Delft University of Technology
MSc. Geomatics

P5 Final Presentation

Usability of the vario-scale approach in interactive and dynamic mapping

by
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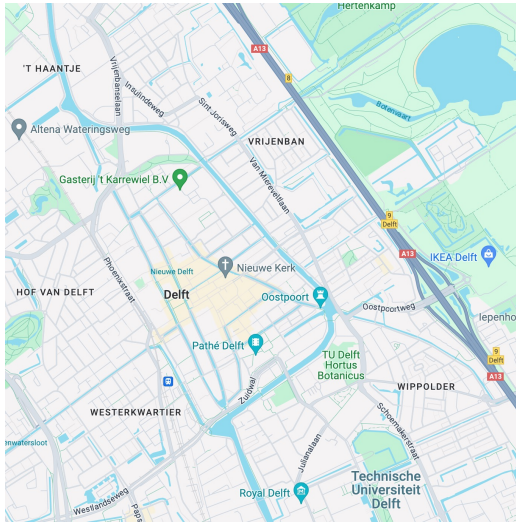
TU Delft

Introduction

Multi-scale Maps

- Multiscale maps change at **predefined scales** while zooming,
  showing **discrete** levels of detail.

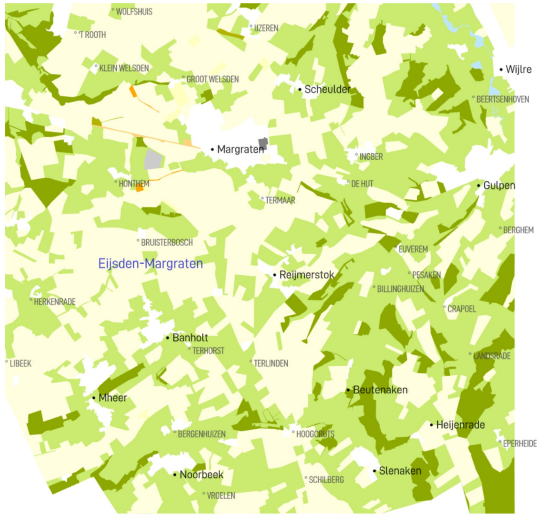


Google Maps

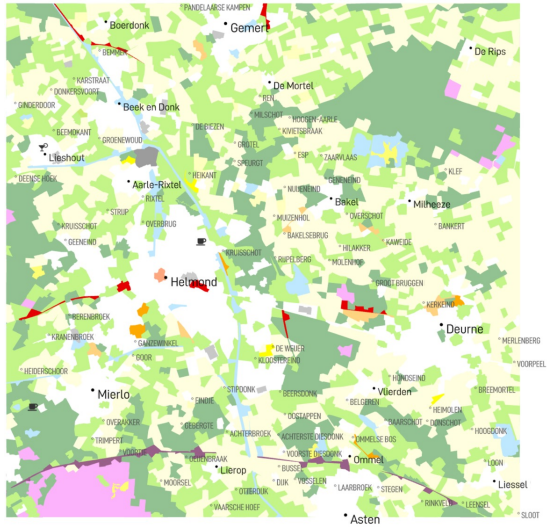
Apple Maps

Vario-scale Maps

- Varioscale maps change **smoothly** while zooming,
  showing **continuous** levels of detail.



Pilot Study



Final Study

Limitations of Multi-scale Maps

- **Data Heterogeneity**

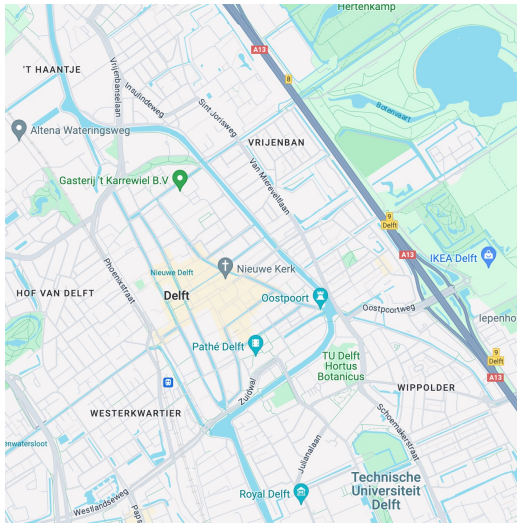
Differences **in data** lead to **inconsistencies** across scales.

- **Symbolisation Choices**

Variations in symbols can **disorient** users during zooming.

- **User Cognitive Load**

Navigating through differences can be confusing, making map **navigation challenging**.



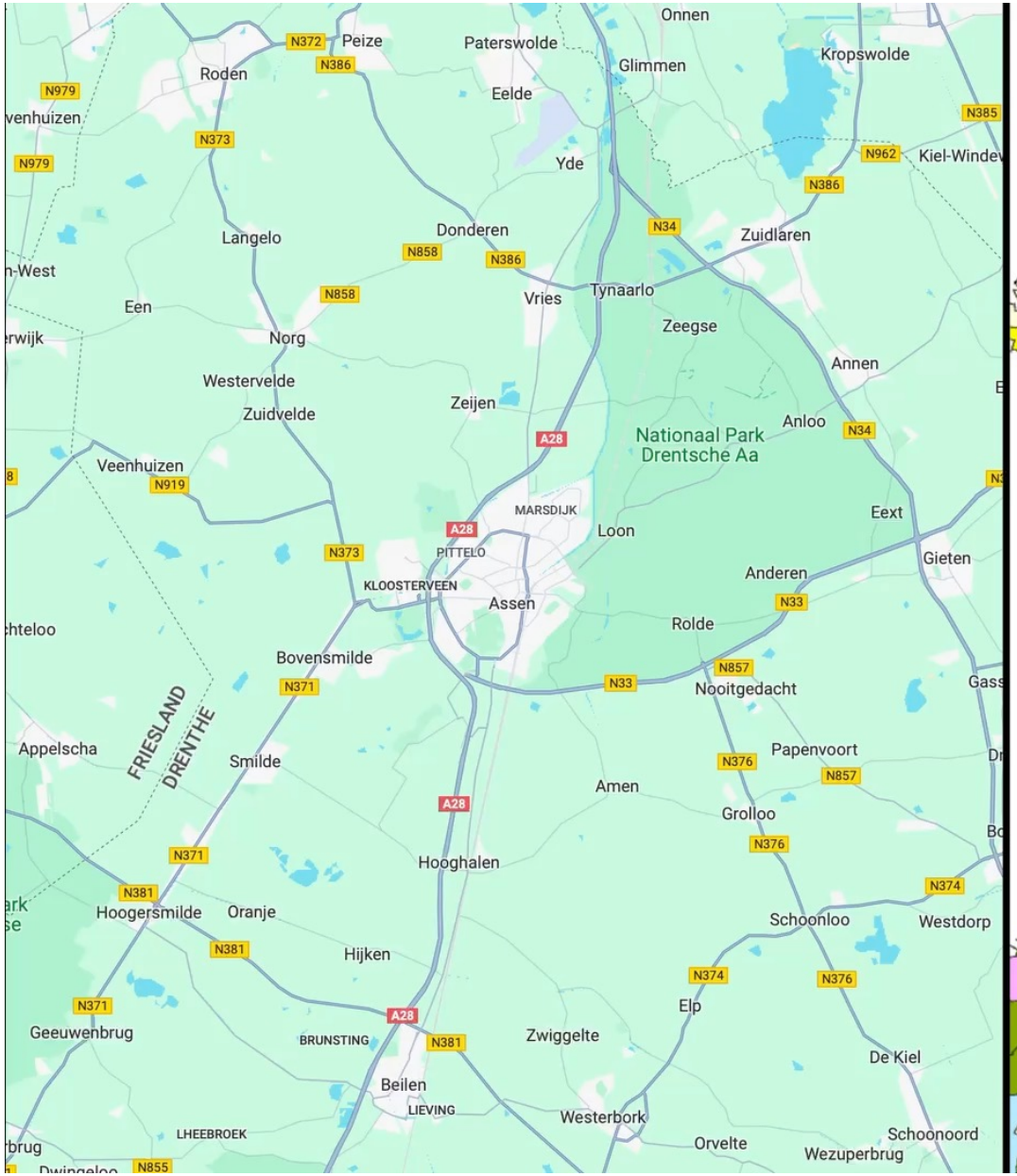
Google Maps

Apple Maps

Multi-scale and Vario-scale **side by side**

Google Maps

TU Delft GDMC Prototype



Research Questions

Main Research Question

► To what extent do vario-scale maps improve user interaction and satisfaction compared to multi-scale map interfaces?

