# Principles of Cognitive-adequate Tactile Maps

## Experimental Results and Research Agenda

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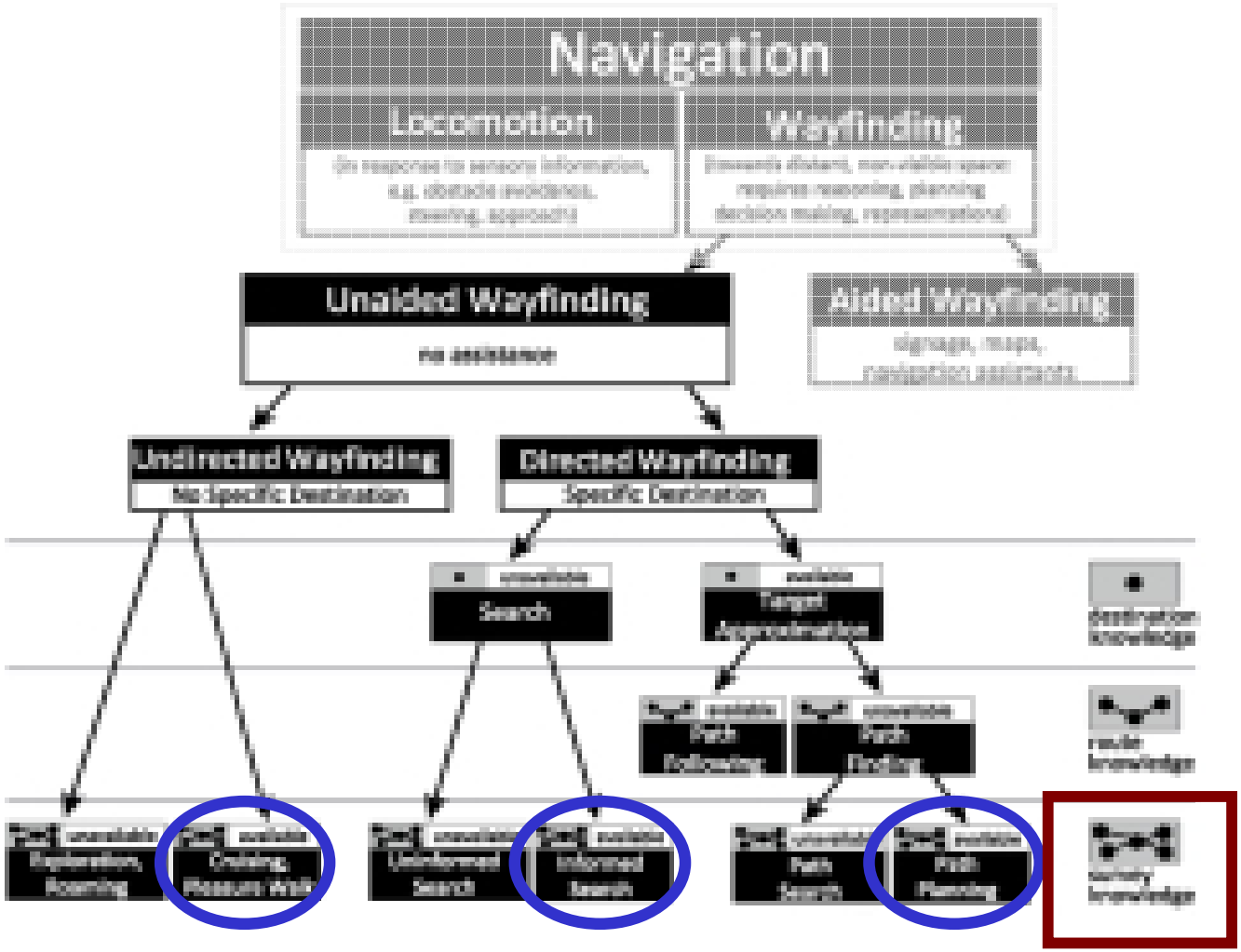
# Context of Research

- Context: Communication of spatial representations
- Problem: Simple adoption of visual maps into tactual format not adequate for blind people

# Motivation

- Knowledge about senso-motor limits in the usage of tactile maps → principles of sensory-adequate design
  - e.g. Minimum separation of map entities
  - e.g. Optimal size for map
- *Principles for cognitive-adequate construction* that ease the understanding of a tactile map: not systematically investigated
- „Understand a (tactile) map“: acquiring *survey knowledge*

