LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Design and Distribution of Physical and Mobile Interfaces for Multi-Tag Interaction

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Diploma Thesis
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Outline

- Motivation
- Topic of the Thesis
- Related Work
- Preliminary Classification of Multi-Tag Interaction
- 1st User Study: Navigation and Selection
- 2nd User Study: Actions and Objects
- 3rd User Study: GUI Widgets
- Summary

Physical Mobile Interaction

- **Interaction between mobile devices and smart objects [Rukzio et al., 2007]**
- **Goals**
  - More intuitive, simpler and direct interaction
  - Overcoming the adversities of mobile devices
- **Single-Tag Interaction**
  - Interaction with single tag ➔ often first interaction step
  - No real physical interface & interaction
  - Suggested classification [Herting et al., 2008]: Presentation of Information, Physical Hyperlinks, Tagging, Broadcasting, Tag Emulation, 2-Way-Interaction
- **Multi-Tag Interaction**
  - Interaction with more than one tag or object
  - Stronger focus on physical interface & interaction
  - No suggested classification

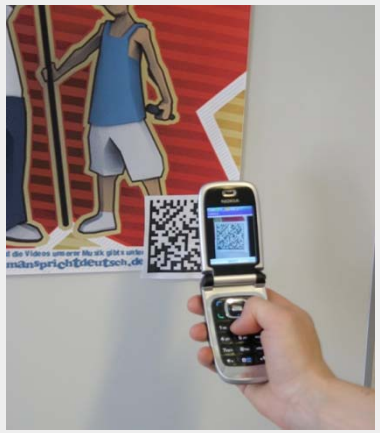
Sources: www.touchandtravel.de, www.visa-asia.com

Topic of the Thesis

- **Investigation of interface and interaction design distributed between physical objects and mobile devices**
- **Classification of Multi-Tag Interactions and Applications**
- **Comparison and evaluation of different designs for Single-Tag Interaction and Multi-Tag Interaction**
  - Categories of Multi-Tag Interaction
  - Specific example applications
  - Different designs for Single-Tag Interaction and Multi-Tag Interaction
- **Best practices for design of multi-tag applications and interfaces**

Related Work

- **Enabling Technologies**
  - Numeric Identifiers, Bluetooth, Infrared, Visual Markers, Laser Pointer, RFID, Near Field Communication (NFC)
- **Basic Physical Mobile Interaction Techniques**
  - Touching, Pointing, Scanning, User Mediated Object Interaction [Rukzio et al., 2007], Hovering [Välkkynen, 1997]
- **Advanced Physical Mobile Interaction Techniques (Multi-Tag Interaction)**
  - Collect & Drop [Broll et al, 2008]
    - Action Items and Data Items
  - Touch & Interact [Hardy et al., 2008]
    - Interaction with public display (cf. touch screens)



Source: [Rukzio et. Al , 2007]

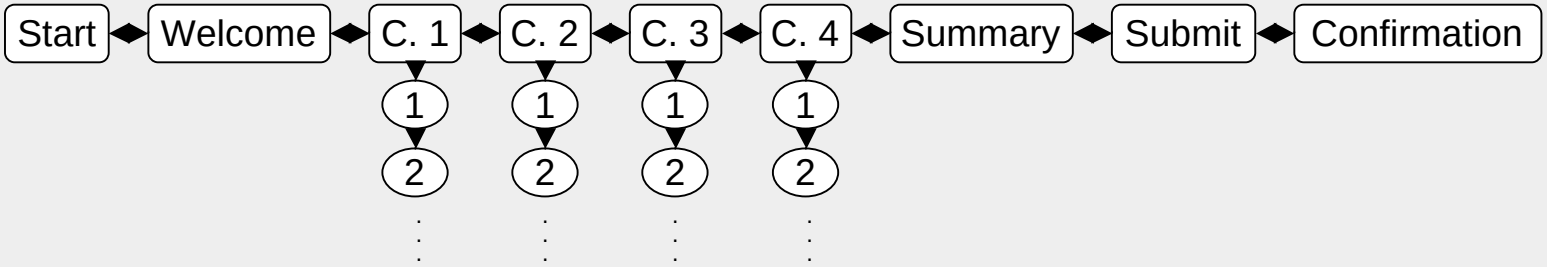
Preliminary Classification of Multi-Tag Interaction

- **Navigation**
  - Interaction-specific
  - Navigation within an application accomplished through physical interaction
  - Different tags offer different entry points to an application
- **Selection**
  - Interaction-specific
  - Selection of options/items accomplished through physical interaction
- **Combination of Information**
  - Application-specific
  - Combination of same/different types of information (e.g. actions and objects)
- **Mapping**
  - Application-specific
  - Mapping of specific application-features to specific tags

The First User Study (1)

- **Tested categories**
  - Selection
  - Navigation
- **Use case**
  - Ordering in a restaurant with the help of an NFC enhanced menu
- **User study design**
  - 16 participants
  - Independent variables: design, task complexity, interface complexity
  - Dependent variables: execution time, errors, attention shifts

Selection \ Navigation	Handy	Poster
Handy	STI	MTI #1
Poster	MTI #2	MTI #3



The First User Study (2)

