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Wayfinding in Unfamiliar Indoor Healthcare Environments: An Evidence Based Design Approach Using Gaze-Tracking Technology

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Eye-Guide LLC

Appalachian State Research Office
Introduction

Importance of Wayfinding

Disorientation can cause frustration, irritation, anxiety, and stress in healthcare environments (Rousek & Hallbeck, 2011, Miller & Lewis, 2000, Cooper, 2010, Leemes, 2010)

Wayfinding is a prerequisite for autonomy, independence, self-sufficiency, and self-esteem.

Zimring (1999), 604 bed hospital, Annual cost of wayfinding: $220,000 for the main hospital. Direct information giving by staff: 4,500 staff hours.
Navigation within buildings involves **multiple cognitive processes**.

- **Form mental representations (cognitive maps).** (Lynch, 1960 & Dominant Framework).

- Seek information from **multiple environmental cues** (Pati et al., 2014).
Previous Studies - Environmental Attributes of Wayfinding

Pati et al., (2014):  
- Cognitive aspects of wayfinding  
- Unfamiliar healthcare Environment  
- Verbal protocol

Ghamari et al., (2015)  
- Visual environmental elements of wayfinding  
- Unfamiliar educational facility  
- Same destination sequence  
- Eye-tracking (eye-fixations)
Ghamari et al., (2016)-Current study

Visual environmental elements of wayfinding
Unfamiliar healthcare facility
Eye-tracking (eye-fixations)
Randomized destination sequence

Objective of the Study:

To identify and rank-order visual environment elements in an unfamiliar healthcare environments that attract gaze fixation during wayfinding.
1- What are the durations of eye-fixations on different visual environmental elements during wayfinding?

2- Age groups?

3- Gender differences?
1- Signs

alphanumeric and symbolic declarations of programmatic spaces, directions and routes.

Types of signage (Huelat, 2007):

• Directional
• Identifying
• Informative
• Safety and Regulatory
2. Maps
   Diagrammatic, two-dimensional representation

3. Lighting
   Highlight hazards

4. Color
   Distinguish between surface
Environmental Attributes of Wayfinding

5. Directories
   Wayfinding tool

6. Functional Clusters
   Clusters of programmatic spaces with supportive and/or complementary functions.

7. Furniture
   Movable equipment with associated accessories
8. Architectural features
   - External spaces from the interiors
   - Multi-level interior views
   - Directional signs in exterior spaces

9. Interior Elements Pairing
   - Logical pairing of interior elements, with associated functions.

10. Other Design Elements
    - Artworks, fixed furniture, millworks, display boards, vending machine, indoor plants, fire extinguishers
Of the five senses, **vision represents 80 percent of human perception** (Seiderman & Marcus, 1989).

**Eye Movements:**

1. **Saccade**
   Consistent movement of the eye
   Different points of interest in the fovea

2. **Fixation**
   The state between saccades where gaze position is fairly fixed.
Research Methodology - Subjects

- **24 subjects** (8 subjects in 3 age groups: 20-29, 40-49, and 60-69)
- **Equal** males and females in each groups (**4 males and 4 females**).
- **Subject in sound health and have normal vision** (with or without glasses or contact lenses).
- None of the subjects had previously visited the Watauga Medical Center (**unfamiliar healthcare environment**)
- Subjects from a **common cultural context** (lived more than 10 years).
Research Methodology - Setting

- **Watauga Medical Center, Boone, NC.**

- The hospital is a *4-story building* with a *centralized courtyard*.

- **Severe wayfinding problems** and *navigation errors*.

- **Under renovation and construction**
### Research Methodology - Destinations

<table>
<thead>
<tr>
<th>Location</th>
<th>Point</th>
<th>Floor</th>
<th>Signage</th>
<th>Sources of Information</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lobby</strong></td>
<td>(O)</td>
<td>First</td>
<td>N/A</td>
<td>N/A</td>
<td>Researcher will meet the subjects at this location and the tasks will end at this point.</td>
</tr>
<tr>
<td><strong>Radiology</strong></td>
<td>A</td>
<td>First</td>
<td>Most</td>
<td>You are here Maps, Multiple signage on the main floor</td>
<td>The contribution of signage to the location of Radiology makes it easy to find according to the information of maps and signs.</td>
</tr>
<tr>
<td><strong>Patient Room 305</strong></td>
<td>C</td>
<td>Third</td>
<td>Majorly</td>
<td>3 as the first digit of the room, which might indicate the location of the room on the third floor</td>
<td>While the room has not been indicated in the directory of the lobby, it is predicted that the subjects go to the third floor to find the room.</td>
</tr>
<tr>
<td><strong>Pain Clinic</strong></td>
<td>B</td>
<td>Second</td>
<td>Minorly</td>
<td>Difficulty of finding of the destination because of the not properly position of the signage.</td>
<td>While there were some signage of this destination in the lobby, the sign was not properly located at the destination.</td>
</tr>
<tr>
<td><strong>2 West Waiting-Inpatient Surgery</strong></td>
<td>D</td>
<td>Second</td>
<td>Least</td>
<td>Information on directories.</td>
<td>There is little source of information for this location.. The only sign of this destination located at the second floor on the west side of the building.</td>
</tr>
<tr>
<td><strong>Lobby</strong></td>
<td>(O)</td>
<td>First</td>
<td>N/A</td>
<td>N/A</td>
<td>The subjects go back to the origin point and finish their navigation tasks.</td>
</tr>
</tbody>
</table>
Research Methodology - Destinations