# Usage of Survey Knowledge in Navigation



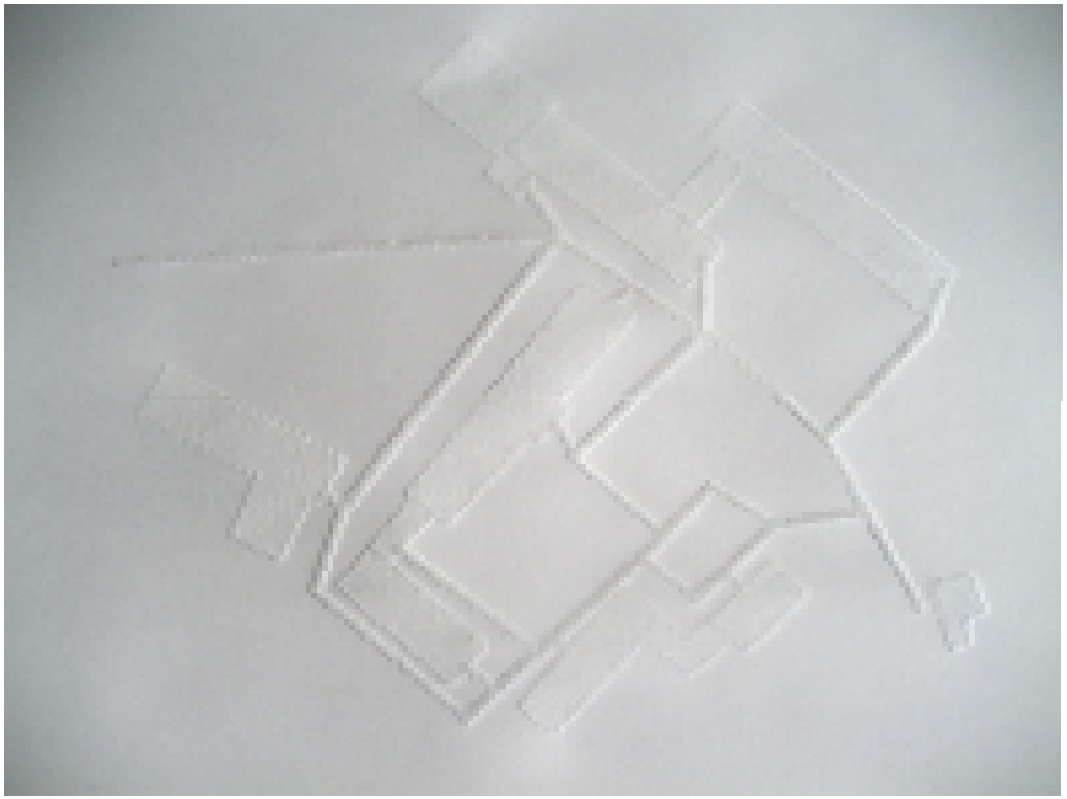

Wiener, Büchner, & Hölscher (2009), Fig. 1

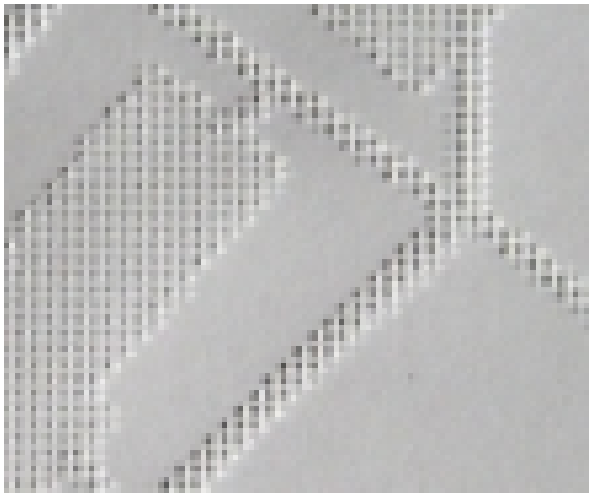
# Field and Goal of Research

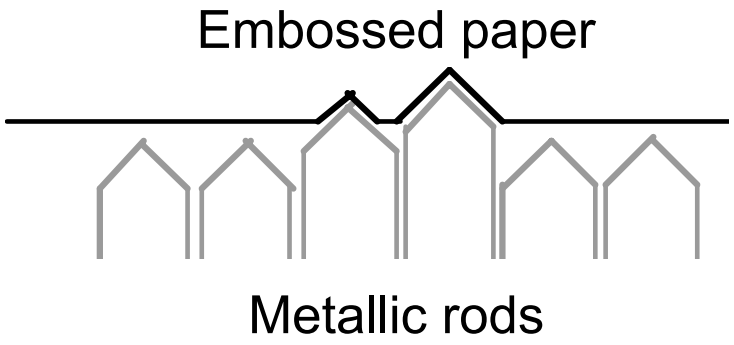
- Tactile maps for orientation
  - Functional nature: means for *preparing* w*ayfinding* in *open spaces* via *locomotion*
  - Structural nature: an *aspect map* in the sense of Barkowsky & Freksa (1997): only main tracks and landmarks, no labels

- Goal: Identification of principles for (computer generated) cognitive-adequate tactile maps

# Example for a Computer Generated Tactile Map



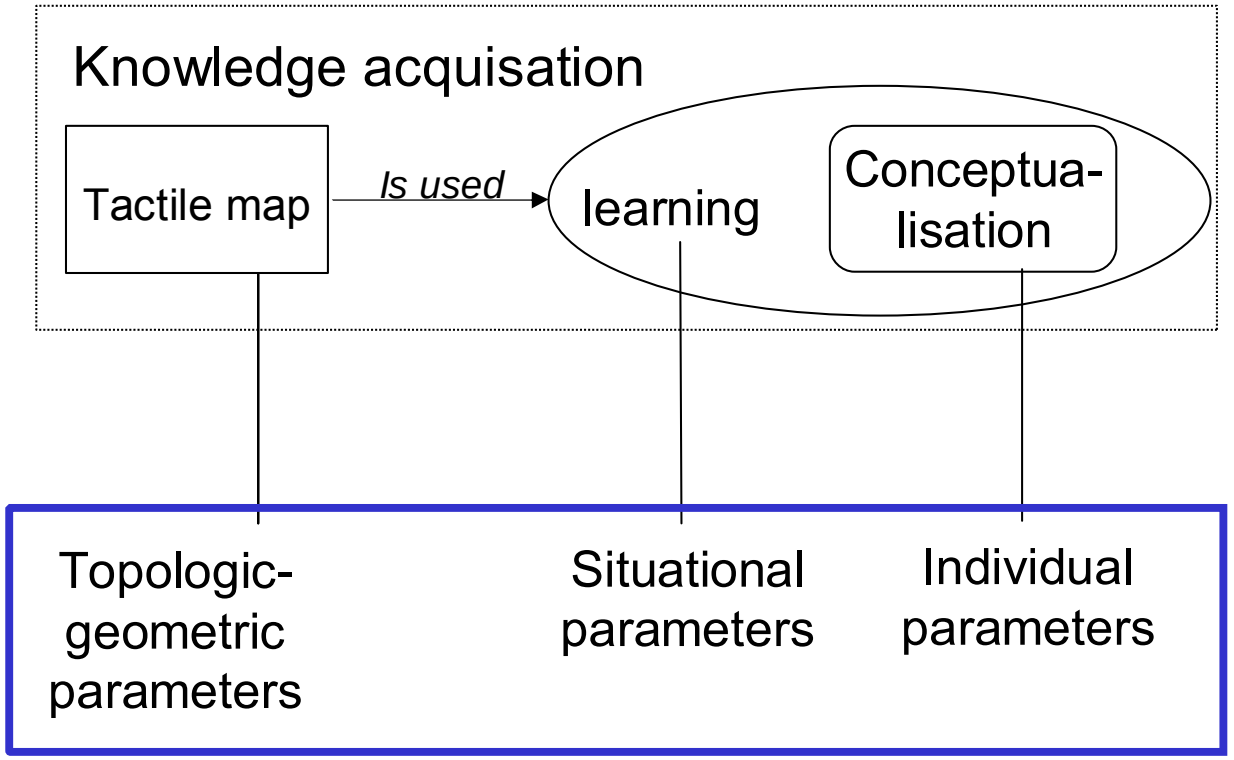




# Cognitive Adequate Tactile Map

- Strube, 1992: Cognitive adequacy (for expert systems)
- Tactile maps are used in a process of knowledge acquisition
- Process of knowledge acquisition should foster adequate mental models
- Concept *cognitive complexity* to model factors in knowledge acquisition