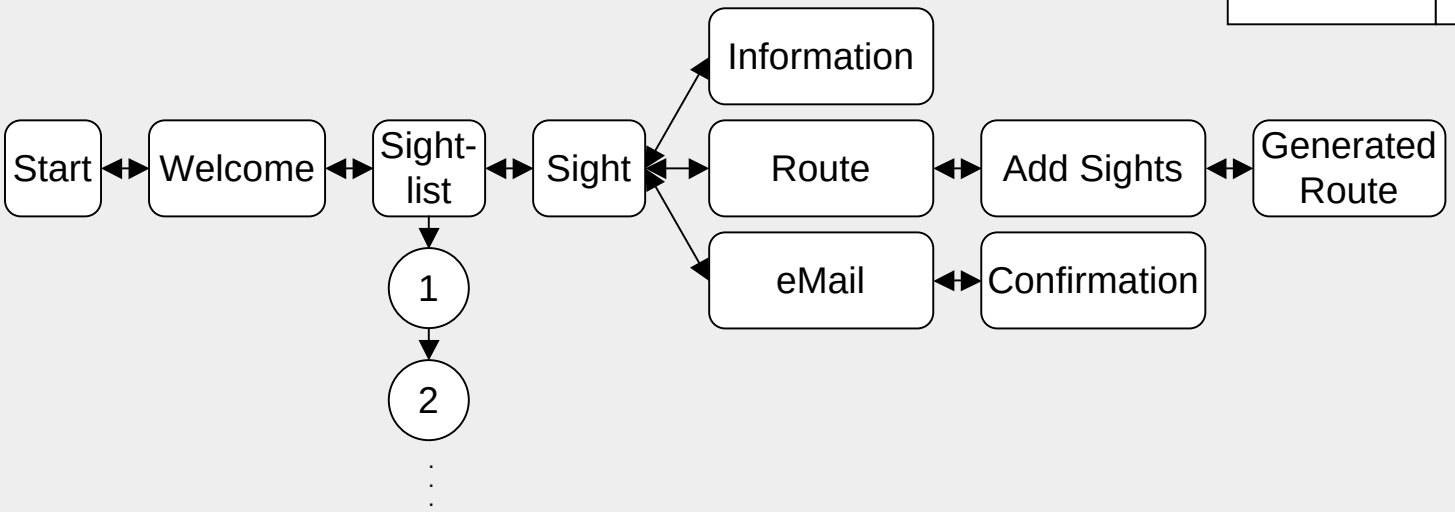
- **Results**
  - The more tags the faster the execution time
  - Problems: usage of radio buttons; handling of NFC
  - Freedom during execution (order of execution, time of correction etc.)
  - no permanent switching between mobile device and poster

  → Multi-Tag Interaction #3

The Second User Study

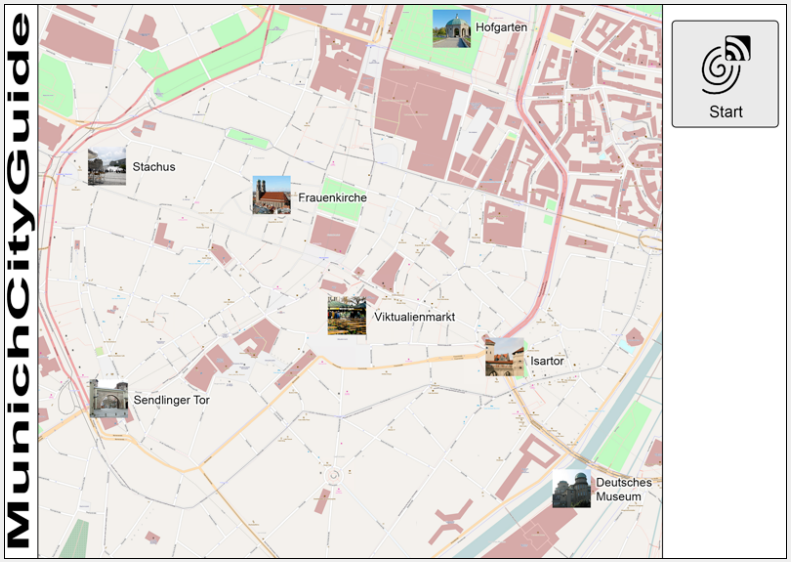
- **Tested category**
  - Combination of Information
- **Use case**
  - Interacting with a City Guide Poster to get information, plan a route or send an e-mail
- **Workflow**