Sub-questions

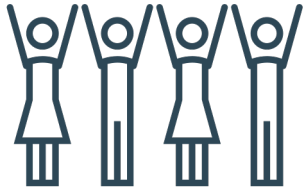
*1. How can **cartographic principles** be applied to develop **effective vario-scale** map prototypes?*

*2. What **features, functionalities and settings** (e.g. zooming and panning speed) are most critical to include in these prototypes to **enhance user interaction**?*

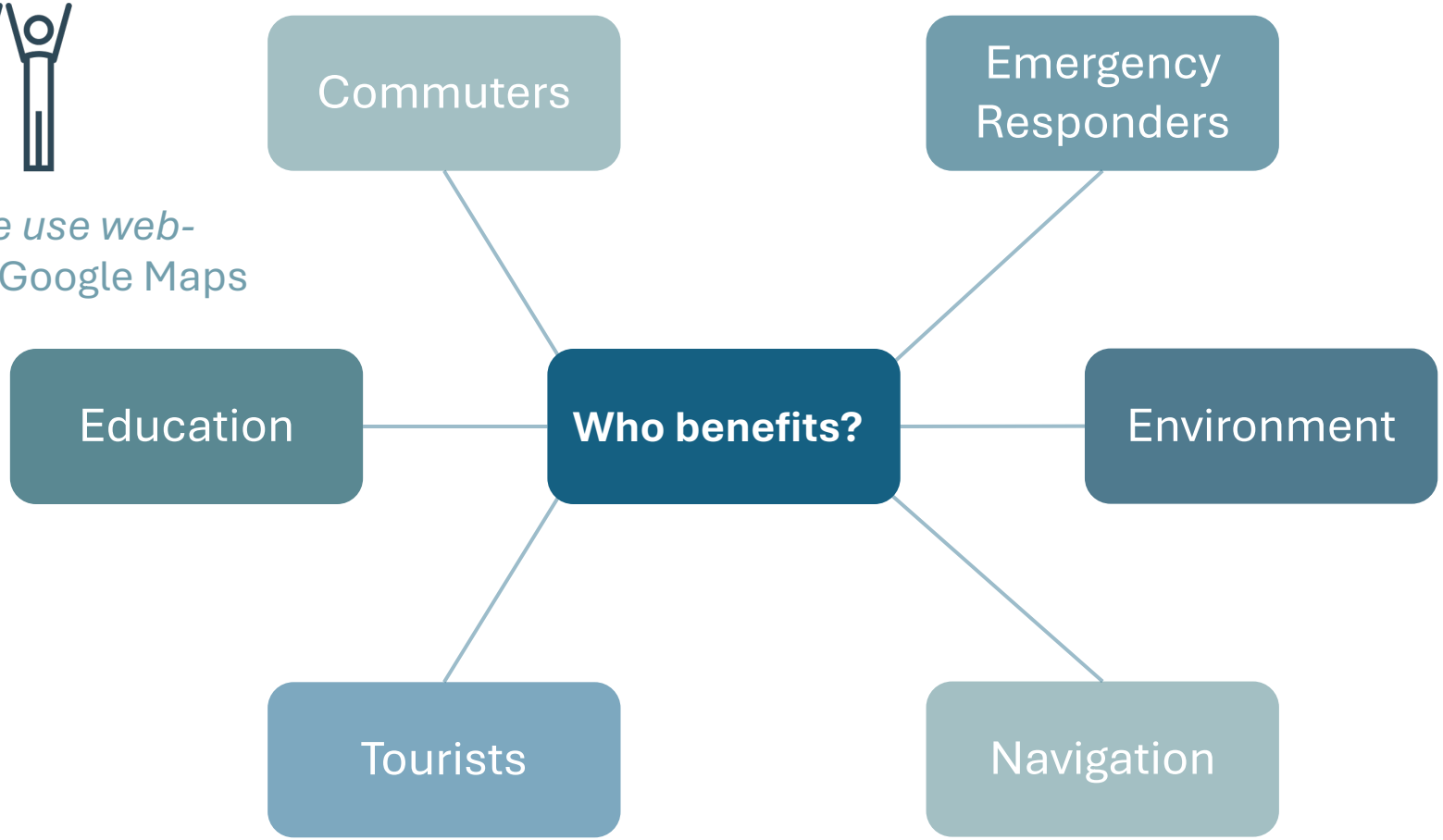
*3. How can the **features and functionalities** of vario-scale maps be **optimised** to improve **user satisfaction and usability**?*

*4. How does the vario-scale approach affect **user performance and satisfaction** in map-use tasks **compared** to multi-scale maps?*

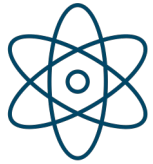
Social Relevance



“Billions of people use web-maps every day”, Google Maps



Scientific Relevance



- **Eye-Tracking**

↳ Objective analysis of users' cognitive processes

- **In-depth analysis of vario-scale usability**

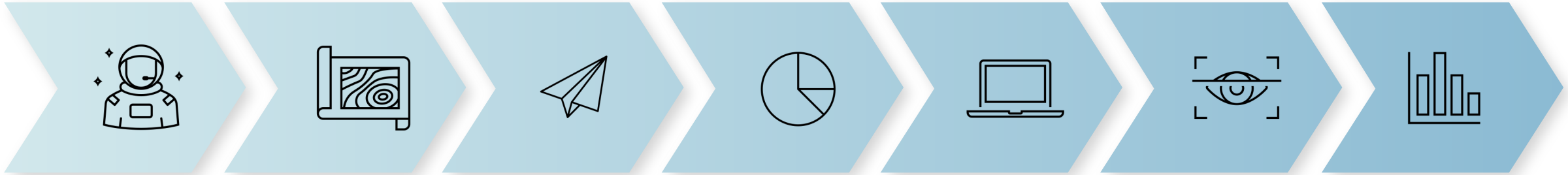
↳ Improving vario-scale through scientific usability testing

- **Improving Digital Cartography**

↳ Through gaining insights on intuitive and user-friendly interfaces

Methodology

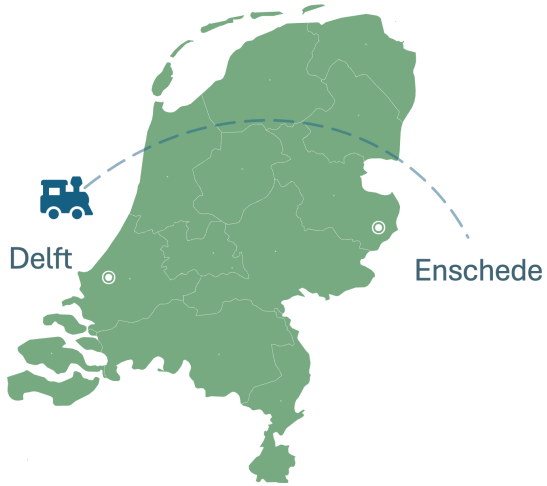
Methodology



1. Exploration Phase
2a. Pilot Study Setup
2b. Pilot Study Execution
2c. Pilot Study Analysis
3a. Final Study Setup
3b. Final Study Execution
3c. Final Study Analysis

Exploration Phase

Exploration Phase



Device Selection

Obtain Eye-tracking Device.

Device and Software Familiarisation

Familiarity with eye-tracking device and software.

Advancing in development tools:
Node.js, npm, HTML, CSS, and JavaScript.

Technical Setup

▶ Assess the computer's capability to handle tasks.

Pilot Study

Focus: Vario-scale

Purpose

- Gather **preliminary data** on user preferences regarding panning, zooming, and map content.

Procedure

- Participants **performed predetermined tasks** with varied panning and zooming settings.
- Collected **feedback** through questionnaires.

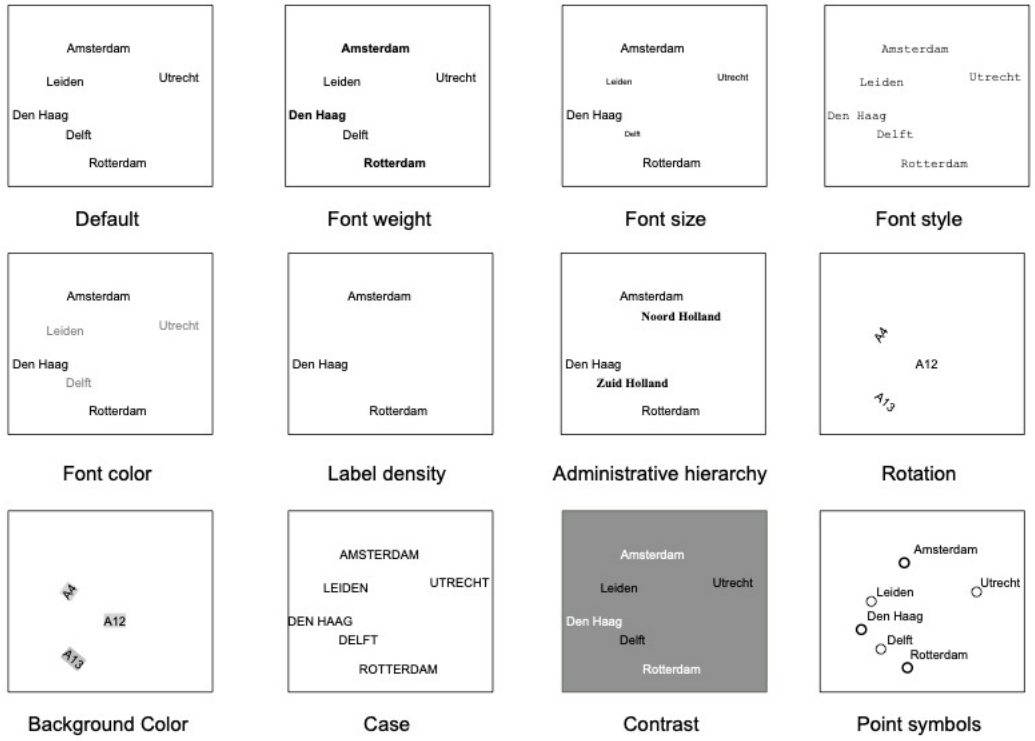
Goal

- Get **insights** regarding **Vario-scale** maps
- Use **insights** to design tasks for the **final experiment**.

Pilot Study Set-up

Map Prototypes Setup

- Adjust **labels, styles, landmarks**, and **symbols**.
- Test different **panning** and **zooming** settings to determine optimal user preferences.



https://pengdlzn.github.io/webmaps/2020/12/dryness/drenthe-dryness-comparer-juxtaposition.html

Hello World and Welcome to my Study! 🌍

Duration: ~10-15 min.