# Parameters of Cognitive Complexity



# Topologic-geometrical Parameters of the Map

- Structural Parameters
  - Topologic parameters
    - e.g. Number of edges, nodes, regions
  - Geometric parameters
    - e.g. Realisation of lines, symbols

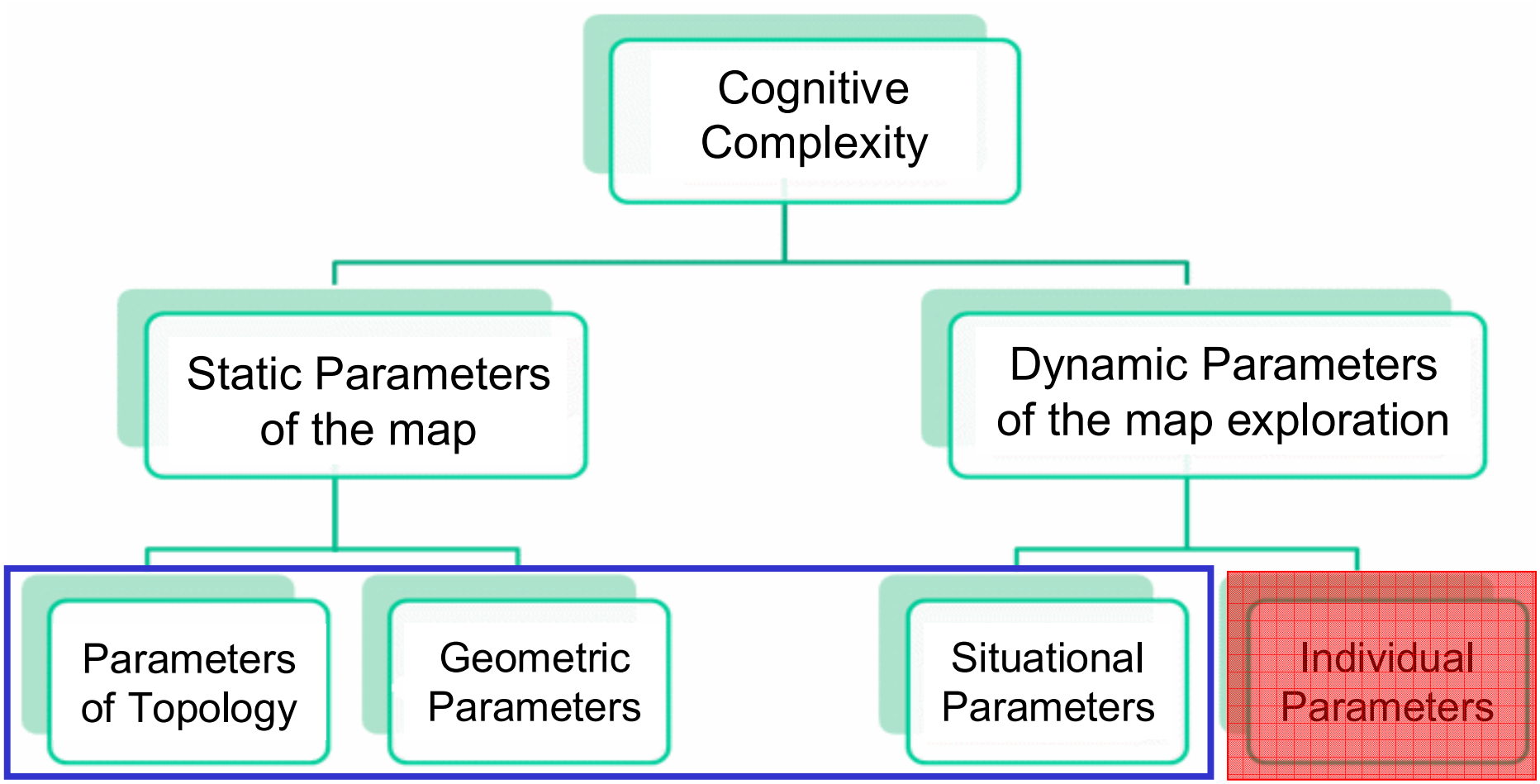
# Situational Parameters of the Map Exploration

- Factors in the learning situation
  - Surrounding of the exploration, e.g. quiet vs. noisy
  - Urgency of the task, e.g. limited vs. unlimited time
  - Emotional state of the user, e.g. aroused vs. depressed (Valence-Arousal-Modell von Russell, 1980)

# Individual Parameters in Cognitive Processing

- Cognitive abilities of the map reader (Hirn, 2009)
  - Exploration strategies, e.g. with or without a second hands for setting a reference point
  - Ability to interpret maps
  - Knowledge of concepts used in maps ← might be a reason not to use blind people for tactile maps!

# Taxonomy of Cognitive Complexity



# A Pilot Study with You-Are-Here Maps

1: Search for the YAH location indicator

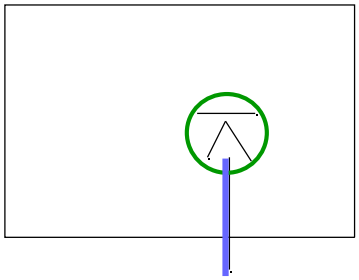
2: Usage of the YAH location indicator to find the YAH location symbol

# Research Goals & Research Questions

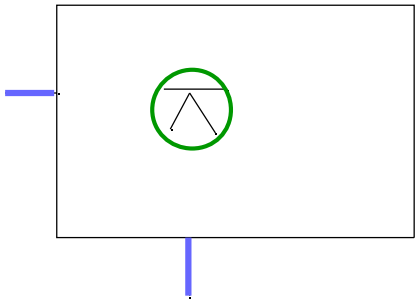
- Goal:
  - Evaluate Efficiency in usage (in Find the YAH Point): Among the three options, which type of indicator is the most efficient for finding the YAH location in a tactile map?
  - Evaluate Cognitive Adequacy (in Map Exploration): How much do the indicators impede the acquisition of a mental representation of the maps?
- Subgoals:
  - Settle key factors on how to realize tactile maps made with an tactile printer
  - Establish a methodology for experiments