Action \ Object	Handy	Poster
Handy	STI	MTI #1
Poster	MTI #2	MTI #3 MTI #4



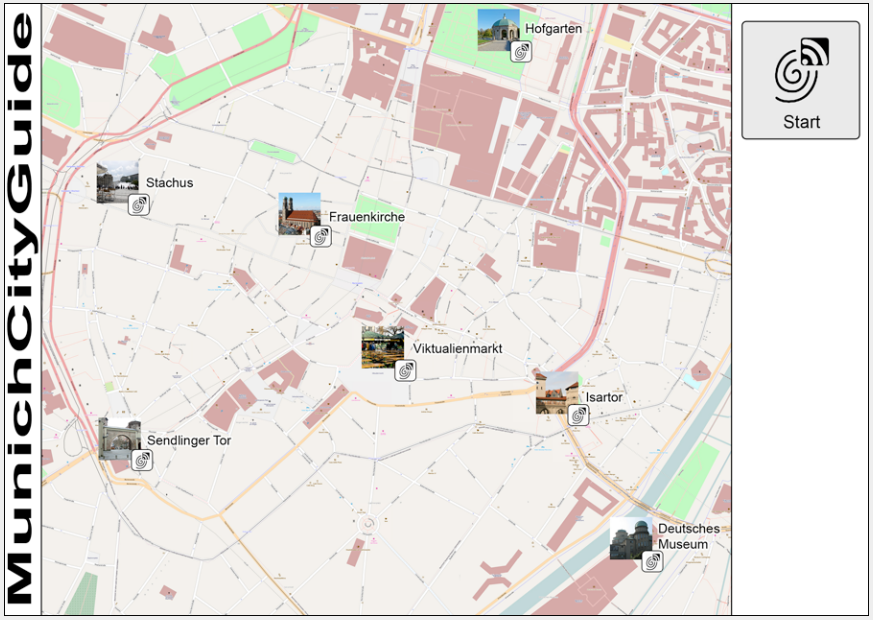
2nd Study: Single-Tag Interaction

- **Tag-Enhanced Poster & Mobile Application**



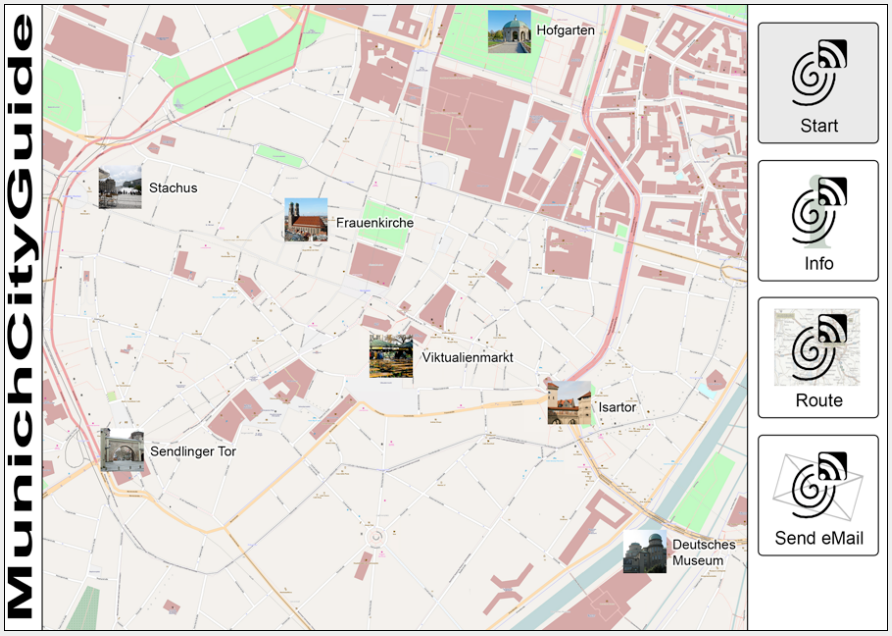
2nd Study: Multi-Tag Interaction #1

- **Tag-Enhanced Poster & Mobile Application**



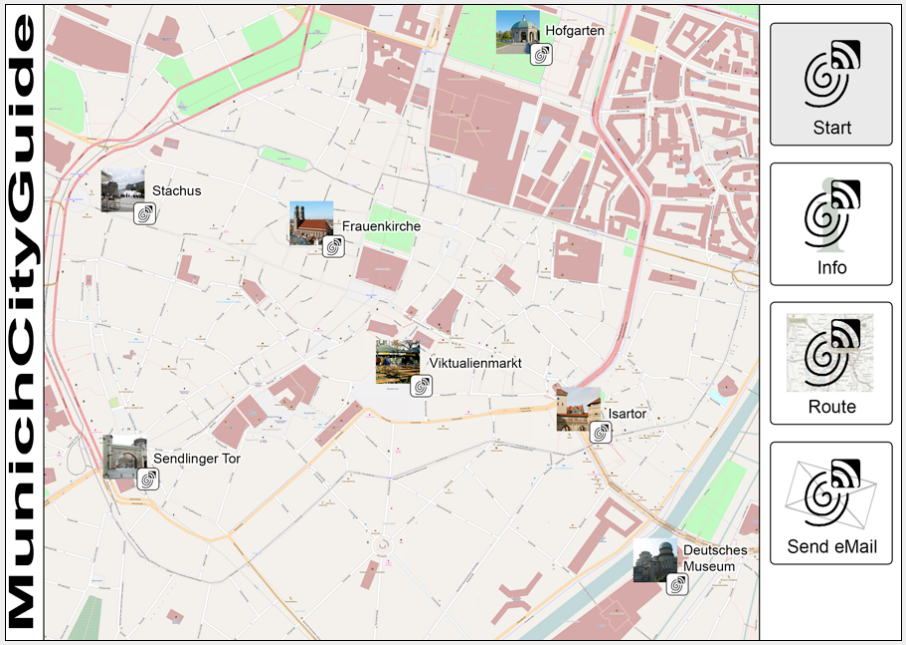
2nd Study: Multi-Tag Interaction #2

- **Tag-Enhanced Poster & Mobile Application**



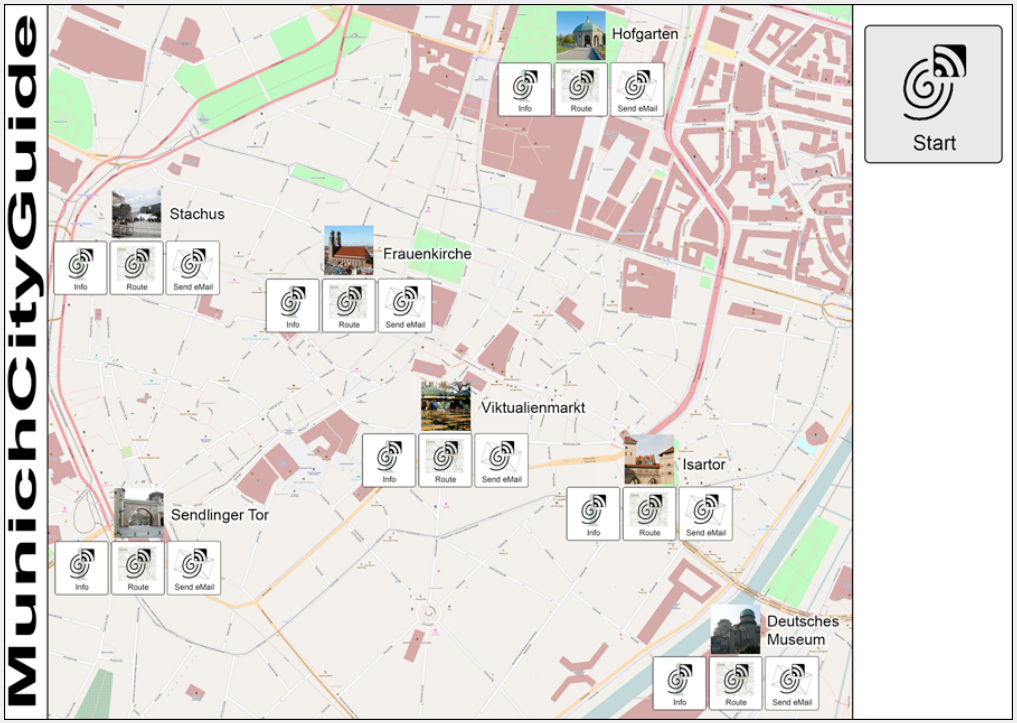
2nd Study: Multi-Tag Interaction #3

- **Tag-Enhanced Poster & Mobile Application**



2nd Study: Multi-Tag Interaction #4

- **Tag-Enhanced Poster & Mobile Application**



2nd Study: Independent Variables

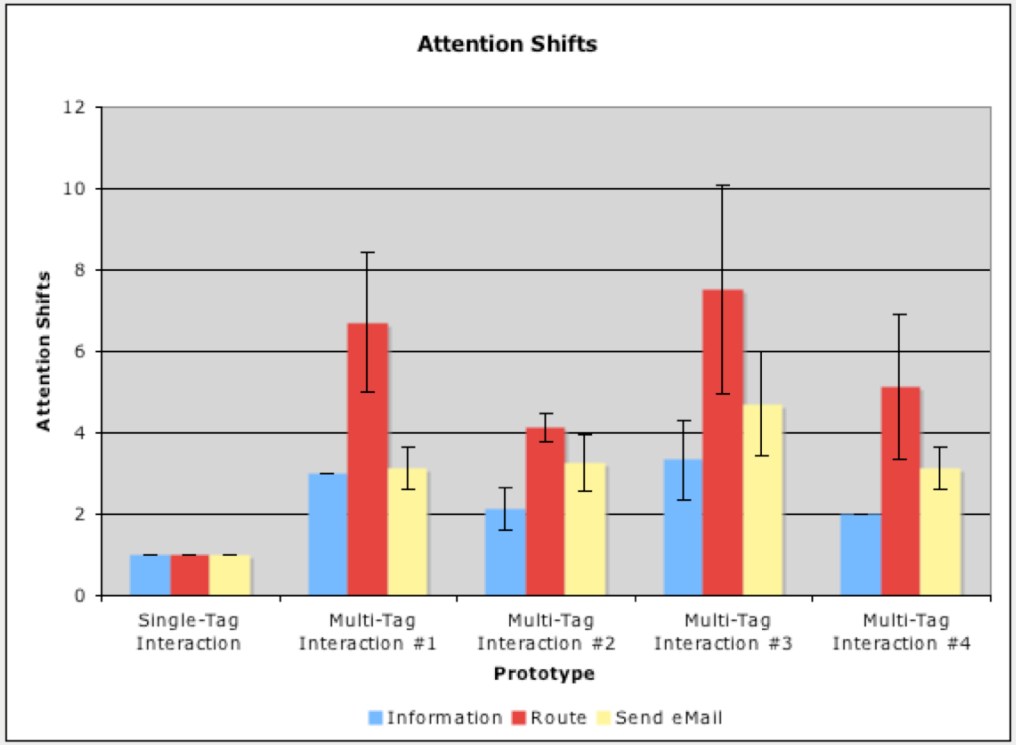
- **Design**
  - Single-Tag Interaction
  - Multi-Tag Interaction #1 (Sights as Tags)
