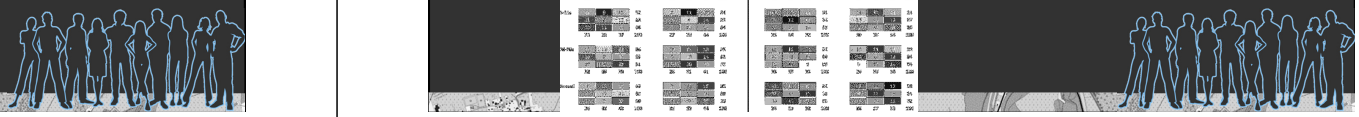
- Task:
  - Visual search
- Techniques:
  - Eye tracking
  - Reaction times
  - Questionnaire
- Analyses:
  - Statistical
  - Visual





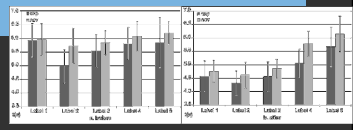
Part I – Experts vs. novices

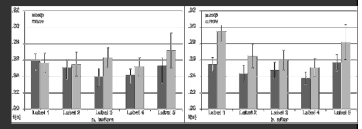
- Aims:
  - Study cognitive processes
  - Difference experts vs. novices?
  - Explain by Cognitive Load Theory
    - Structure WM: Cognitive load
    - Influence of map design
      - Content
      - Symbolisation
    - Room for learning

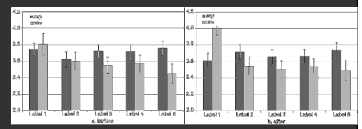


Part I – Experts vs. novices

- Results:
  - Reaction time measurements
  - Fixation duration
  - Fixation count
  - Fixation distribution

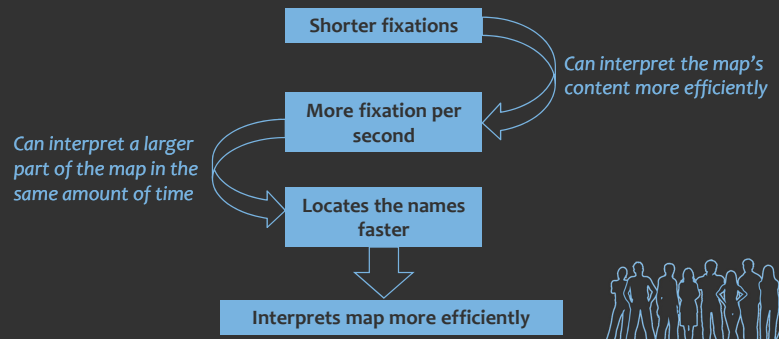






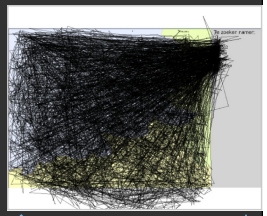
Part I – Experts vs. novices

- Conclusion
  - Similar trend in both user groups: CLT
  - Experts significantly faster at locating the names
  - Explained by eye movement metrics

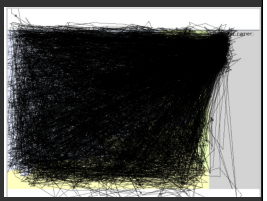


Part I – Visual Analytics

- Aims:
  - Extend statistical analyses
    - Maps: communicate spatial information
    - Study spatial dimension
    - Influence of map layout
  - Visual Analytics Toolkit
    - Filter data: time & attributes
    - Aggregate data