# YAH Map Usage: Indicators to Find the YAH Point

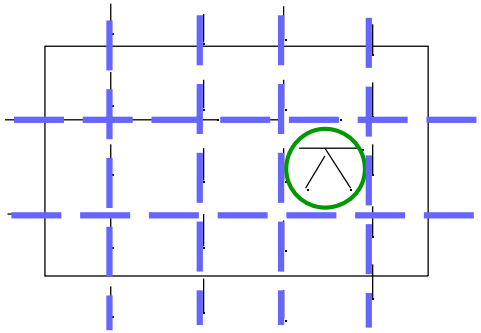
YAH Location Indicator & YAH Location Symbol must be adopted for the tactile domain



Indicator line



Frame marks

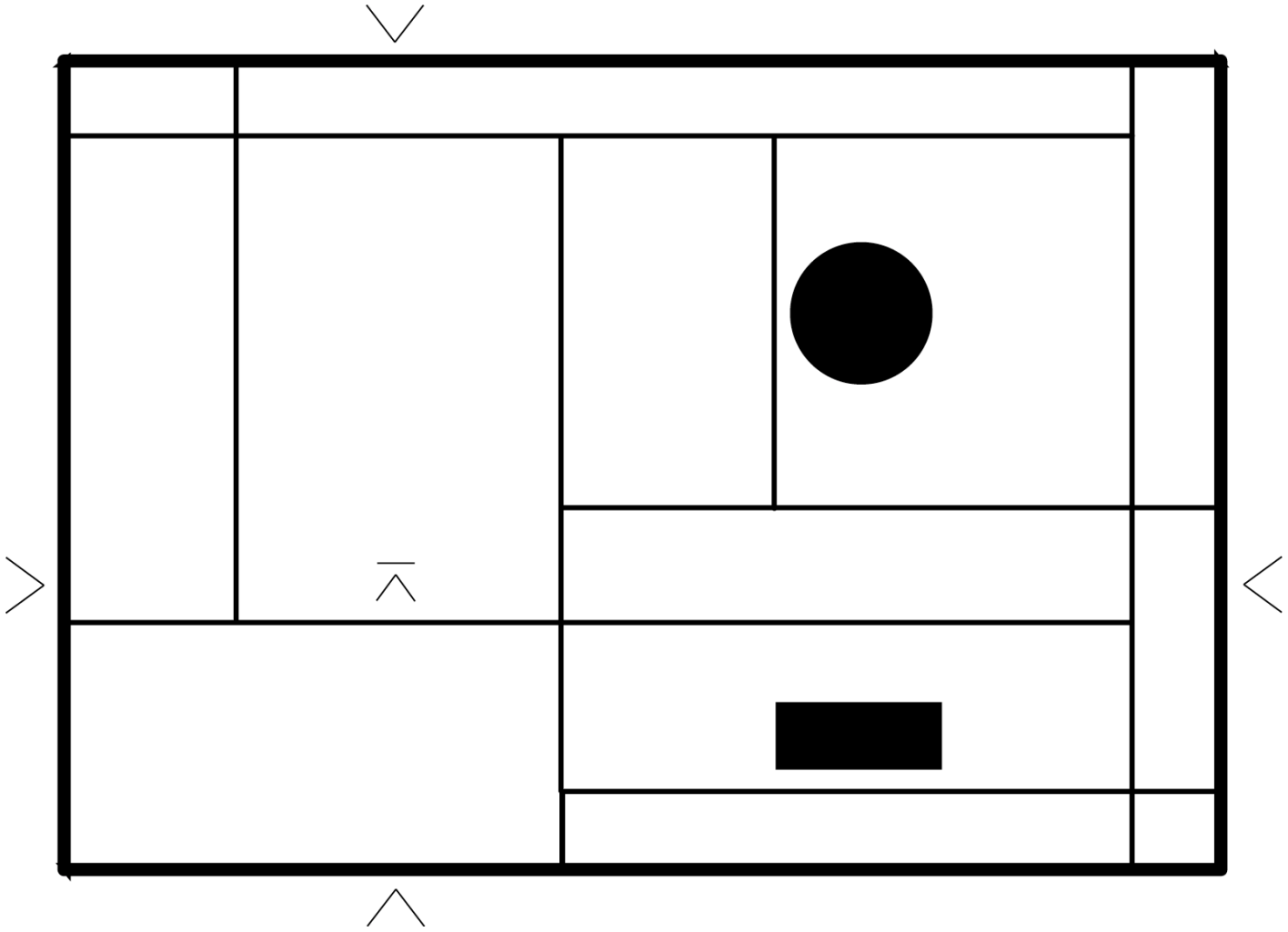


Grid

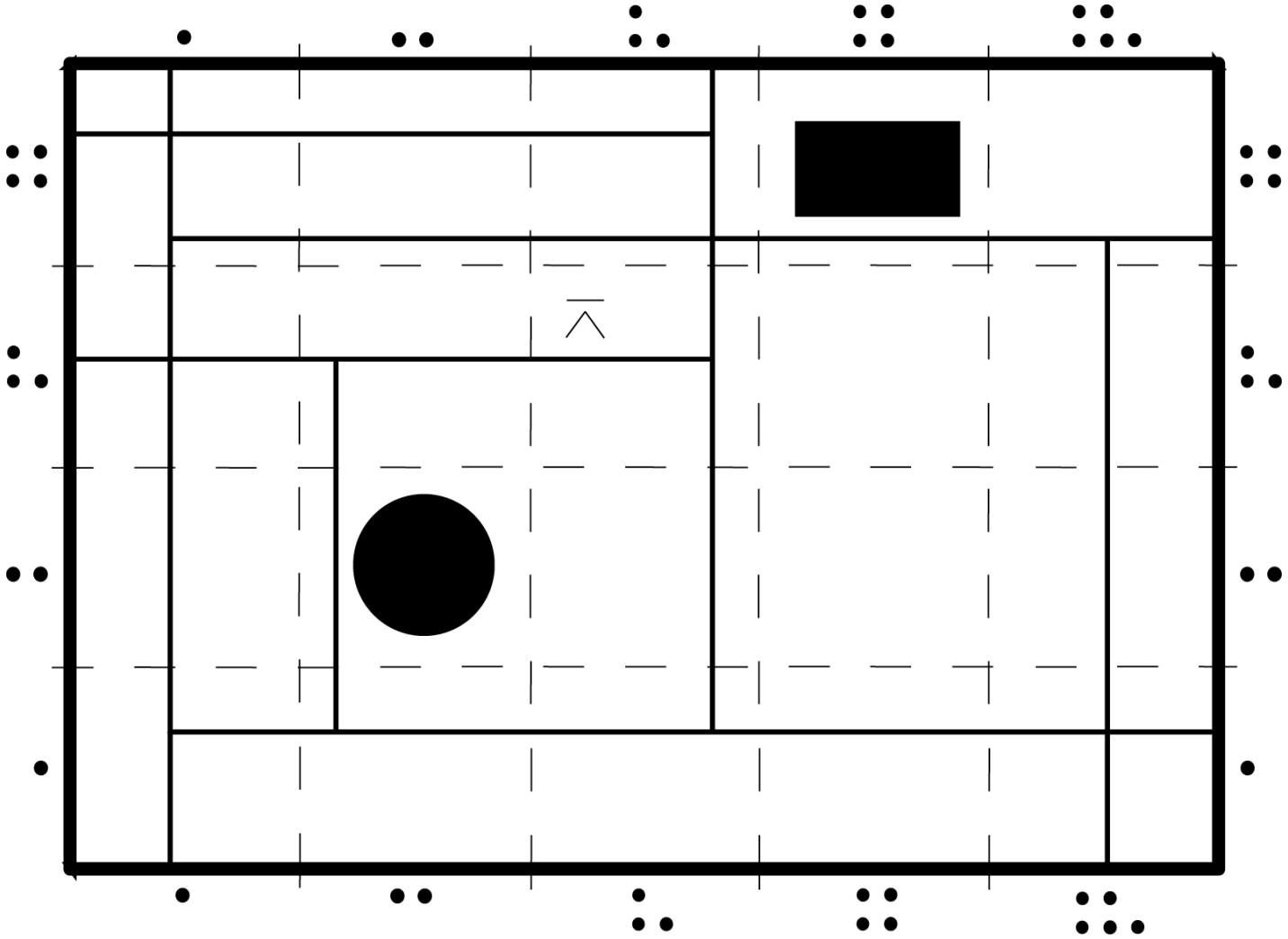
YAH location symbol

YAH location indicator

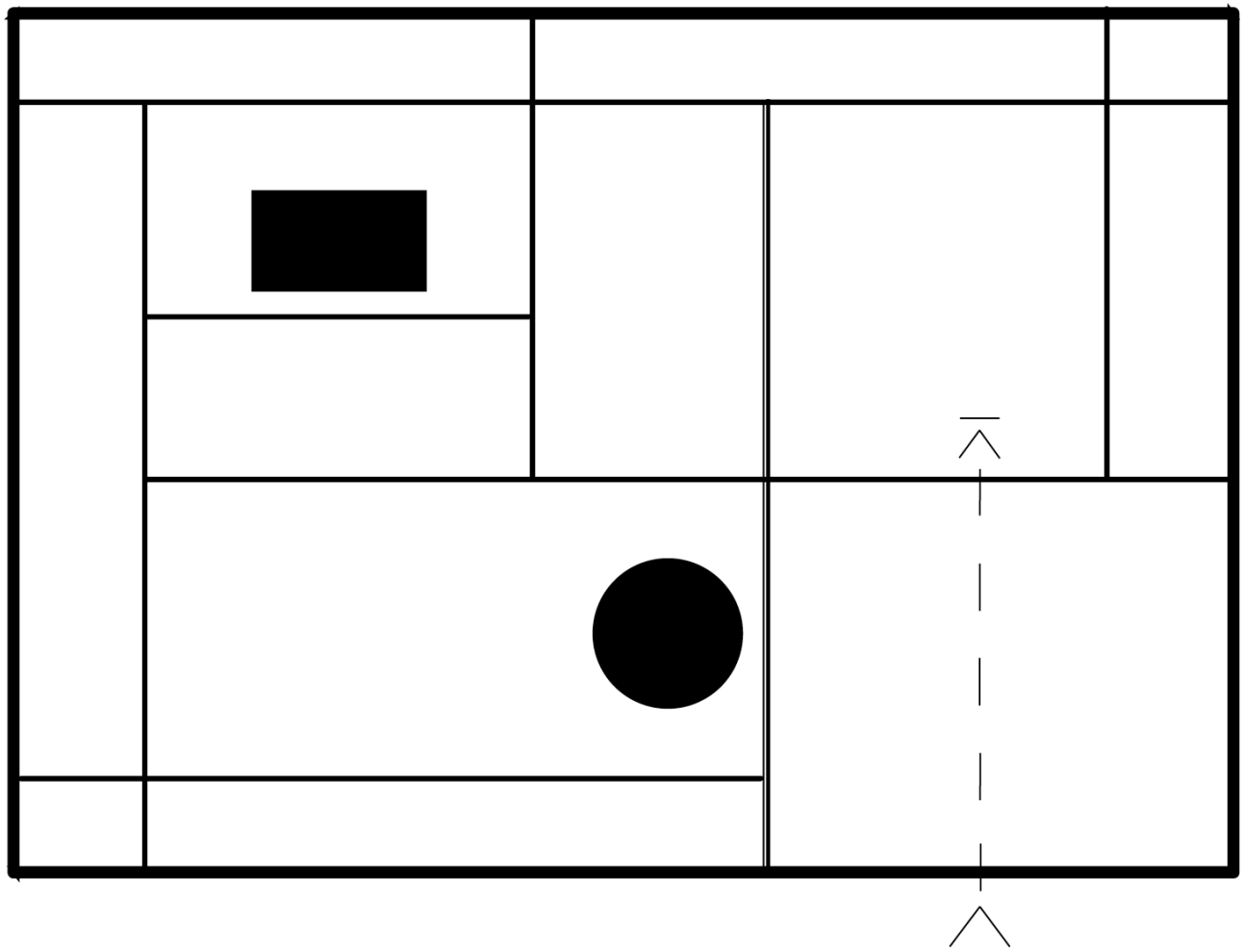
# Condition Frame Marks



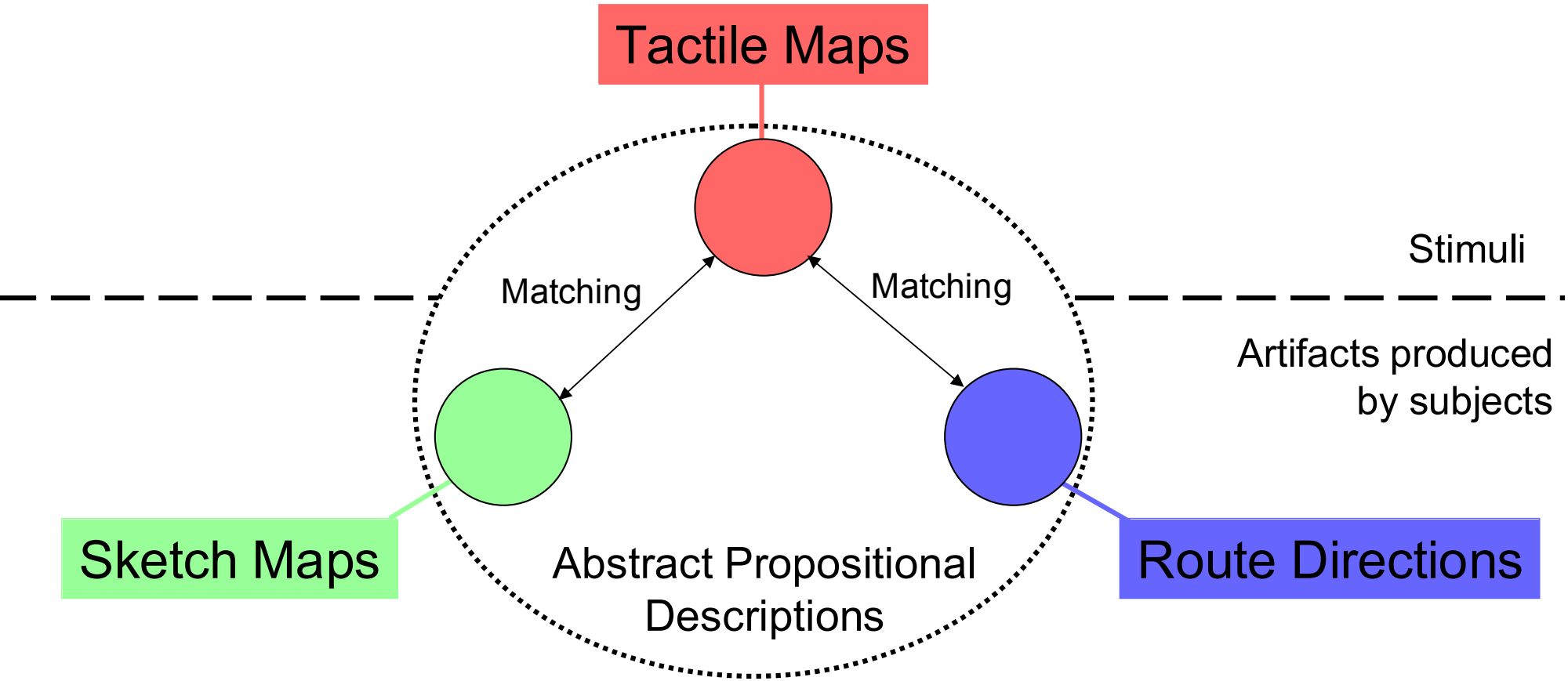