  - Multi-Tag Interaction #2 (Actions as Tags)
  - Multi-Tag Interaction #3 (Sights and Actions as Tags)
  - Multi-Tag Interaction #4 (Actions for each Sight as Tags)
- **Task**
  - Information (Combination of object and action)
  - Route (Combination of several objects and an action)
  - Send eMail (Combination of object, action and additional information)

2nd Study: User Study Design

- **Implementation**
  - Java ME, Nokia 6131 NFC SDK, J4ME
- **User Study Design**
  - 15 Participants (Latin Square Design)
  - Demographic Questionnaire, Modified IBM “Computer System Usability Questionnaire”, Comparing Questionnaire
  - Video Analysis
  - Dependent Variables: Attention Shifts, Errors and Execution Time
  - Beforehand analysis with the Keystroke-Level-Model
  - Evaluation with SPSS

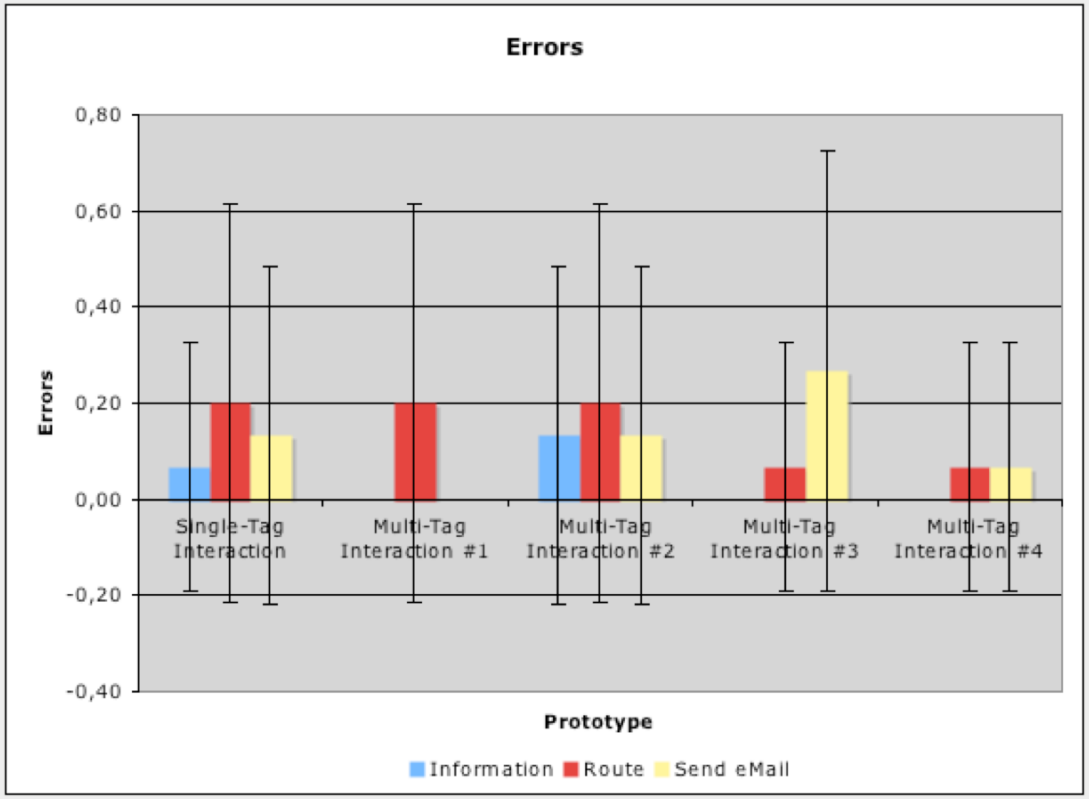
2nd Study: Evaluation (1)