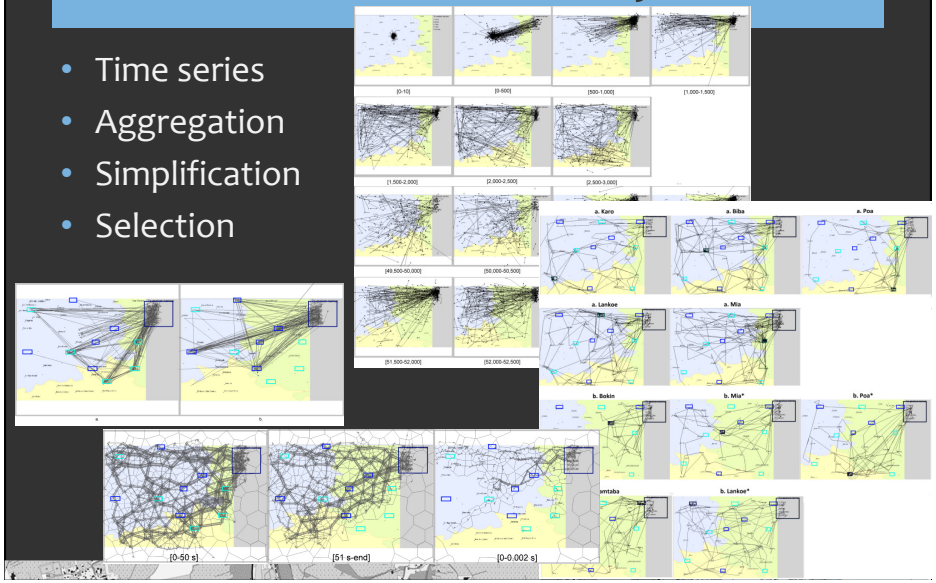


↑1 participant | 10 seconds ↓



Part I – Visual Analytics

- Time series
- Aggregation
- Simplification
- Selection

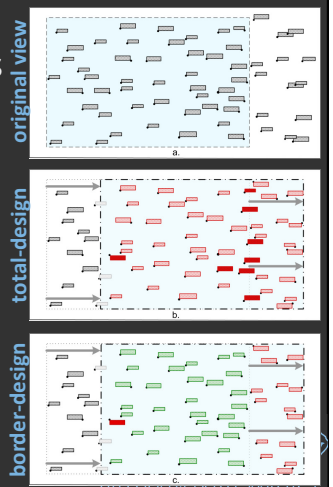


Part I – Visual Analytics

- Conclusion
  - Selection, aggregation, simplifation
    - Tools are indispensable
  - Patterns: search behaviour
    - Time series: evolution search behaviour
    - Influence of map layout (labels)
    - Individual differences

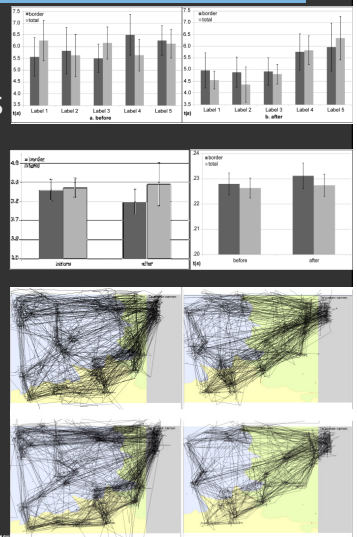
Part I – Efficient and effective labels?

- Aims:
  - Evaluate different map designs
    - Label placement algorithm
      - Improved efficiency
      - Lower map quality
  - Influence on (novice) users?
    - Effectiveness of the map?



Part I – Efficient and effective labels?

- Results
  - Reaction time measurements
  - Eye movements
    - Fixation duration
    - Fixation count
    - Visualisation scanpaths
  - Questionnaires

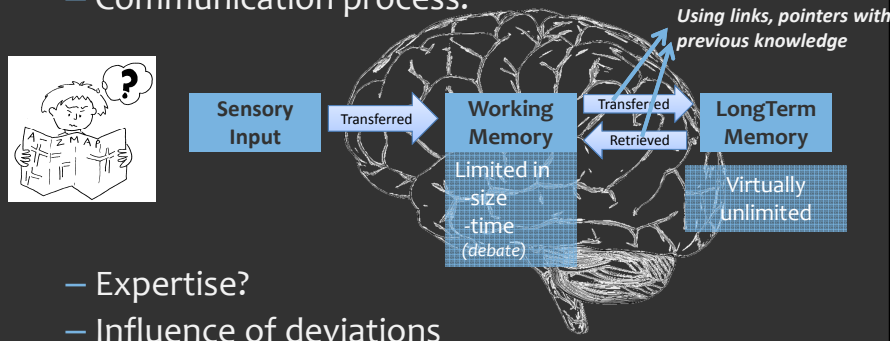


Part I – Efficient and effective labels?

- Conclusion
  - Improved (algorithmic) efficiency
  - No influence on effectiveness
    - Consiously: user statements
      - "no difference was seen"
    - Unconsiously: measurements
      - No deviations in
        - » Reaction time measurements
        - » Eye movement metrics

Part II – Complex Map Design

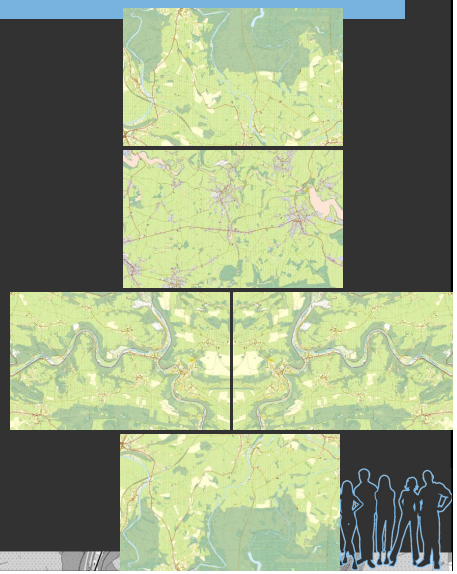
- Aims:
  - Communication process:



  - Expertise?
  - Influence of deviations

Part II – Complex Map Design

- Task:
  - Study & draw
- Techniques:
  - Eye tracking
  - Thinking aloud
  - Sketch maps
  - Questionnaire
- Analyses:
  - Statistical
  - Visual



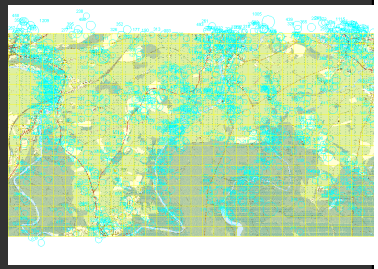
Reading and Interpretation

- Eye movement:
  - Metrics
    - Average fixation duration:
      - →Experts significantly shorter
    - Number of fixations per second
      - →Experts significantly more

→ Same findings as in previous studies

Reading and Interpretation

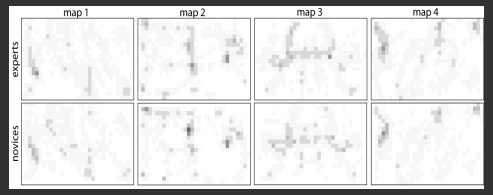
- Eye movements
  - Gridded visualisations
    - Fixation count
    - Total dwell time
    - Average fixation duration
    - Average per user group
    - Maximum per user group



Variable	Classification and colour schemes							
FixCount	[0-1[	[1-2[	[2-4[	[4-6[	[6-8[	[8-10[	[10-20[	[20-...]
FixDur	[.000-.325[	[.325-.650[	[.650-1.300[	[1.300-1.950[	[1.950-2.600[	[2.600-3.250[	[3.250-6.500[	[6.500-.....]
Colour (RGB)	255	247	217	189	150	99	37	0

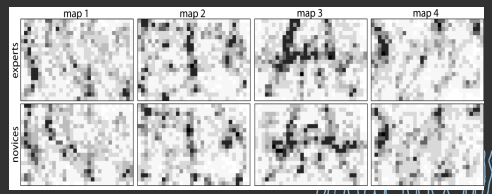
Part II – Reading and Interpretation

- Eye movements
  - 2D gridded visualisations



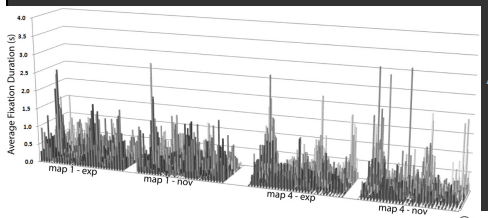
Average fixation count

Maximum fixation count

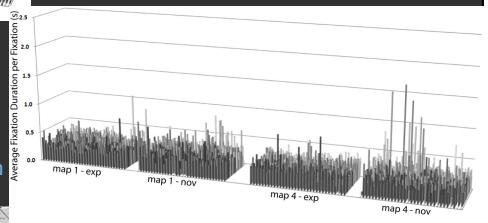


Part II – Reading and Interpretation

- Eye movements
  - 3D gridded visualisation



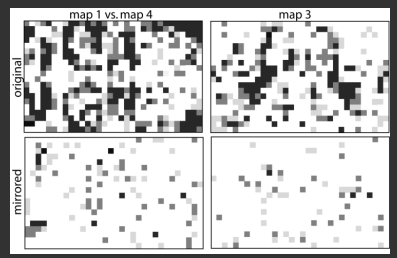
Average total fixation duration



Average fixation duration per fixation

Part II – Reading and Interpretation

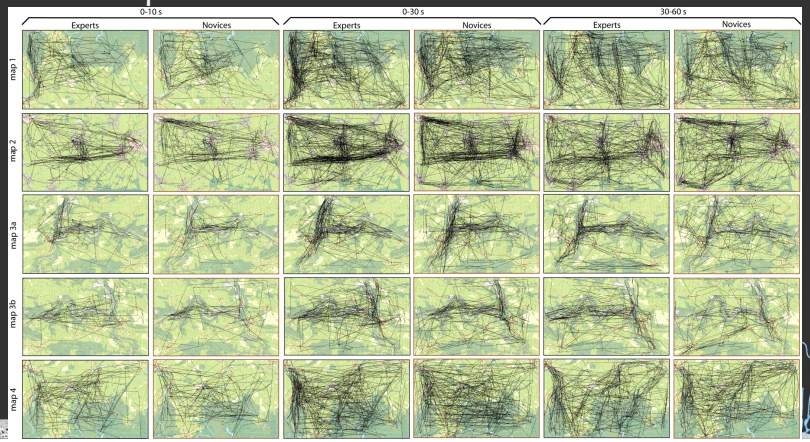
- Eye movements
  - Gridded visualisation: statistical comparison