# Condition Grid



# Condition Indicator Line

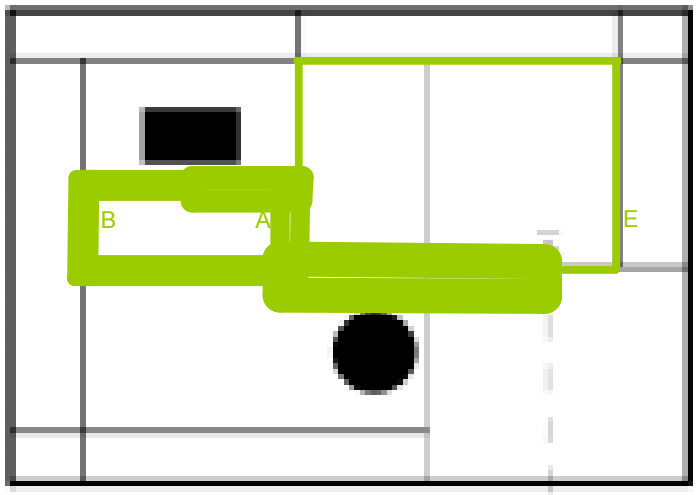


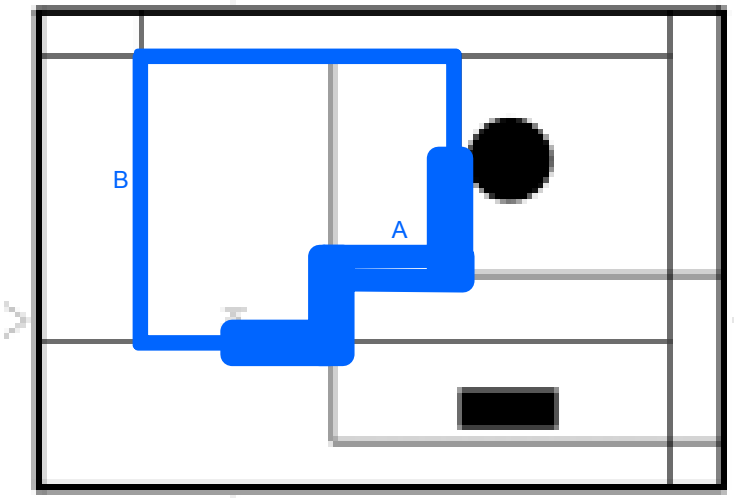
# Methodology of Evaluation

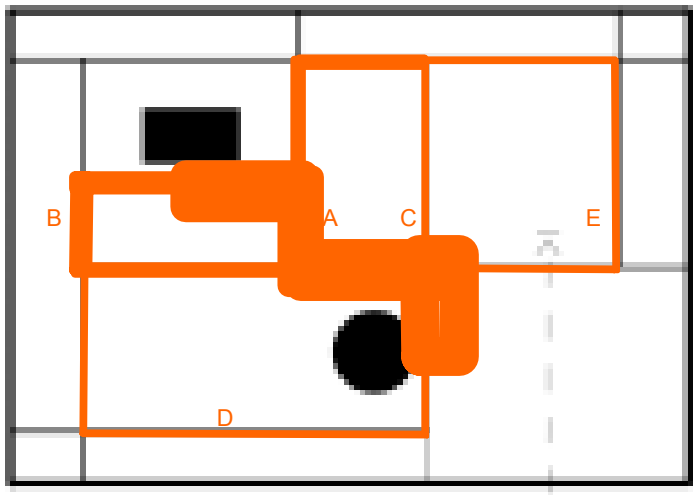


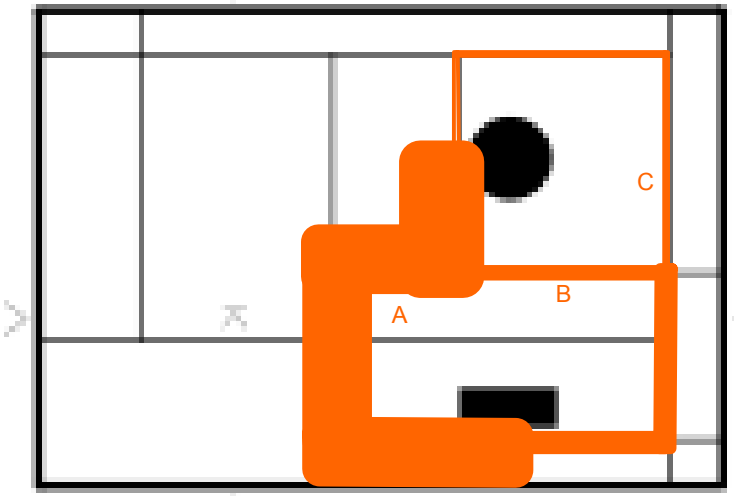

External representations used in analyzing the data

# Visualisation of Route Directions (a selection)



# Interpretation of Results

## Efficiency in usage:

The grid is significantly worse than the indicator line or the frame marks.