- **Attention Shifts**
  - Between mobile device and poster
  - Equal number of Attention Shifts due to forced execution order (except errors)
  - Differing number of Attention shifts by series of tags (trust of haptic feedback)
  - Multi-Tag Interaction #3 highest number of attention shifts



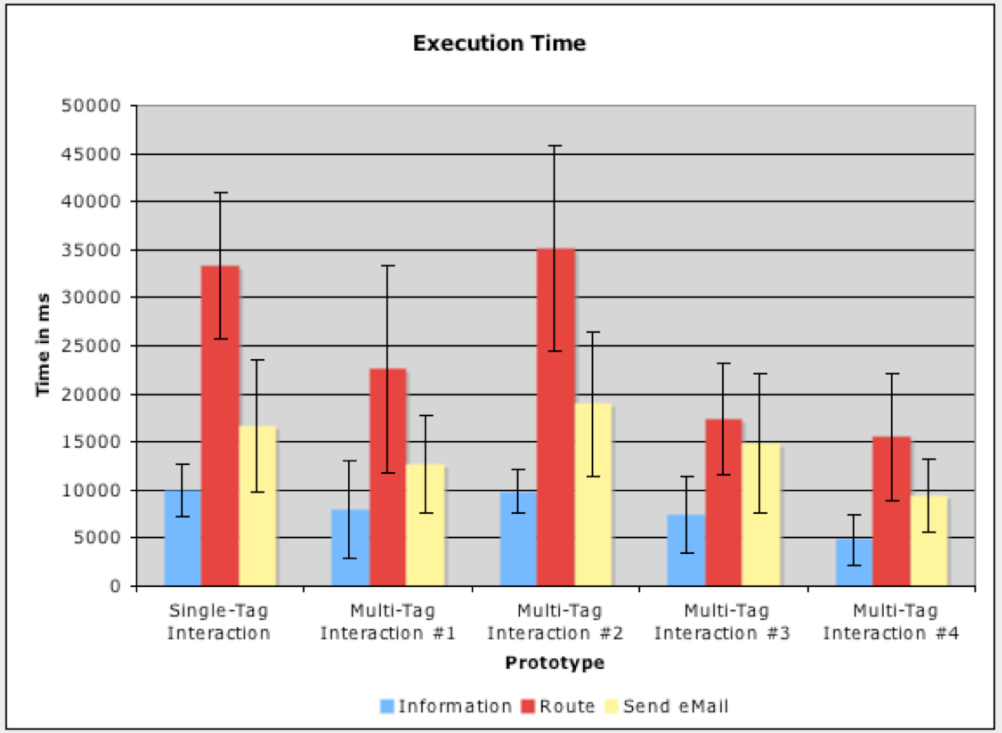
2nd Study: Evaluation (2)

- **Errors**
  - Hardly any errors
    - Explanation and practice beforehand
  - Problems:
    - Handling of radio buttons
    - Forgotten confirmation
    - E-mail: Information unnecessarily added
    - Confusion when to touch route-tag



2nd Study: Evaluation (3)

- **Execution Time**
  - Time from “Start” to “Submit”
  - From slowest task to fastest: Route, Send eMail, Information
  - Slowest Prototype: Multi-Tag Interaction #2
  - Fastest Prototype: Multi-Tag Interaction #4
  - Comparison with Keystroke-Level Model
    - Adjustment of attention shifts
    - Problems with “sequences of tags“ (mental acts (1.35s), pointing faster, KLM based on old Nokia phone)
    - More tags ➔ bigger difference

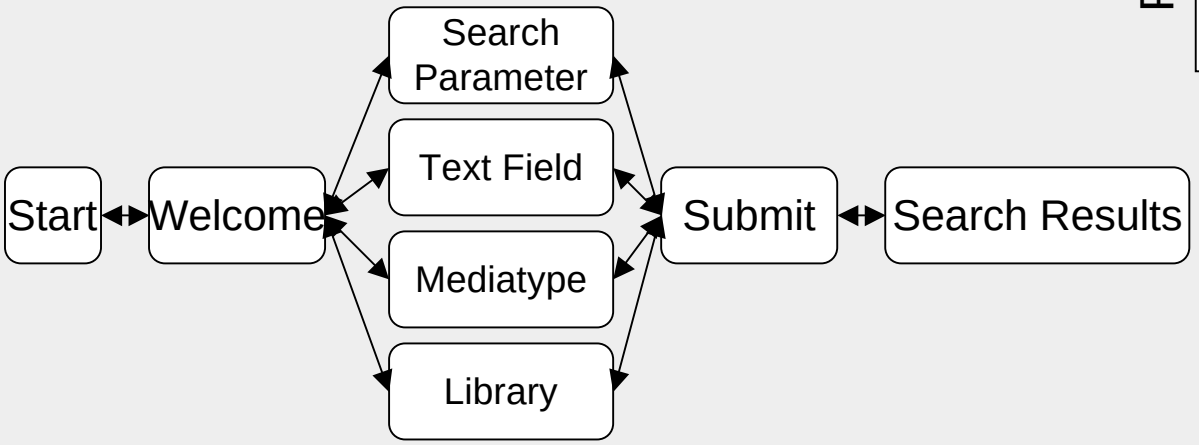


2nd Study: Qualitative Evaluation

- **(Nearly) equally liked: Multi-Tag Interaction #3 (5 users) and Multi-Tag Interaction #4 (6 users)**
  - Reasons: Fewer keypad input; less forced attention shifts
- **Least liked: Multi-Tag Interaction #2**
  - Reasons: Unintuitive work-flow (actions on poster, sights on mobile interface)
- **Suggestions for improvements**
  - Correction of already given input (e.g. sights during selecting a route)
  - Reduce confirmation on mobile interface

