Landmark-Based Pedestrian Navigation Processes
- An Eye Tracking Study -

Conrad Franke
Jürgen Schweikart

Beuth University of Applied Sciences Berlin
Introduction

- Navigation in an unfamiliar environment is a challenging mental process
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- Landmarks are intuitively perceived and used for navigation
Introduction

- Maps are used for navigation purposes
- Investigate cognitive effect of map content, in particular landmarks
Introduction

- User perspective in a real environment
Introduction

- User perspective: mobile eye tracking technology
Introduction

- **User perspective**: mobile eye tracking technology
- Eye-Mind-Assumption: longer fixation = intensive mental processing
Objective

Investigation of local landmarks from a **viewer perspective**, to identify map content which stimulates the landmark knowledge and **spatial thinking**.
Research questions

1) Are objects *fixated longer* and more *frequently* when there is a change in direction and are they transferred to the *landmark knowledge*?

2) How often is the map used as a *navigational aid* when finding the way?

3) Is the *sustainability of landmark knowledge* improved by visualizing landmarks on maps?
Study design

- 20 participants in an unknown environment: Berlin Spandau old town
Study design

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- Two groups (landmark group 3 women; control group 5 women)
Study design

- 20 participants in an unknown environment: Berlin Spandau old town
- Two groups (landmark group 3 women; control group 5 women)
- 1. Part:
  - Task: Navigation + Eye tracking (Fixations)
  - Interviews (with a featureless map) **WITHOUT using street names**
- 2. Part:
  - Memory test two weeks after the outdoor navigation task
Results 1: Interview

- 37 different landmark objects were named 153 times
Results 1: Interview

- 37 different landmark objects were named 153 times

<table>
<thead>
<tr>
<th></th>
<th>Landmark group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of different landmarks</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td>Ø Landmark recalls per interview</td>
<td>8.3</td>
<td>7.0</td>
</tr>
</tbody>
</table>
Results 1: Interview

- Landmarks recalls along the route

Franke & Schweikart (2016): Landmark-based navigation
Results 2: Eye tracking

- Fixation duration on landmark objects

<table>
<thead>
<tr>
<th>Average fixation duration per participant</th>
<th>Landmark group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>On a landmark*</td>
<td>409 ms</td>
<td>599 ms</td>
</tr>
<tr>
<td>On other objects with at least one fixation</td>
<td>236 ms</td>
<td>209 ms</td>
</tr>
</tbody>
</table>

* Objects named in the interview
Results 2: Eye tracking

- Fixation counts on landmark objects

<table>
<thead>
<tr>
<th>Average fixation counts per participant</th>
<th>Landmark group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>On a landmark*</td>
<td>2.45</td>
<td>3.89</td>
</tr>
<tr>
<td>On other objects with at least one fixation</td>
<td>1.66</td>
<td>1.29</td>
</tr>
</tbody>
</table>

* Objects named in the interview
Results 2: Eye tracking

- Navigation performance: Fixation duration on map (Landmark group)

<table>
<thead>
<tr>
<th>Map usage</th>
<th>Ø Fixation duration per participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landmark group</td>
<td>16.8 sec.</td>
</tr>
</tbody>
</table>
Results 2: Eye tracking

- Navigation performance: Fixation duration on map (Control group)

<table>
<thead>
<tr>
<th>Map usage</th>
<th>Ø Fixation duration per participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landmark group</td>
<td>16.8 sec.</td>
</tr>
<tr>
<td>Control group</td>
<td>29.5 sec.</td>
</tr>
</tbody>
</table>

almost twice as much
Results 3: Memory test

<table>
<thead>
<tr>
<th></th>
<th>Located correct</th>
<th>Located wrong</th>
<th>Memory without location</th>
<th>No memory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landmark group</td>
<td>6.2</td>
<td>1.4</td>
<td>4.8</td>
<td>10.8</td>
</tr>
<tr>
<td>Control group</td>
<td>3.3</td>
<td>4.7</td>
<td>5.3</td>
<td>10.4</td>
</tr>
</tbody>
</table>

- Correct located objects: **Difference between groups** is significant (Kruskal-Wallis test: p=0.05)
Results 4: Eye-Mind-Assumption

- Spearman’s rank correlation analysis between landmark recalls and eye movements (**Eye-Mind-Assumption confirmed**)

<table>
<thead>
<tr>
<th></th>
<th>Landmark-recall/Fixation-duration (ms)</th>
<th>Landmark-recall/ Fixation-count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landmark group</td>
<td>0.670**</td>
<td>0.674**</td>
</tr>
<tr>
<td>Control group</td>
<td>0.584**</td>
<td>0.601**</td>
</tr>
</tbody>
</table>

(** p < 0.01)**
Conclusion 1

Eye-Mind-Assumption was confirmed in a real world environment ...  
... because: Objects, that are focused longer are more probably mentally processed.
Conclusion 2

Visualization of landmark icons on maps...

... creates a more detailed **mental image** of the environment **because**: more landmarks are recalled during the interview
Conclusion 3

Landmark icons on maps …
… improve the navigation performance, **because**: the map is used less often as an navigational aid.
Conclusion 4

Landmark icons on maps …

… improve the sustainability of information in a mental map, \textbf{because}: significantly more landmarks are recalled and located correctly
Summary

The results show that landmarks on maps ...

✓ … improve navigation processes
✓ … improve both short-term and long-term the landmark knowledge and the mental storage of spatial information.

Thank you for your attention
Franke & Schweikart (2016): Landmark-based navigation