Your participation is essential to the success of my Master's Thesis at TU Delft, MSc. Geomatics. The specific topic we're exploring together is: "Usability of the vario-scale approach in interactive and dynamic mapping".

Privacy 🛡️

Your answers are anonymous. We won't store, use, or share any of your personal information.

About the Study 🗺️

This research is centered around varioscale maps, which adjust their level of detail dynamically as you zoom in or out. The goal of my thesis is to examine how user-friendly these maps are.

Study Details 🖥️🖱️

For the best experience, please use a computer with a mouse to complete the tasks. Mobile phones and tablets won't give you the full functionality needed for the activities.

Important: Each participant will receive an anonymous autogenerated ID. Please do not modify this ID; it is automatically completed and should not be changed.

Each task is timed ⏱️. The timer pauses when you click "Show Instructions" and continues when you are actively working on the map.

Please focus on using only the maps provided in this study, and try to complete all the tasks in one go.

I hope you find the experience enjoyable! 😊

The Prototypes

Task 1: **Landmarks**

- Variation A → Icons on
- Variation B → Icons off

Task 2: **Zooming Speed**

- Variation A → slow
- Variation B → medium
- Variation C → fast

Task 3: **Panning Animation Duration**

- Variation A → off
- Variation B → regular
- Variation C → long

**Randomised selection of Variation per study participant*

Pilot Study Execution

- ✓ Duration: 15 days
- ✓ Participants: Under 18 – Over 65
- ✓ Various Backgrounds – Cartography
- ✓ Multiple Levels of Familiarity with Technology
- ✓ Anonymous answers
- ✓ Autogenerated unique ID per participant

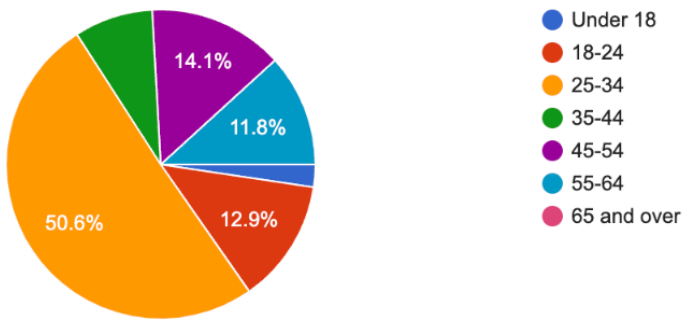
Results Analysis

Pilot Study

Intro Questions (85 responses)

What is your age?

85 responses



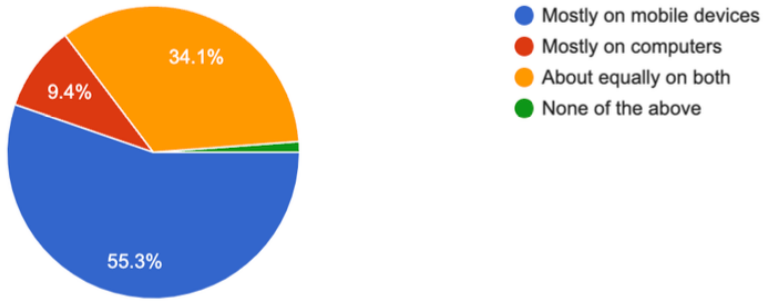
My studies/work are relevant to Cartography:

85 responses

Intro Questions (85 responses)

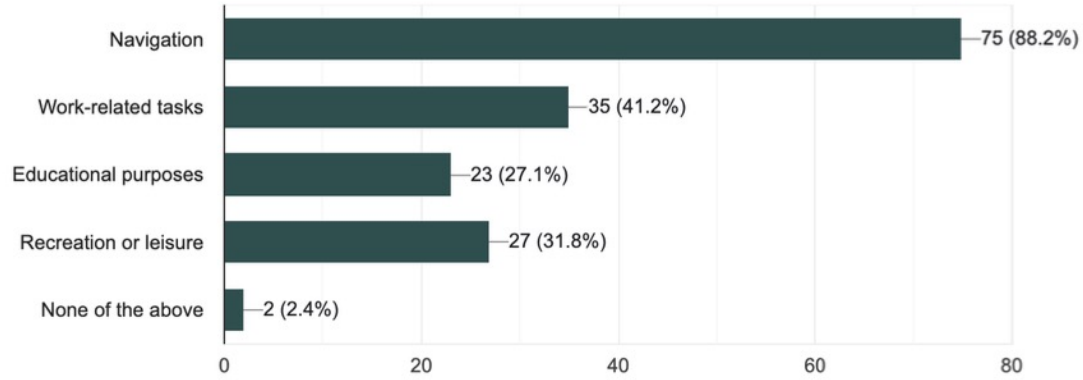
Do you often use web maps on mobile devices/tablets or computers?

85 responses

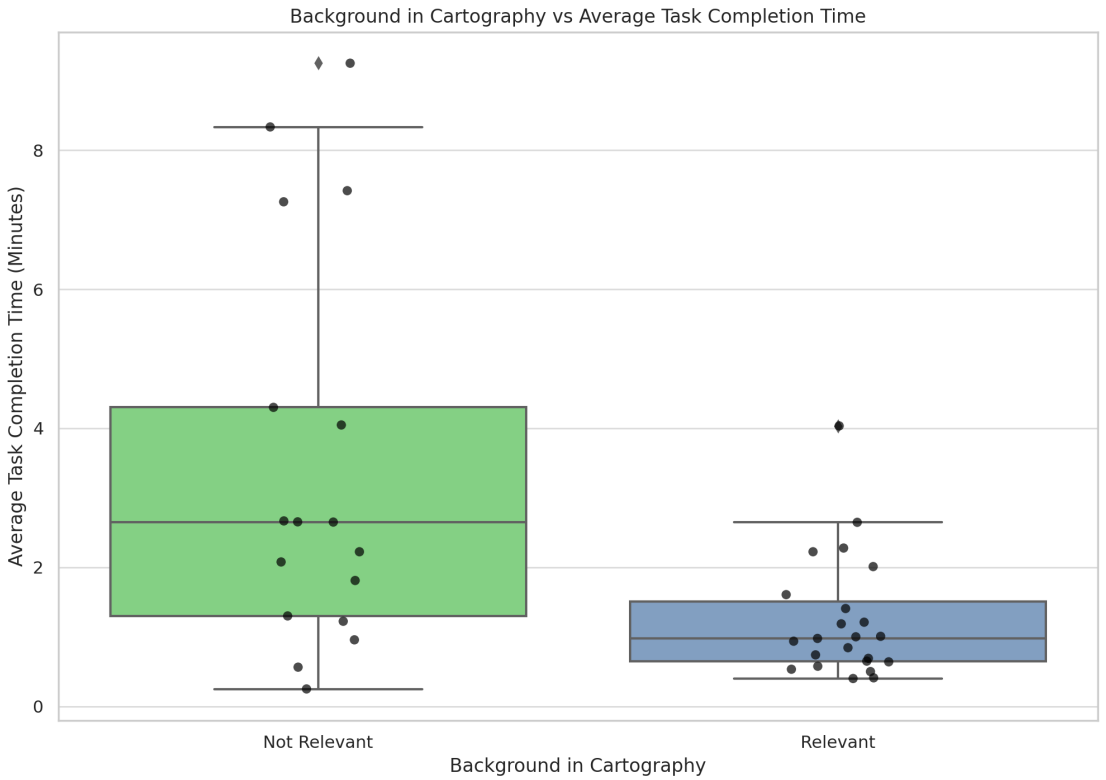


What do you usually use Web Maps for:

85 responses



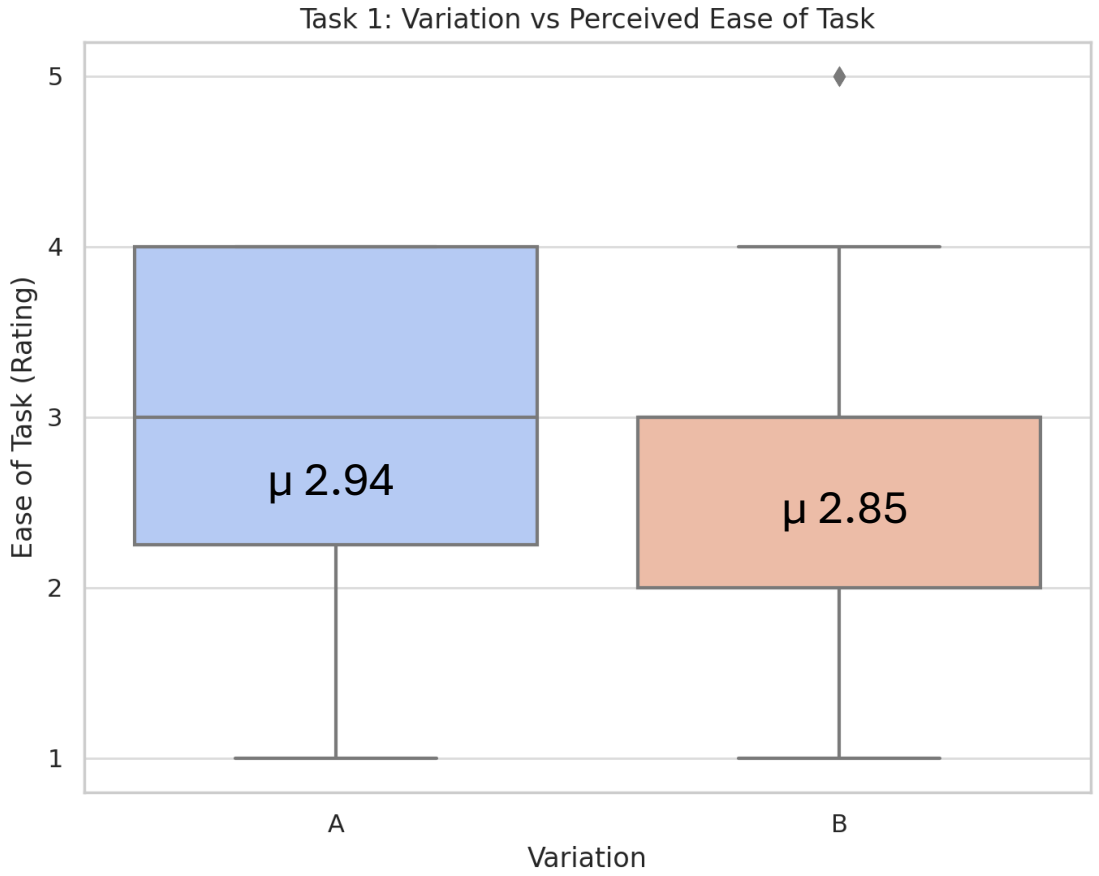
Cartography Background vs Completion Time