The Third User Study

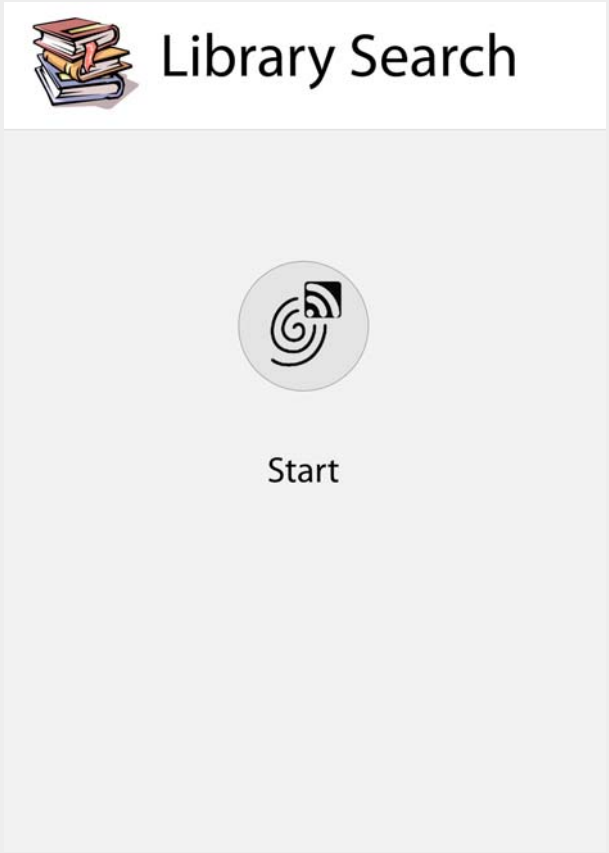
- **Tested categories**
  - Navigation and Selection
- **Use case**
  - Searching for a book in a library
- **Workflow**



Selection \ Navigation	Handy	Poster
Handy	STI	MTI #1
Poster	---	MTI #2

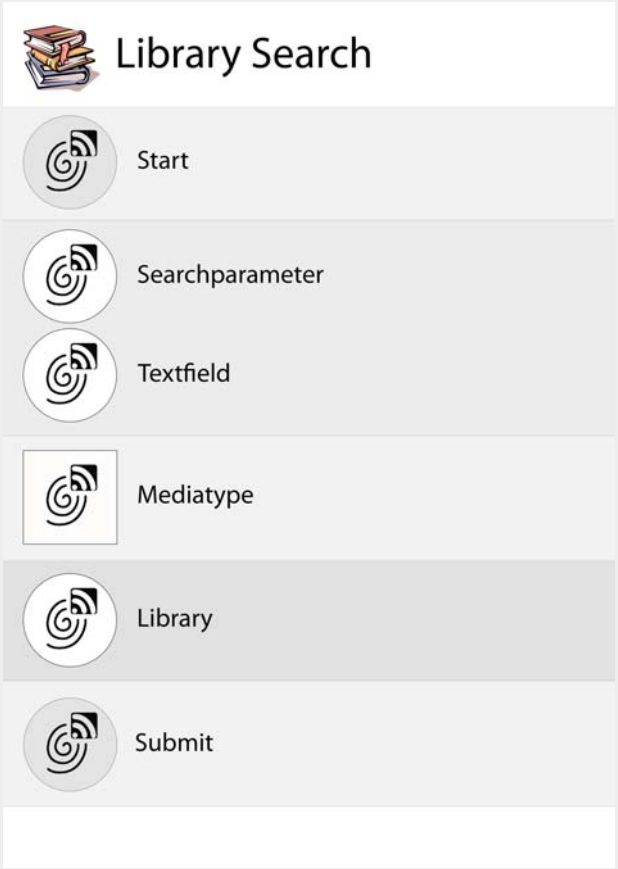
3rd Study: Single-Tag Interaction

- **Tag-Enhanced Poster & Mobile Application**



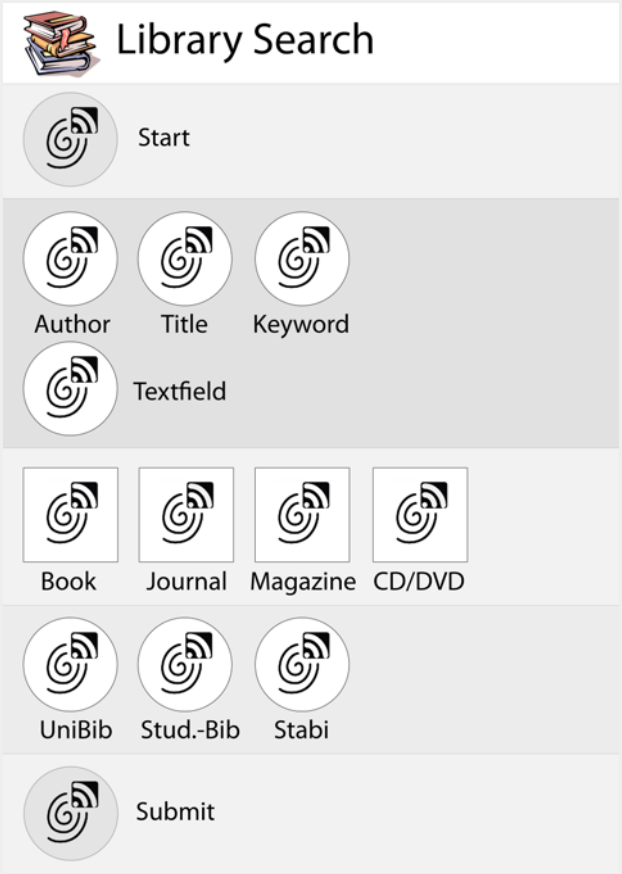
3rd Study: Multi-Tag Interaction #1

- **Tag-Enhanced Poster & Mobile Application**



3rd Study: Multi-Tag Interaction #2

- **Tag-Enhanced Poster & Mobile Application**



3rd Study: Independent Variables

- **Design**
  - Single-Tag Interaction
  - Multi-Tag Interaction #1
  - Multi-Tag Interaction #2
- **Task Complexity**
  - Low Complexity (no changes)
  - High Complexity (changes in the end)