Results in the frame marks condition do not significantly differ from results in indicator line condition.

## Cognitive Adequacy:

The grid has an significant detrimental effect on acquiring a mental representation that stores survey knowledge.

The good results in the indicator line condition do not significantly differ from results in the frame marks condition.

Subjective ratings appear to support this result.

# Expectations Reviewed

## Efficiency in usage:

- Subjects perform best with Guiding line (✓)
- Subjects perform worst with Grid ✓

## Cognitive Adequacy:

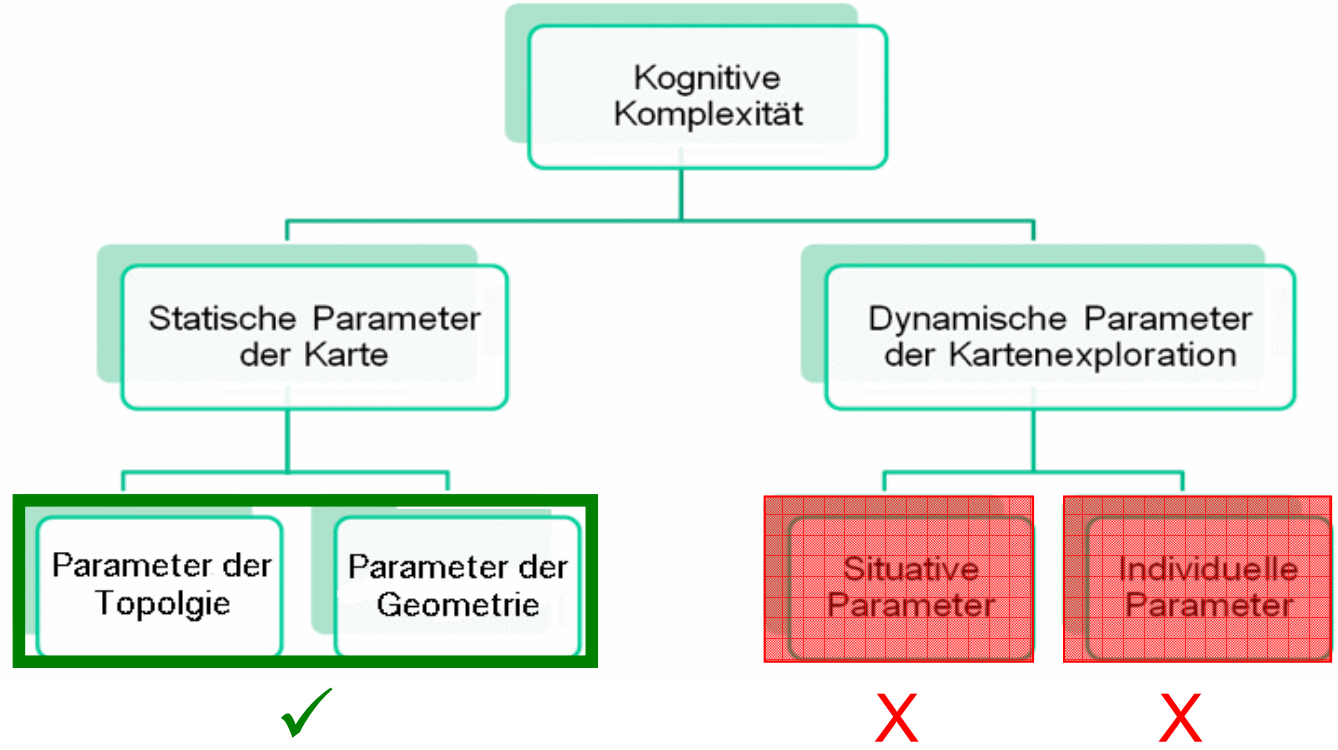
- Subjects perform best with Frame marks (✓)
- Subjects perform worst with Grid ✓

Guiding line & Frame Marks not differ that much.

Recommendation: Use an indicator line or frame marks to indicate the position of an entity in a tactile map, not a grid.