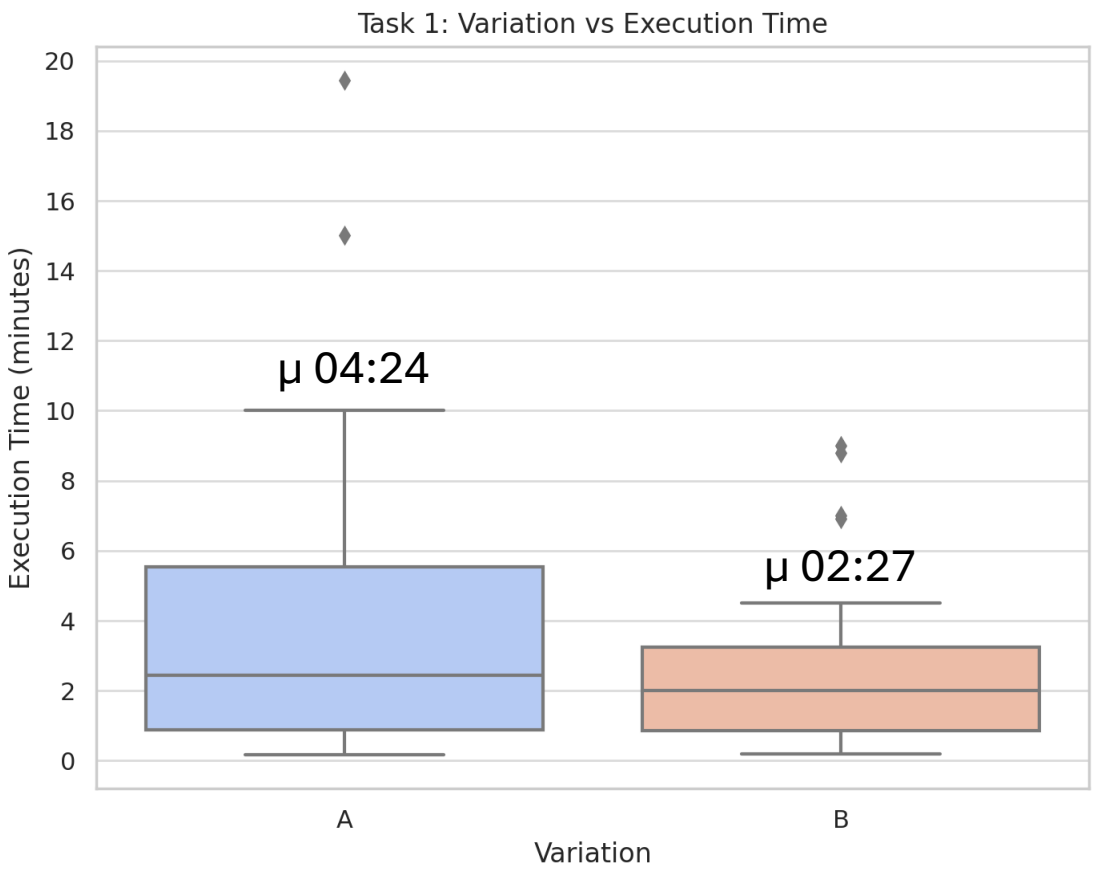
Correlation: -0.497 p-value: 0.0011

Statistically significant

Task 1 Results

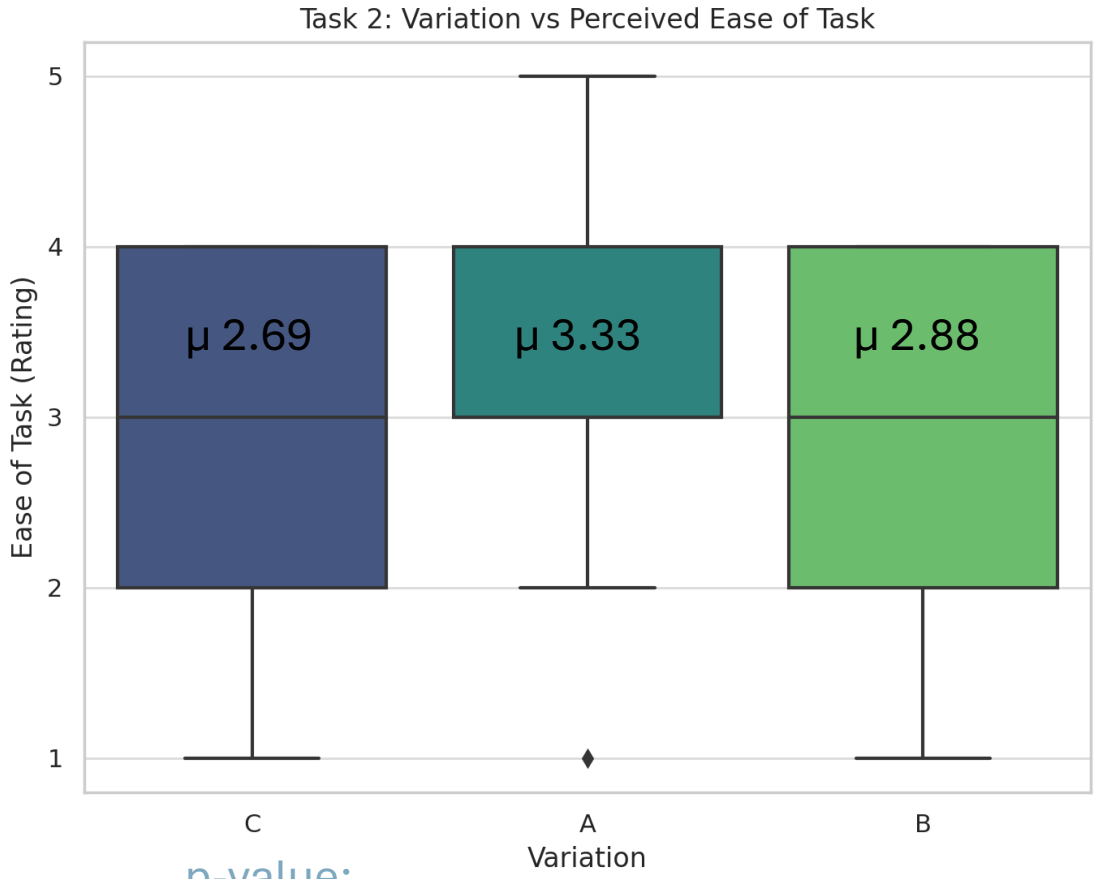


p-value: 0.788

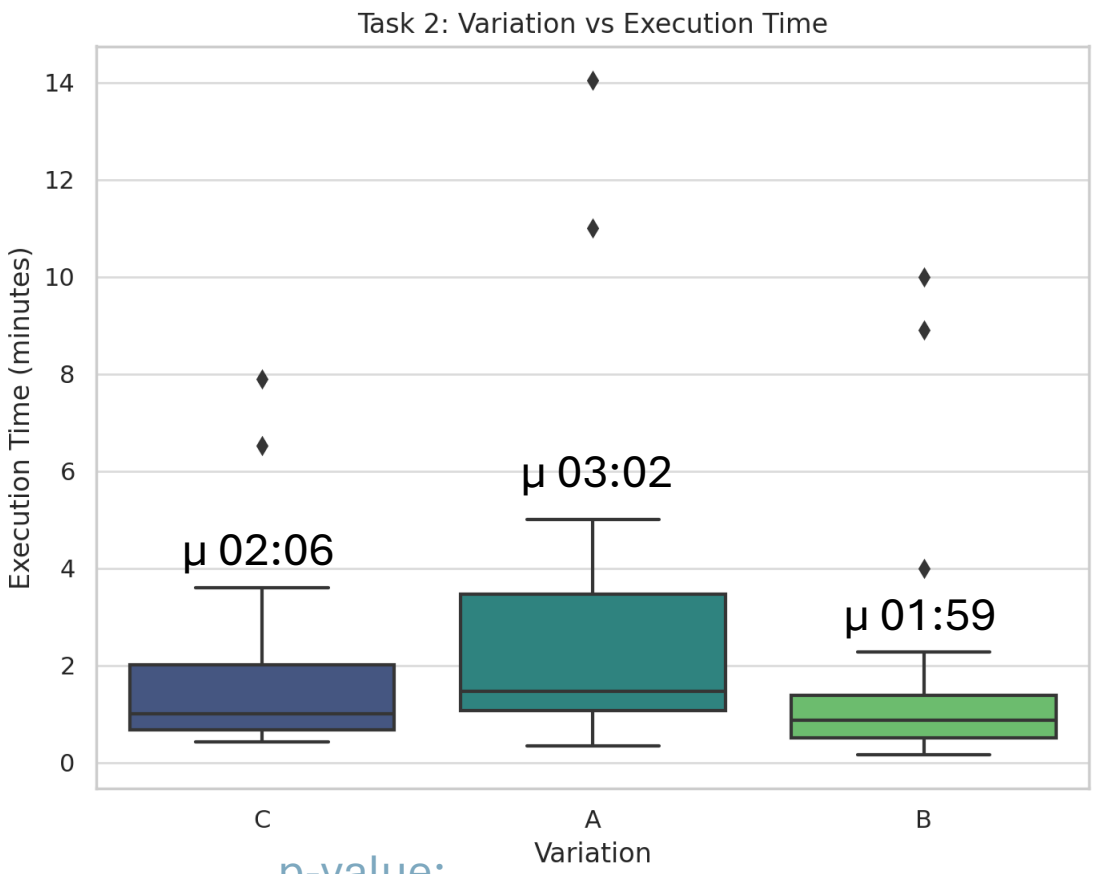


p-value: 0.14

Task 2 Results

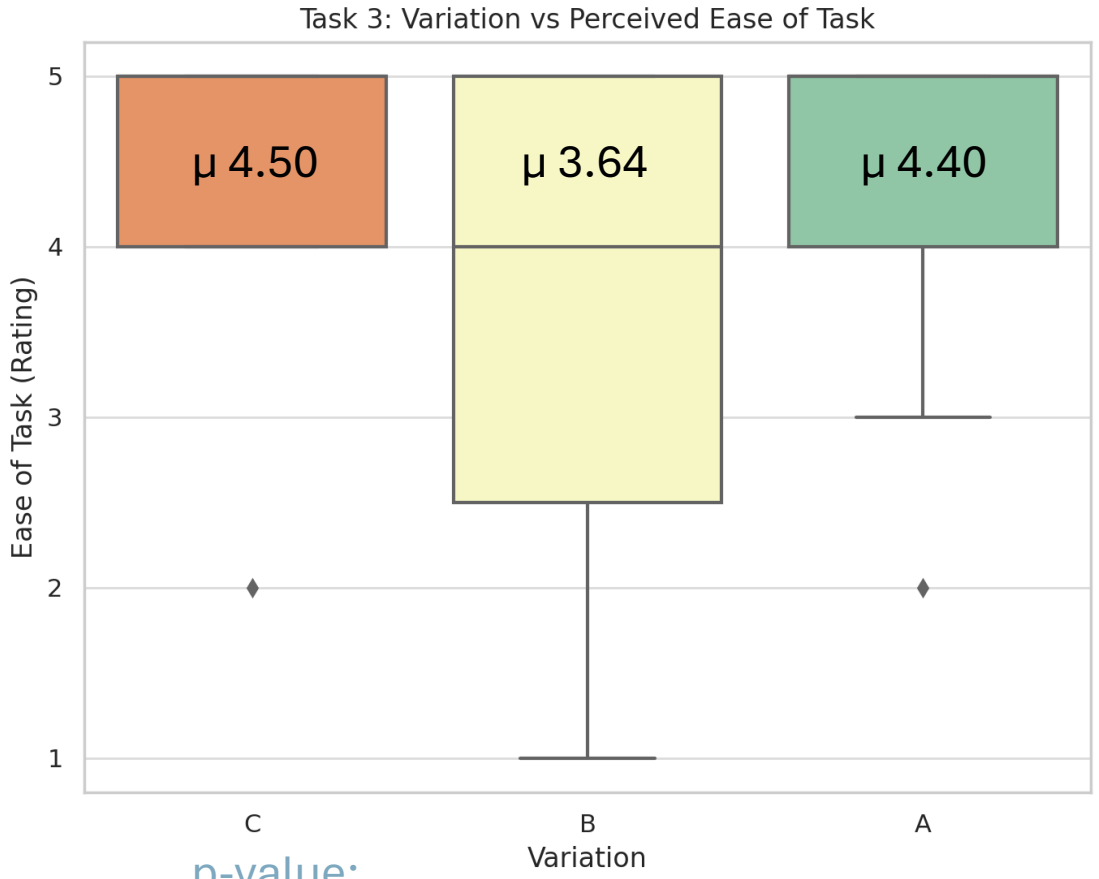


p-value:
A with B: 0.25
A with C: 0.15
B with C: 0.63

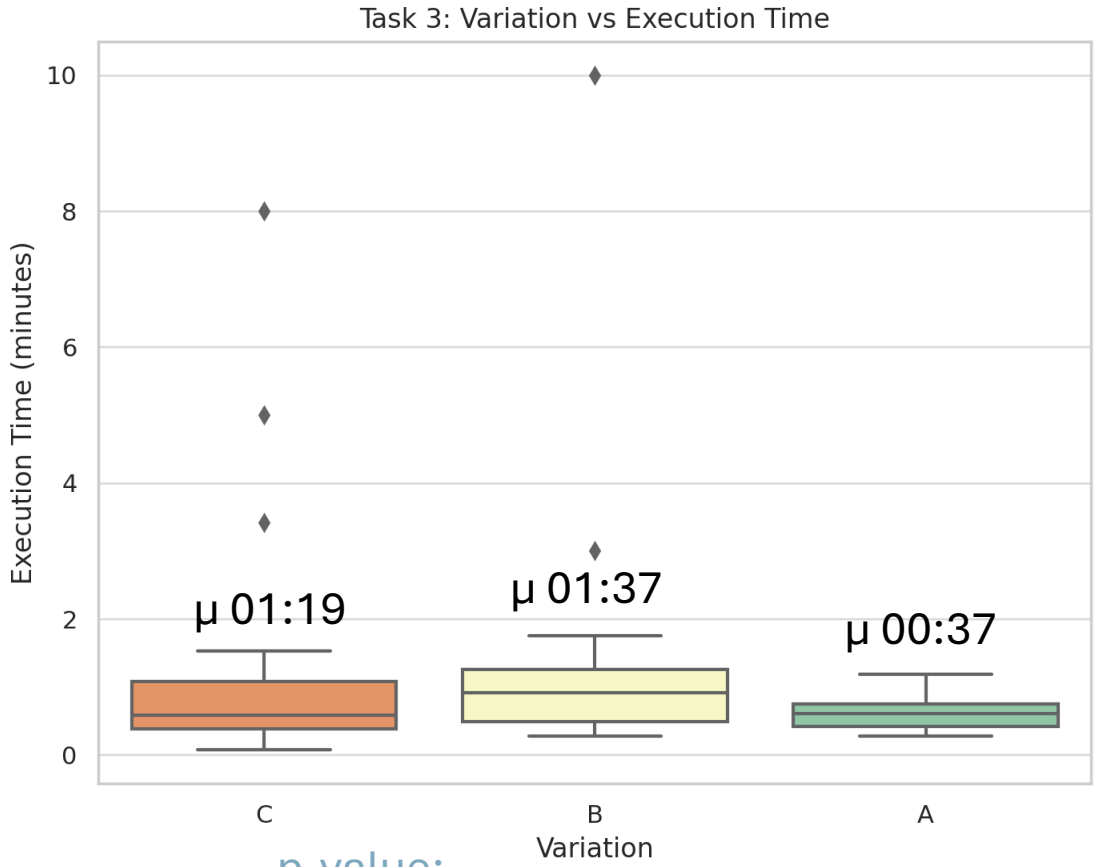


p-value:
A with B: 0.32
A with C: 0.38
B with C: 0.89

Task 3 Results



p-value:
A with B: 0.127
A with C: 0.704
B with C: 0.088



p-value:
A with B: 0.159
A with C: 0.116
B with C: 0.701

Conclusions

Pilot Study

Conclusions for Final Study Design

Icons

- It took longer for people to find a specific location on the map with an icon anchored to it → For area feature finding, do not combine with icons

Zooming speed

- Slow zooming speed was easiest, but medium was the fastest → use speed between slow and medium

Panning animation

- No animation was both easiest and fastest → deactivate animation

Considerations

Pilot Study

► Highlight Required Forms
Mention Google Forms in the initial instructions.

► Consider Screen Ratios
Account for different screen resolutions.

► Offer Hints
Guide participants struggling with tasks to avoid drop-off.

► Additional Instructions
Give more specific instructions on locating places.

Final Study

Focus: Vario-scale & Multi-scale approach

Purpose

- Assess vario-scale map **effectiveness** compared to multi-scale maps.
- Provide **recommendations** for improving vario-scale map design and functionality.

Eye-tracking Integration

- **Enhancing Usability Research**

Eye movements (saccades and fixations) ➜ indicate visual attention and cognitive processing.