→Statistical comparison (ANOVA)

Part II – Reading and Interpretation

- Eye movements
  - Scanpaths



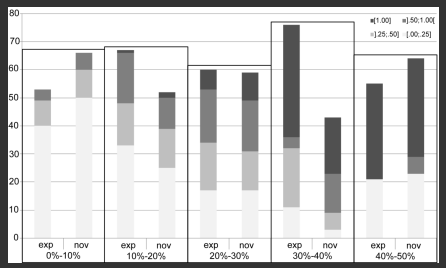
Part II – Reading and Interpretation

- Eye movements
  - Conclusion
    - Focus on general structuring elements
      - Experts: more pronounced
      - Experts fixate more on the left side
    - Influence of deviations
      - No influence for less important elements
      - Confusion for structuring elements
        - » Colour water bodies
        - » Mirrored map elements
      - Novices: more pronounced

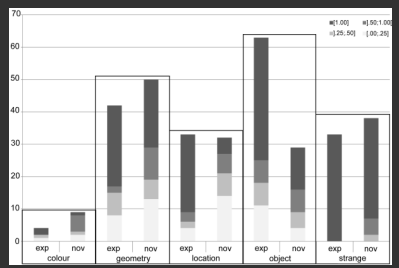
Part II – Cognition and Memory

- Thinking aloud
  - Word segmentation *(count in ‰)*

Based on frequency ↓

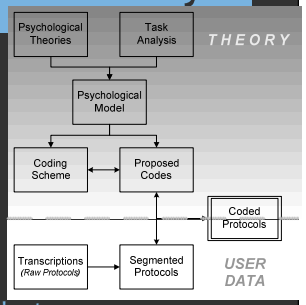


Based on theme ↓



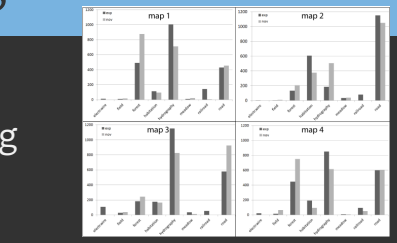
Part II – Cognition and Memory

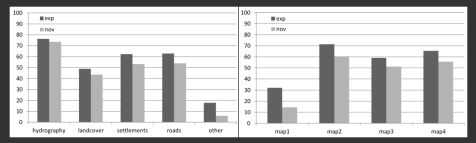
- Thinking aloud
  - ‘Full thought’
    - 4 Levels of codes:
      - Level 1: Map Level
        - Orientate – Execute - Evaluate
      - Level 2: Item Level
        - Gather Thougts – Draw – Correct - Evaluate
      - Level 3: Confidence
        - Confident – Neutral – Not Confident
      - Level 4: Actions
        - Check – Correct – Draw – Erase – Fill Colour – Talk – Take Pencil
    - Time ratio for each code: [0-1]



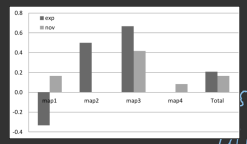
Part II – Cognition and Memory

- Sketch maps
  - Order of drawing
  - Scores on maps





- Questionnaire
  - Stated confidence



Part II – Cognition and Memory

- Conclusion
  - General structures: similar
    - Novices: store more information
      - Descriptions, locations, etc.
      - No extra knowledge
      - Not derive extra information
    - Experts: can retrieve more information
      - Know objects' names
      - Background information
        - » Derive information
      - Larger chunks in WM

More Info?

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1. Ooms, K., De Maeyer, P., Fack, V., Van Assche, E., & Witlox, F. (2012). Interpreting maps through the eyes of expert and novice users. *International Journal of Geographical Information Science*, 26 (10), 1773-1788.
2. Ooms, K., Andrienko, G., Andrienko, N., De Maeyer, P., & Fack, V. (2012). Analysing the spatial dimension of eye movement data using a visual analytic approach. *Expert Systems with Applications*, 39(1), 1324-1332.
3. Ooms, K., De Maeyer, P., Fack, V., Van Assche, E., & Witlox, F. (2012). Investigation the effectiveness of an efficient label placement method using eye movement data. *The Cartographic Journal*, 49(3), 234-246.
4. Ooms, K., De Maeyer, P., & Fack, V. (under revision). Understanding expert and novice map users: Reading and interpretation. *Cartography and Geographic Information Science*.
5. Ooms, K., De Maeyer, P., & Fack, V. (accepted). Listen to the map user: Cognition, memory, and expertise. *The Cartographic Journal*.

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Thank you for your attention!

Questions?

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