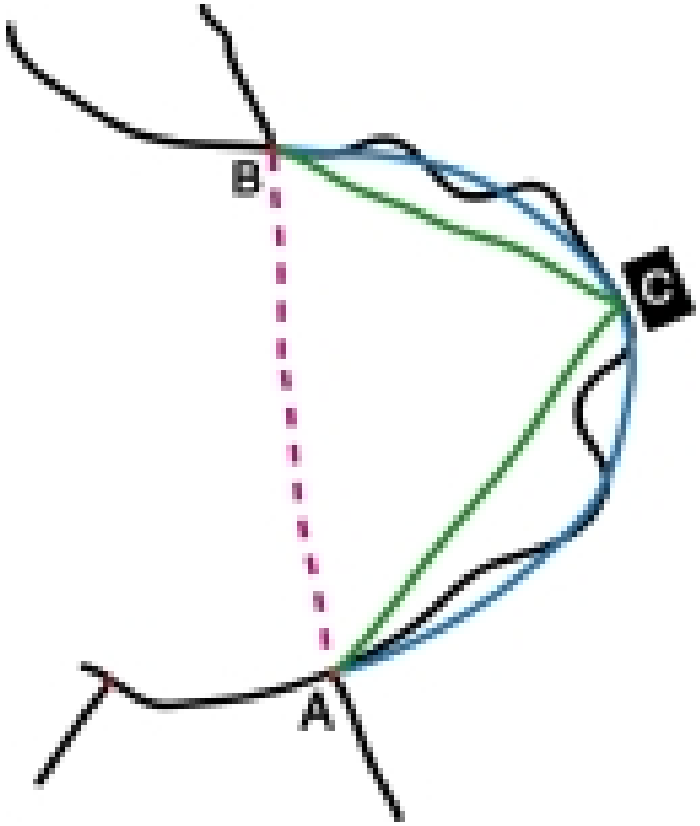
# Further Studies: Interplay of geometry and topology

- Interplay of geometry and topology on the cognitive complexity
- What is the quality of omitting or generalization?



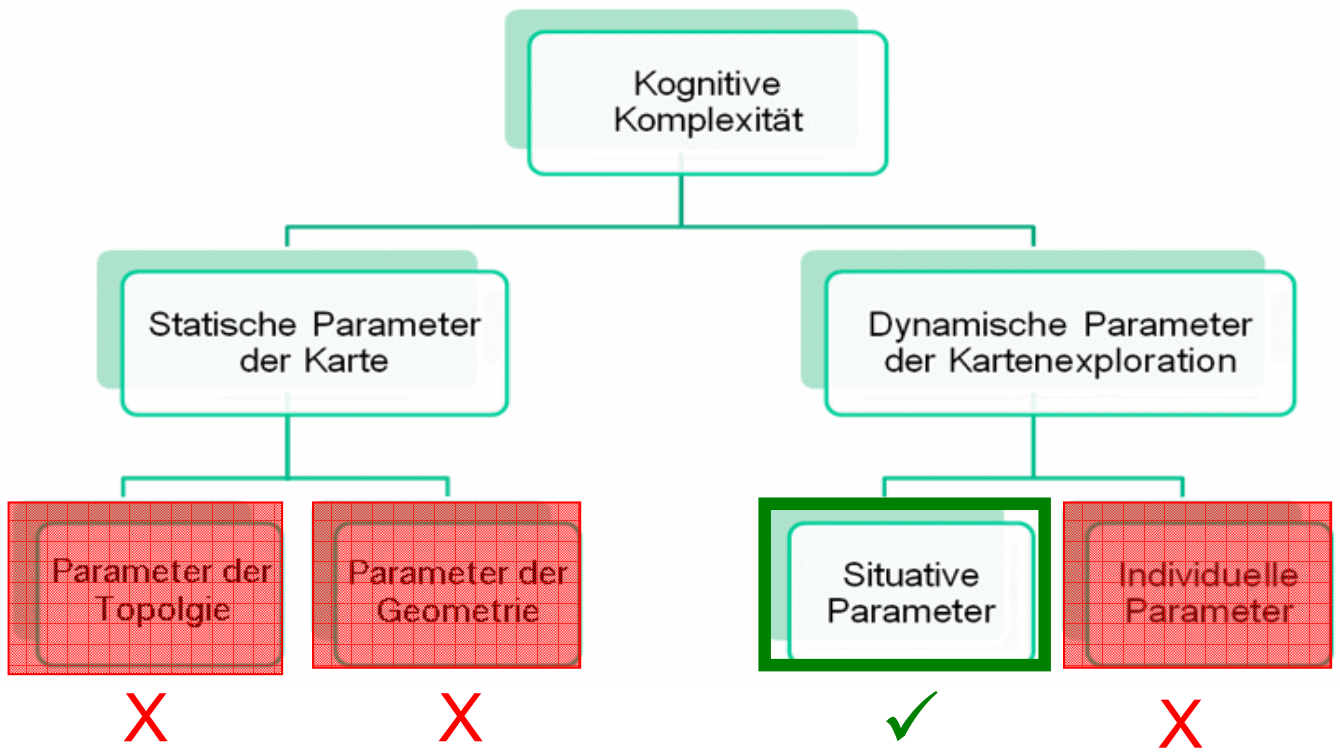
# Experiment: Interplay of Geometry and Topology

- Conceptualisation of tracks in relation to track style, existence of landmarks and overall map complexity



# Further Studies: Situational Parameters

- Effect of situational parameters on the cognitive complexity of the map exploration



# Experiment: Exploration Style

- Using a reference point in exploration vs. Free exploration:
- Are topological and geometric properties better understood?

# What I see as Common Interest with CoSy

- Common interest: Spatial Cognition, especially knowledge acquisation with maps
- Route Knowledge contributes to survey knowledge, but experiments on survey knowledge underrepresented
- Interplay of survey knowledge and route knowledge might be interesting: e.g. in project I6 NavTalk

Thank you for your attention.

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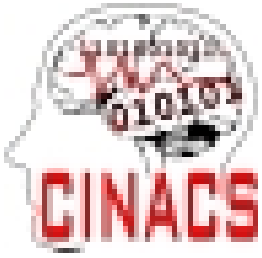
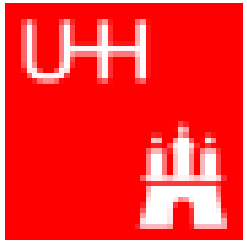
This work was supported by



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