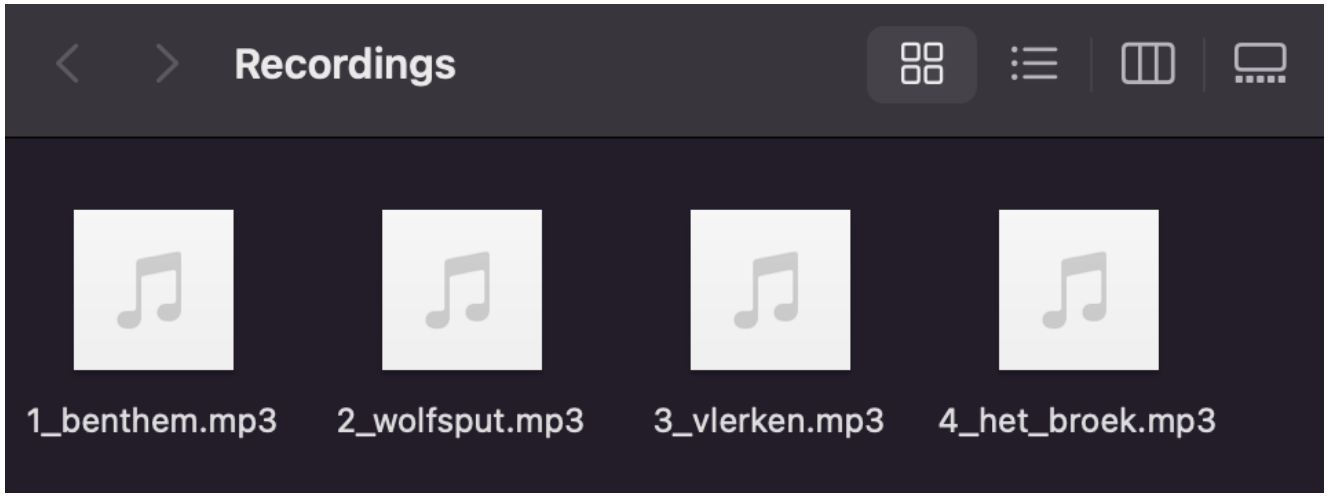
- **Cognitive Insights**

Allows a deeper, more intuitive understanding of user engagement.

Final Study Setup

EventType	Center.x	Center.y	Timestamp	LowerLeft.x	LowerLeft.y	ScaleDenom	MapType
Animation	177000.00000000006	387000.0000000002	2024-12-10T18:49:19.420Z	160119.58333333343	378420.88541666686	49999.9999999999	varioscale
mouseDown	177000.00000000006	387000.0000000002	2024-12-10T18:49:33.865Z	160119.58333333343	378420.88541666686	49999.9999999999	varioscale
mouseDrag	177000.00000000006	387000.0000000002	2024-12-10T18:49:33.943Z	160119.58333333343	378420.88541666686	49999.9999999999	varioscale
mouseDrag	177000.00000000006	387000.0000000002	2024-12-10T18:49:33.953Z	160119.58333333343	378420.88541666686	49999.9999999999	varioscale
mouseDrag	177000.00000000006	387013.2291666669	2024-12-10T18:49:33.980Z	160119.58333333343	378434.1145833336	49999.9999999999	varioscale
mouseDrag	177000.00000000006	387026.45833333366	2024-12-10T18:49:33.997Z	160119.58333333343	378447.34375000035	49999.9999999999	varioscale

Map log file



Task Recordings

SCRIPT

Welcoming

Hi! My name is Eirini, and I'll be guiding you through this session today. Before we get started, I'd like to go over some information with you to make sure everything is clear.

You probably have a general idea of why I asked you to join me, but let me explain briefly. We're conducting a study to compare two types of interactive map interfaces: **vario-scale maps** and **multi-scale maps**. We want to understand how each type of map impacts user experience. This session will last around 45 minutes, depending on the tasks and any follow-up questions.

First, I want to emphasise that we're testing the maps, not you. There are no right or wrong answers here, and you can't make any mistakes. In fact, anything you find confusing or challenging will help me better understand how users experience the two types of maps.

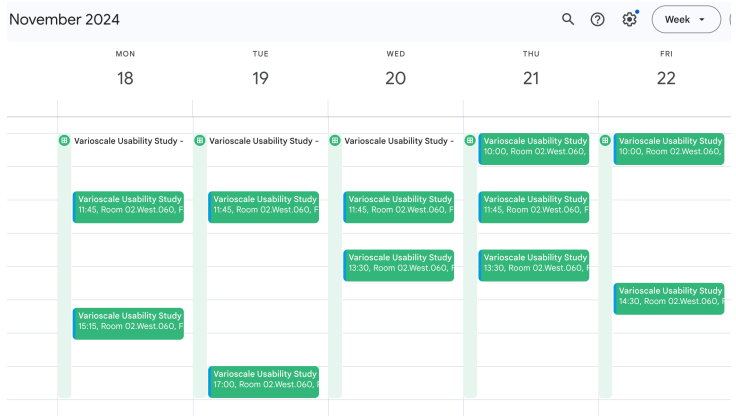
As you work with each map, I'd like you to think out loud as much as possible. This means sharing what you're looking at, what you're trying to do, and what's going through your mind. Your honest reactions will help me understand how you interact with the maps and identify any challenges you encounter.

Please don't worry about hurting my feelings. This is a research study, and genuine feedback is needed to understand how users interact with each map design. If something doesn't make sense or feels frustrating, please let me know!

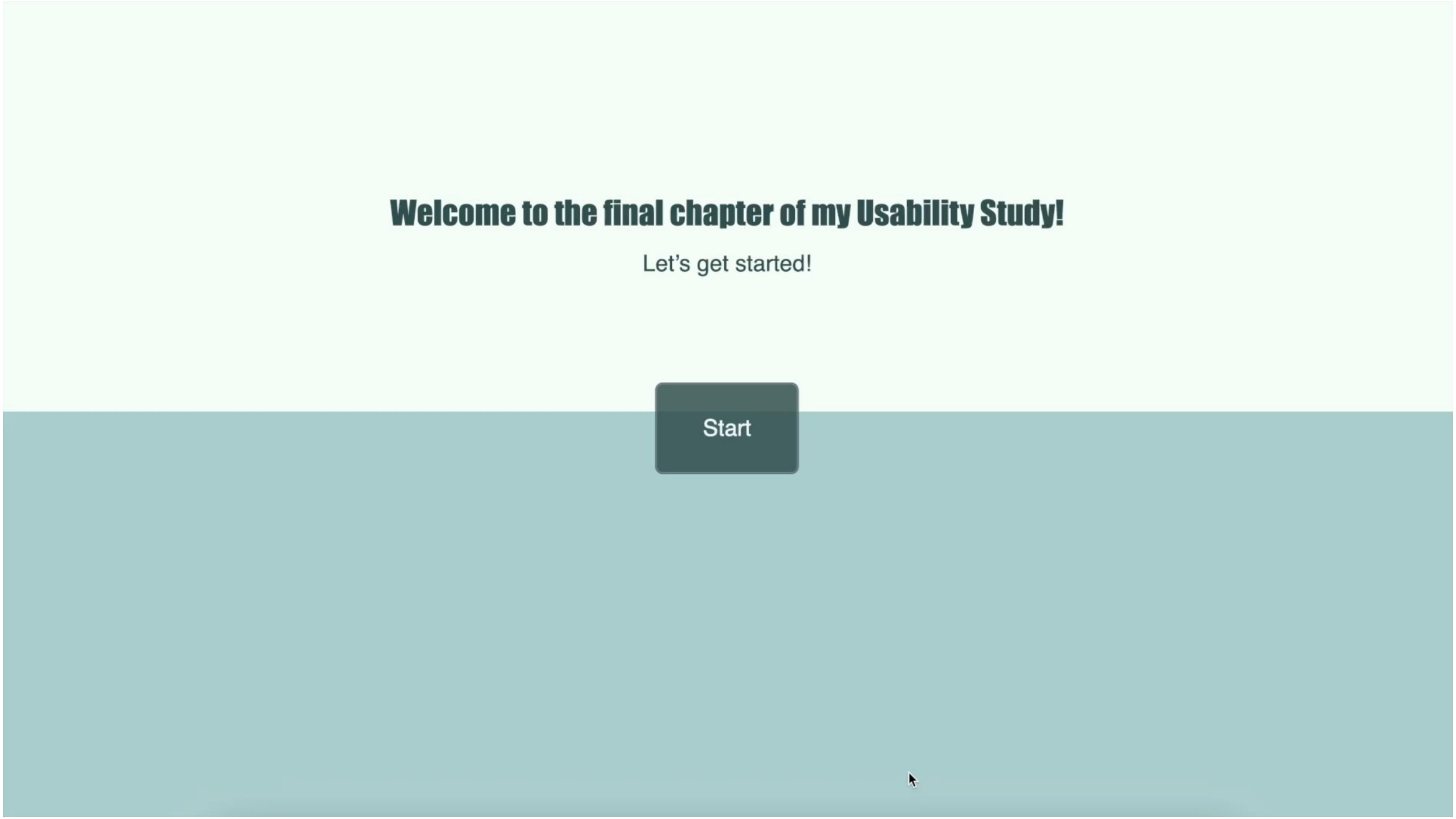
If you have any questions as we go along, feel free to ask. I may not be able to answer them immediately, as I'm interested in observing how you navigate the maps without additional guidance. However, I'll be happy to answer any remaining questions at the end of the session.

You'll notice we have a Tobii Pro Fusion eye tracker set up. With your permission, I'll be recording your eye movements on the screen, along with our conversation. This helps us understand where you focus your attention as you interact with each map. Only I will view this recording, and it will be used solely for analysis.

If you're comfortable with this, I'll ask you to sign a permission form that confirms you agree.



Experiment Scheduling


Welcome to the final chapter of my Usability Study!
Let's get started!
Start

Intro Questionnaire

Participant: [ ]

For some questions, more than one option may apply. Please select all that apply.

