Digital maps and their users
Kristien Ooms
Department of Geography – Ghent University
PhD (2012): ‘Maps, how do users see them?’

Research Objectives

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

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.

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.
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

Ch 2-4: Basic Map Design

RQ 2
• Visual search
• Between user study design
• Reaction times

Ch 3:
• Visual search
• Visual analytics
• Evolution behaviour over time
• Influencing factors

Ch 4:
• Visual search
• Within user study

RQ 4
• Visual search
• Within user study
• Analyses of coded protocols

Ch 5-6: Complex Map Design

Ch 5:
• Read and interpret screen map
• Between user study design
• Statistical and visual comparison

Ch 6:
• Remember map from memory
• Between user study design
• Analyses of coded protocols

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

• Results:
  – Reaction time measurements
  – Fixation duration
  – Fixation count
  – Fixation distribution

• Conclusion
  – Similar trend in both user groups: CLT
  – Experts significantly faster at locating the names
  – Explained by eye movement metrics
    Shorter fixations
    Can interpret the map's content more efficiently
    More fixation per second
    Can interpret a larger part of the map in the same amount of time
    Locates the names faster
    Interprets map more efficiently

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
Part I – Visual Analytics

- Time series
- Aggregation
- Simplification
- Selection

Part I – Visual Analytics

- Conclusion
  - Selection, aggregation, simplification
    - 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
    - Consciously: user statements
      - “no difference was seen”
    - Unconsciously: measurements
      - No deviations in
        - Reaction time measurements
        - Eye movement metrics

Part II – Complex Map Design

- Aims:
  - Communication process:
    - Expertise?
    - Influence of deviations

- 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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Classification and colour schemes</th>
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<tr>
<td>FixCount</td>
<td>[0-1] [1-2] [2-4] [4-6] [6-8] [8-10] [10-20] [20-...]</td>
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<td>FixDur</td>
<td>[.000-.325] [.325-.650] [1.300-1.950] [1.950-2.600] [2.600-3.250] [3.250-6.500] [6.500-...]</td>
</tr>
<tr>
<td>Colour</td>
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</table>

Part II – Reading and Interpretation

- Eye movements
  - 2D gridded visualisations
    - Average fixation count
    - Maximum fixation count

- Eye movements
  - 3D gridded visualisation
    - Average total fixation duration
    - Average fixation duration per fixation

- 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 %)

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?
Kristien.Ooms@UGent.be


Thank you for your attention!

Questions?
Kristien.Ooms@UGent.be