3rd Study: User Study Design

- **Implementation**
  - Java ME, Nokia 6131 NFC SDK
- **User Study Design**
  - 15 Participants (Latin Square Design)
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  - Dependent Variables: Attention Shifts, Errors and Execution Time
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  - Equal number of attention shifts due to forced execution order (except errors (e.g. MTI #1))
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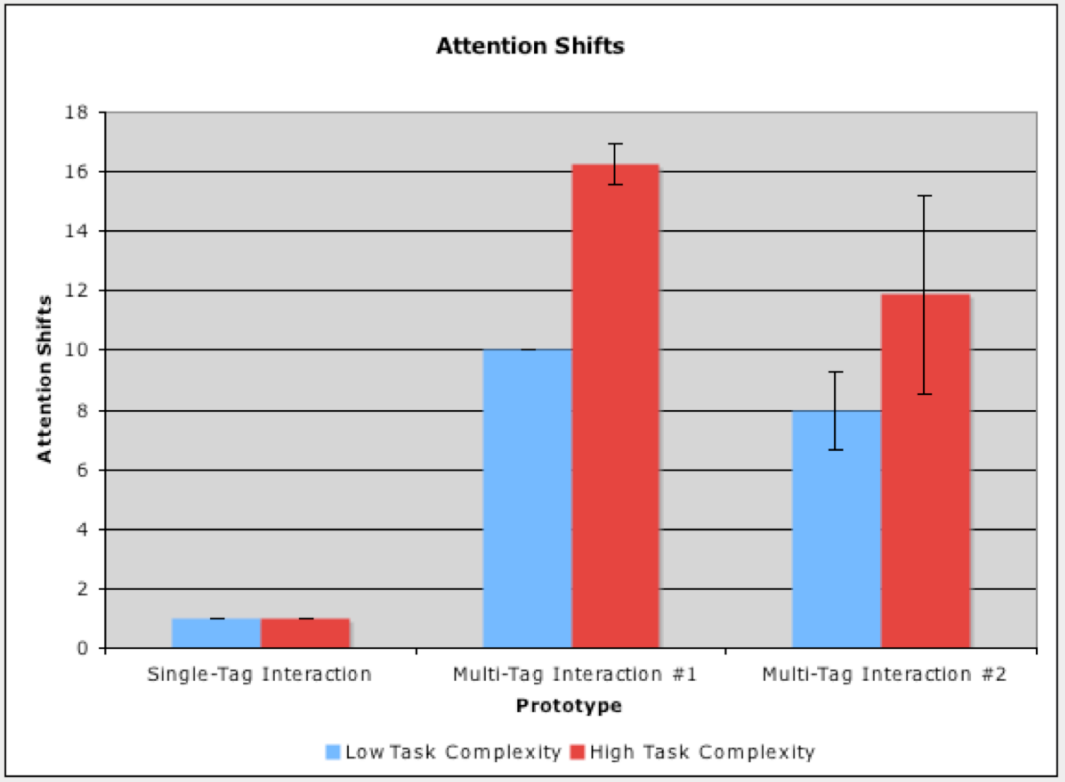
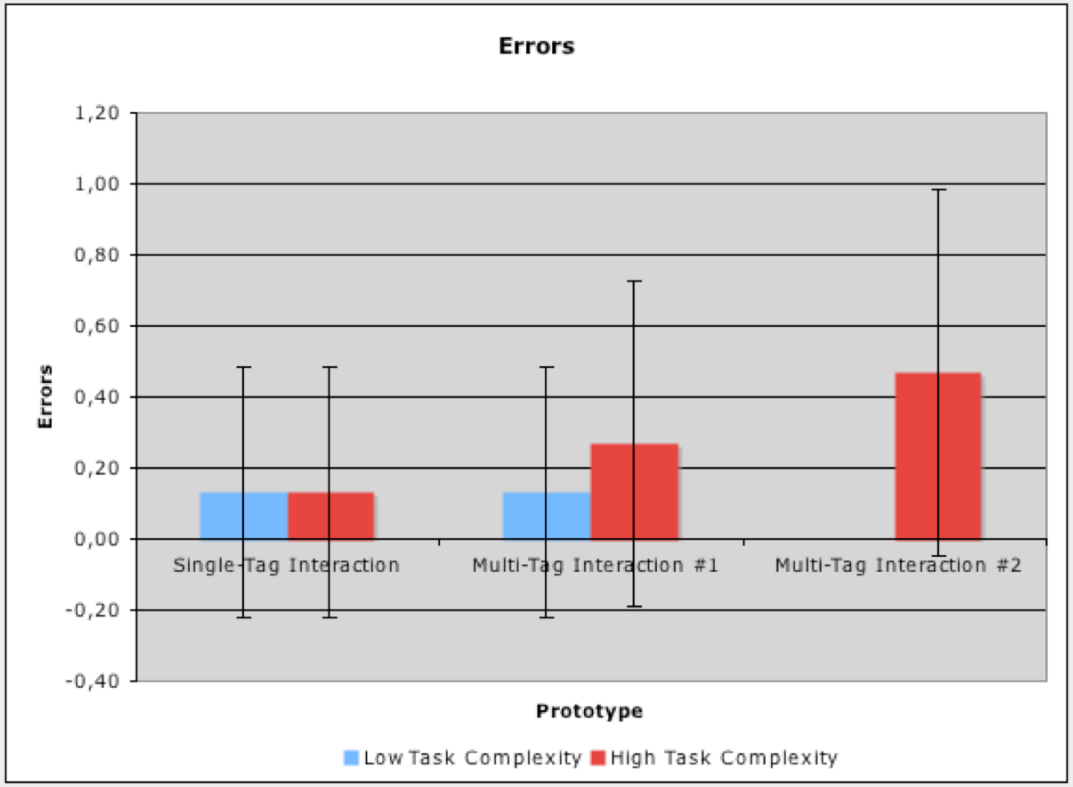


3rd Study: Evaluation (2)

- **Errors**
  - Hardly any errors
    - Explanation and practice beforehand
  - Problems:
    - Dropdown
    - Multi-Tag Interaction #1: Confirmation
    - Multi-Tag Interaction #2: Handling of “radio buttons” and “checkboxes” on poster



3rd Study: Evaluation (3)