1. **Have you previously participated in usability testing for digital interfaces?**
   - ☐ Yes
   - ☐ No

2. **How would you rate your overall proficiency with technology?**
   - ☐ **Not proficient**: You might find technology challenging and generally need help with basic tasks.
   - ☐ **Slightly proficient**: You can manage basic functions but might often require assistance for more complex tasks.
   - ☐ **Moderately proficient**: You are comfortable using common technologies and can solve basic issues on your own.
   - ☐ **Very proficient**: You are quite adept with a variety of technologies and can easily learn new tools and software.
   - ☐ **Extremely proficient**: You excel in using diverse technologies and can independently resolve complex issues.

3. **Are your studies/work relevant to Cartography:**
   - ☐ Yes, my activities involve maps.
   - ☐ No, my activities do not involve maps.

4. **Do you know the difference between vario-scale and multiscale maps?**
   - ☐ Yes:_____
     _____
   - ☐ I am not sure

Task 1 Feedback

Participant: [ ]

1. **What did you think about the overall difficulty level of the task?**

	1	2	3	4	5	
Too easy	○	○	○	○	○	Too difficult

2. **How clear were the given instructions?**

	1	2	3	4	5	
Not very clear	○	○	○	○	○	Very clear

3. **Did you find the task easier to execute with one map type than the other?**
   - ☐ Yes, easier with the vario-scale map
   - ☐ Yes, easier with the multi-scale map
   - ☐ No, I found the tasks equally manageable with both
   - ☐ I didn't manage to complete the task

4. **Comments**

_____

_____

_____

_____

_____

_____

Overall Feedback

Participant: [ ]

1. **How would you rate the fairness of comparing the two types of maps (vario-scale and multi-scale) in this test?**
   - ☐ **Very fair:** The comparison feels balanced and unbiased.
   - ☐ **Mostly fair:** There are minor differences, but overall, the test is fair.
   - ☐ **Neutral:** I don't feel strongly about the fairness of the comparison.
   - ☐ **Somewhat unfair:** One map type seems to have an advantage in the test setup. Please indicate which one:_____
   - ☐ **Very unfair:** The comparison feels biased towards one map type.'

2. **Did the tasks feel realistic and relevant to how you would use web maps in real life?**
   - ☐ Yes, very realistic
   - ☐ Somewhat realistic
   - ☐ Neutral
   - ☐ Not very realistic
   - ☐ Not realistic at all

3. **Which map type did you find more efficient for completing tasks?**
   - ☐ I strongly find varioscale more efficient
   - ☐ I slightly find varioscale more efficient
   - ☐ I find both equally efficient
   - ☐ I slightly find multiscale more efficient
   - ☐ I strongly find multiscale more efficient

4. **What did you see as advantages of varioscale?**

_____

_____

Final Study Questionnaires

Final Study Execution

- ✓ Duration: 5 days
- ✓ Participants: 11
- ✓ On-site: GEOS office
- ✓ Eye tracker Tasks & Questionnaires
- ✓ Various Backgrounds – Cartography
- ✓ Multiple Levels of Familiarity with Technology
- ✓ Anonymous answers

Experiment setup

Tools and Data

Tools

- **Professional Eye-Tracking Device / Webcam**
- **Software |** Professional (Tobii Pro Lab)
- **Voice Recording |** Study computer
- **Video Documentation |** Study computer
- **Mouse Tracking |** Custom-developed code
- **Map position and Scale Recording | CSV file**
- **Monitor, Mouse, Keyboard**
- **Questionnaires**

Data

Eye-Tracking Data

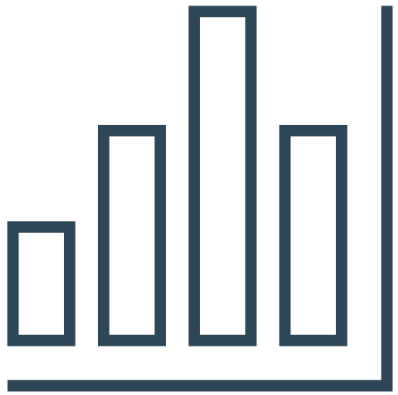
- **Heatmaps**
  - Visual representation of user **attention areas**
- **Metrics**
  - Gaze duration
  - Fixation points
  - Saccades (rapid movements between fixations)

Viewport Logs

- **Patterns** and **behaviours**

Questionnaire Feedback

- Task **difficulty**
- **Satisfaction** with instructions
- **Ease** of navigation
- **Suggestions** for improvements



Results Analysis

Final Study

Metrics

- **Fixation Count:**

A higher number of fixations may indicate less **efficient searching**, as the user needs to fixate on more points to locate the target (Goldberg, 1999).

- **Fixation Duration:**

Longer fixation durations can signify difficulty with the display or the information presented, implying increased **cognitive load** (Goldberg, 1999).

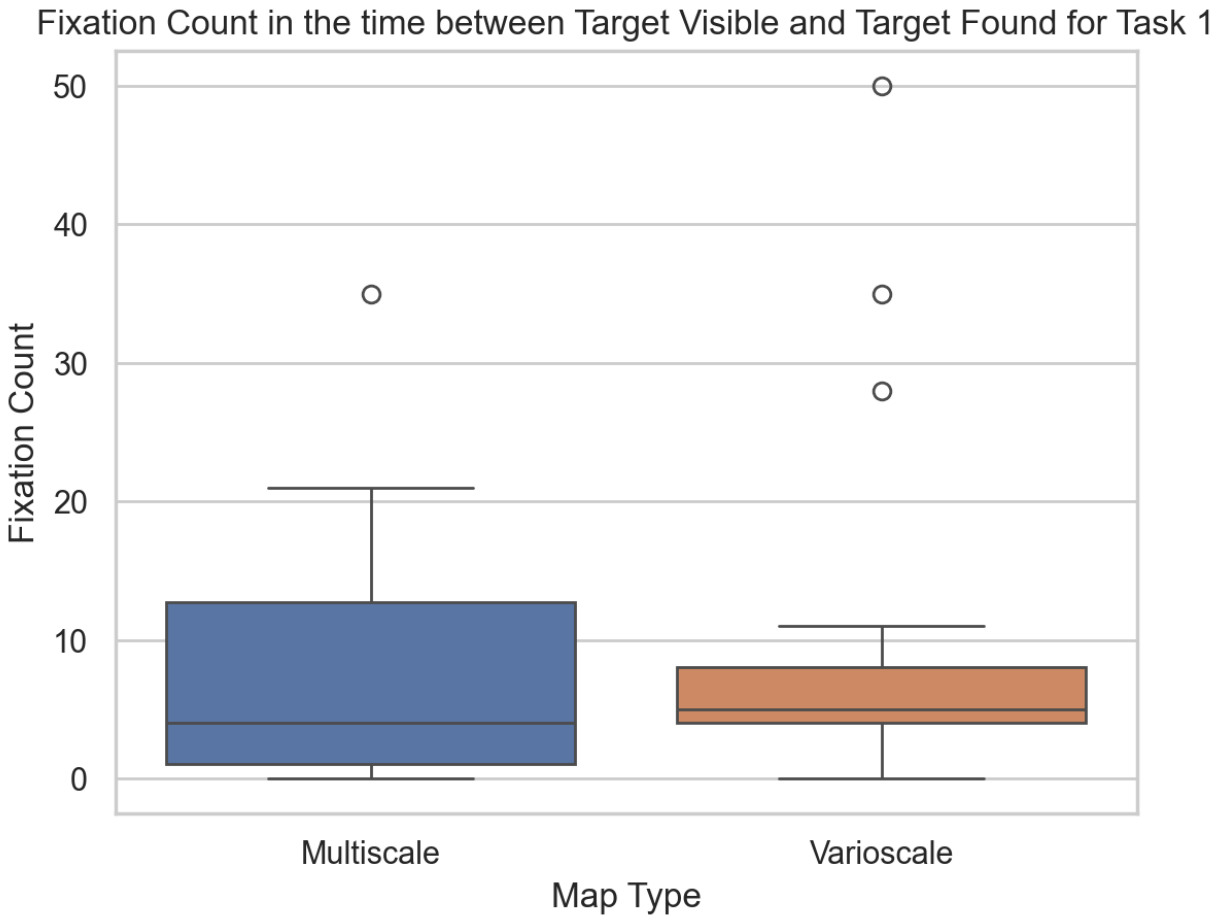
- **Scanpath Length:**

A longer scanpath may indicate less efficient **searching patterns**, reflecting more extensive eye movements across the display (Goldberg, 2002).

- **Time to First Fixation on Target:**

Measures the time it takes for the participant to fixate on the target after it becomes visible, indicating **search efficiency** (Byrne, 1999).