- **Execution Time**
  - Time from “Start” to “Submit”
  - Slowest prototype: Multi-Tag Interaction #1
  - Comparison with Keystroke-Level Model
    - Adjustment of attention Shifts
    - Problems with “sequences of tags“ (mental acts (1.35s), pointing faster, KLM based on old Nokia phone)
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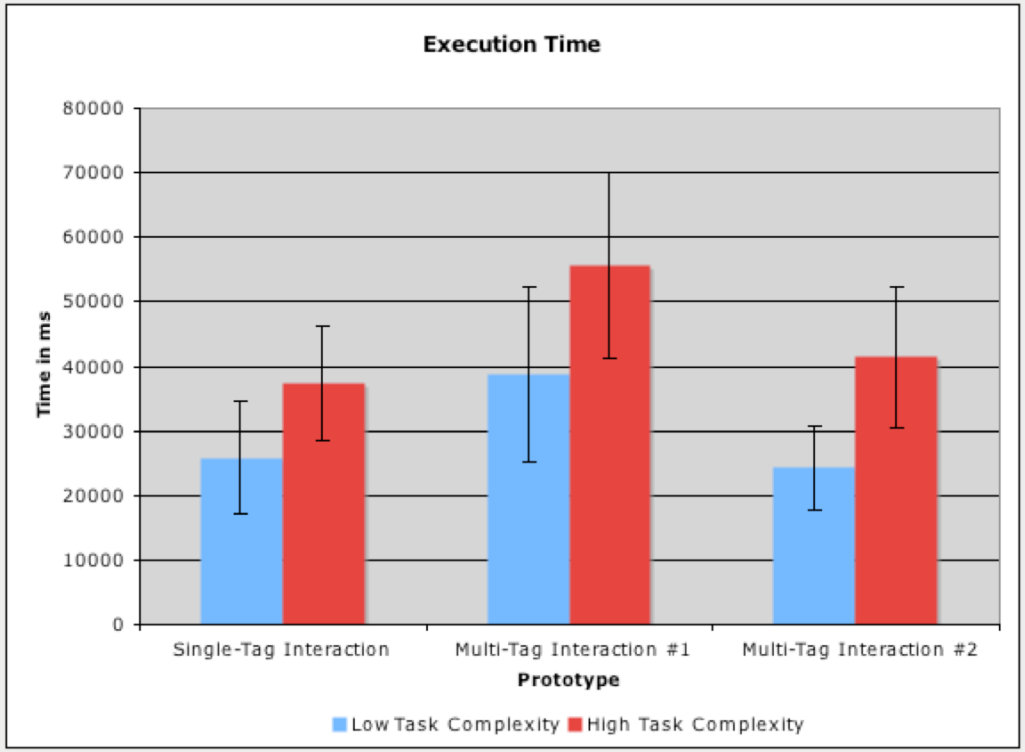


3rd Study: Qualitative Evaluation

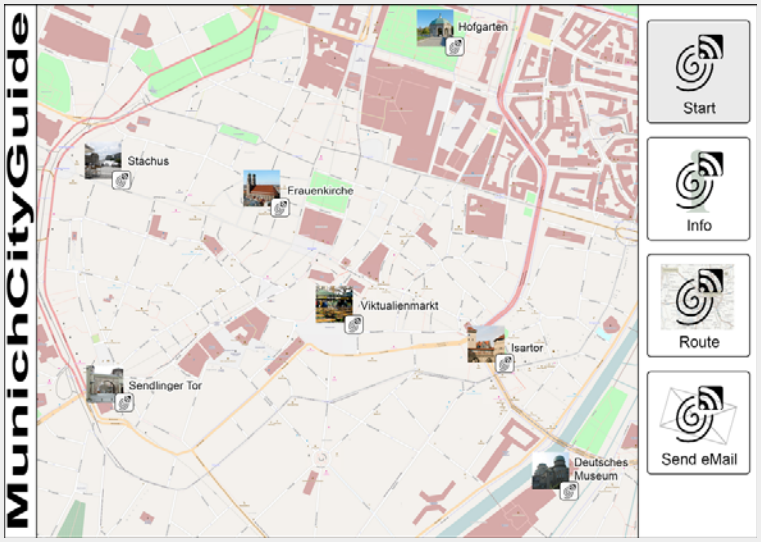
- **(Nearly) equally liked: Single-Tag Interaction (7 users) and Multi-Tag Interaction #2 (8 users)**
  - Reasons for STI: similar to known online form
  - Reasons for MTI #2: less keypad usage; good overview
- **Least liked: Multi-Tag Interaction #1**
  - Reasons: many forced attention shifts; confirmation after each selection
- **Suggestions for improvements**
  - Clear distinction between radio buttons and checkboxes (e.g. colors)

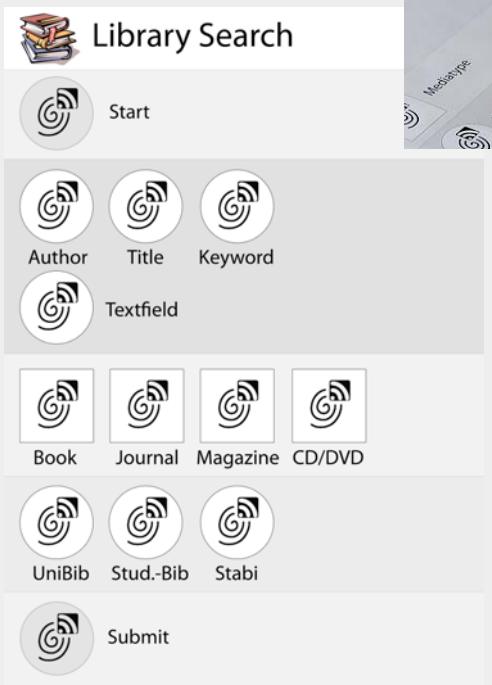
Conclusion

- **Summarized results**
  - NFC usage only for navigation rather annoying than benefit
  - Using NFC for greater number of items for selection is fine for users
  - Minimization of attention shifts
  - Freedom during interaction important
  - Crucial interaction steps (e.g. submit) as buttons on mobile interface preferred
  - Differences in the processing of tags (e.g. radio buttons vs. checkboxes) has to be clearly distinguished
- **Suggestions for further research**
  - Fourth category “Mapping”
  - Provision and placement of help

Questions?

Thank You!





Action	Object: Handy	Object: Poster
Handy	STI	MTI #1
Poster	MTI #2	MTI #3 MTI #4