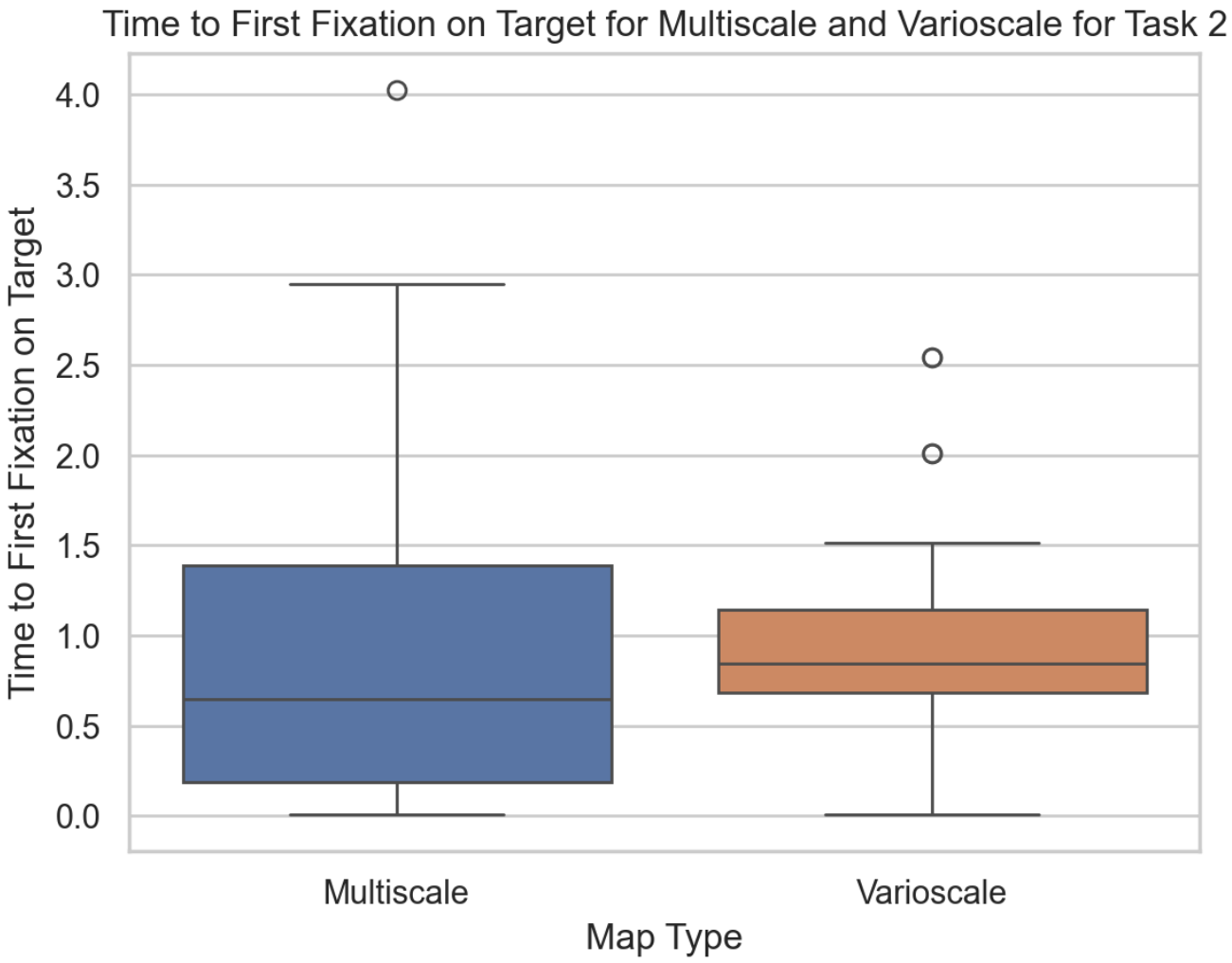
Task 1



Metrics

- **Fixation Count (While visible)**
  - Vario-scale: 10.0
  - Multi-scale: 8.68
  - **P-value: 0.72**
- **Fixation Duration**
  - Vario-scale: 0.277 s
  - Multi-scale: 0.281 s
  - **P-value: 0.70**
- **Time to First Fixation on Target (While visible)**
  - Vario-scale: 2.47 s
  - Multi-scale: 2.02 s
  - **P-value: 0.61**
- **Scanpath length (While visible)**
  - Vario-scale: 2462 px
  - Multi-scale: 1666 px
  - P-value: 0.39

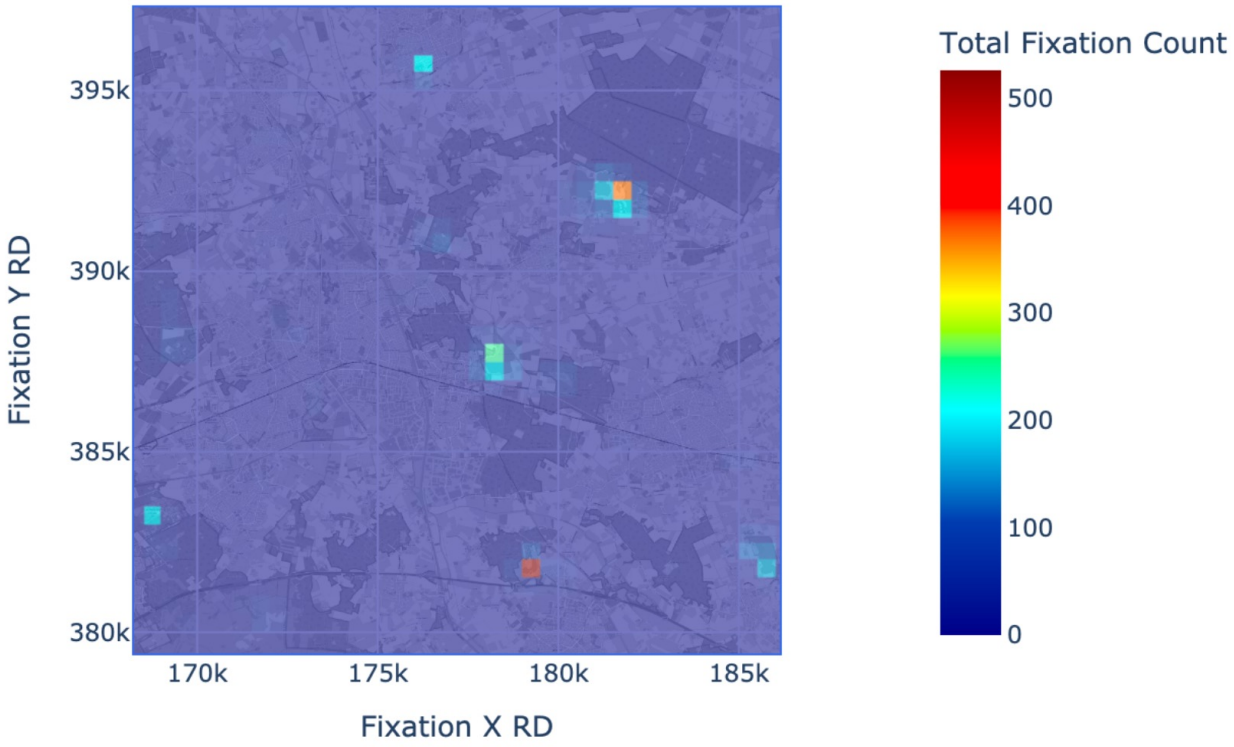
Task 2



Metrics

- **Fixation Count**
  - Vario-scale: 404.3
  - Multi-scale: 404.5
  - **P-value: 1.0**
- **Fixation Duration**
  - Vario-scale: 0.241 s
  - Multi-scale: 0.245 s
  - **P-value: 0.52**
- **Time to First Fixation on Target (While visible)**
  - Vario-scale: 0.96 s
  - Multi-scale: 0.97 s
  - **P-value: 0.96**
- **Scanpath length**
  - Vario-scale: 120451 px
  - Multi-scale: 118546 px
  - **P-value: 0.97**

Task 3



Metrics

- **Fixation Count**
  - Vario-scale: 351.6
  - Multi-scale: 336.8
  - **P-value: 0.56**
- **Fixation Duration**
  - Vario-scale: 0.261 s
  - Multi-scale: 0.266 s
  - **P-value: 0.34**
- **Scanpath length**
  - Vario-scale: 86787 px
  - Multi-scale: 86252 px
  - **P-value: 0.96**

Questionnaires (1/2)

- **Difficulty**
  - Mostly between 2 (slightly easy) and 4 (somewhat difficult)
- **Instructions clarity**
  - Mostly 5 (Very clear) with some 4 (and 3 (moderately clear).
- **Ease of task vario-scale or multi-scale (Total)**
  - 11: Yes, easier with the vario-scale
  - 7: Yes, easier with the multi-scale map
  - 16: No, I found the tasks equally manageable with both
  - 0: I didn’t manage to complete the task

Questionnaires (2/2)

- **Fairness**
  - Mostly “Very fair” and “Mostly fair”
- **Realism of tasks**
  - Mostly “Very realistic”, some “Somewhat realistic”
- **Efficiency preference vario-scale or multi-scale**
  - 27%: Strong vario-scale preference
  - 18%: Slight vario-scale preference
  - 36%: No preference
  - 18%: Slight multi-scale preference
  - 0%: Strong multi-scale preference

Conclusions

Final Study

Eye-Tracking Metrics

- No statistically significant difference between vario-scale and multi-scale
  - Search efficiency (Scan path length, fixation count, TTFF)
  - Cognitive load (Fixation duration)

Participant Preference

- Overall preference for vario-scale over multi-scale
  - Enhanced usability
  - Smoother transitions
  - More intuitive
  - Modern experience

Considerations

Final Study

Sample Size

- More participants could benefit quantitative statistical analyses

More varied demographics

- Broader age range

Task Design

- More controlled tasks

Insights

Deploying qualitative and quantitative methods

- Combines insights from user experience and objective measurement

The value of pre-test pilots

- Testing the study on a small participant group for iterative refinement

Eye-tracking

- The value of being able to get immediate access to cognitive processes

Future Work

Touch-based interfaces

- Test vario-scale usability on touchscreen devices

Vision Deficiencies

- Incorporate visually distinguishable colour palettes for accessibility research

Dynamic Labelling

- Refining algorithms for dynamic label placement

Closing Thoughts

Thank you