(O)

(A)

(C)

(B)

(D)

Visual Environmental Attributes/Elements of Wayfinding in Unfamiliar Healthcare Environments
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Visual Environmental Attributes/Elements of Wayfinding in Unfamiliar Healthcare Environments
Visual Environmental Attributes/Elements of Wayfinding in Unfamiliar Healthcare Environments
Research Methodology - Instrumentation

**EyeGuide Tracking Technology**

<table>
<thead>
<tr>
<th>Interface Design</th>
<th>Video based headset</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eye-tracking</strong></td>
<td>Monocular, Right eye</td>
</tr>
<tr>
<td><strong>Gaze accuracy</strong></td>
<td>0.5°</td>
</tr>
<tr>
<td><strong>Data Rate</strong></td>
<td>60 Hz</td>
</tr>
<tr>
<td><strong>Calibration</strong></td>
<td>9 point - Field and screen</td>
</tr>
<tr>
<td><strong>Compatibility</strong></td>
<td>Contact lenses or glasses</td>
</tr>
</tbody>
</table>

Visual Environmental Attributes/Elements of Wayfinding in Unfamiliar Healthcare Environments
Research Methodology - Destinations

**Calibration:** Each destination

**Time limits:** 7 minutes

**Fail in finding the destination:** researchers guided the subjects to the next destination.

Researchers *walked behind the subject* during navigations.

**Randomization Sequence** for all participants

**No question** during navigations.
# Visual Environmental Attributes/Elements of Wayfinding in Unfamiliar Healthcare Environments

## Research Findings

<table>
<thead>
<tr>
<th>Route</th>
<th>Participants</th>
<th>Succeeded</th>
<th>Failed</th>
<th>Mean Time (S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-O</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>36.6</td>
</tr>
<tr>
<td>A-O</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>63.8</td>
</tr>
<tr>
<td>D-O</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>77.3</td>
</tr>
<tr>
<td>D-C</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>104.5</td>
</tr>
<tr>
<td>B-A</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>104.5</td>
</tr>
<tr>
<td>D-A</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>112.8</td>
</tr>
<tr>
<td>C-O</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>113.6</td>
</tr>
<tr>
<td>O-A</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>115.83</td>
</tr>
<tr>
<td>A-C</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>116</td>
</tr>
<tr>
<td>C-A</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>123.8</td>
</tr>
<tr>
<td>D-B</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>141.8</td>
</tr>
<tr>
<td>O-C</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>146</td>
</tr>
<tr>
<td>B-C</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>149.1</td>
</tr>
<tr>
<td>B-D</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>154.3</td>
</tr>
<tr>
<td>C-B</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>188.1</td>
</tr>
<tr>
<td>A-B</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>194.6</td>
</tr>
<tr>
<td>C-D</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>216</td>
</tr>
<tr>
<td>O-D</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>251.6</td>
</tr>
<tr>
<td>A-D</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>263.5</td>
</tr>
<tr>
<td>O-B</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>290.1</td>
</tr>
</tbody>
</table>

### Easiest
- Going back to lobby
  - Familiarity with environment

### Easier/Faster/More Successful Routes:
- Destinations A, C
- Both have the most contribution of signage, maps, and directories.

### Harder/Slower/More Failed Routes:
- Destinations B, D
- Both destinations had the least contribution from env elements.
Research Findings - Q1 What are the durations of eye-fixations on different visual environmental elements during wayfinding?

<table>
<thead>
<tr>
<th>Visual Attributes</th>
<th>Eye-Fixations(ms)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying Signs</td>
<td>342556</td>
<td>29.1%</td>
</tr>
<tr>
<td>Informative Signs</td>
<td>245567</td>
<td>20.8%</td>
</tr>
<tr>
<td>Architectural Features</td>
<td>133232</td>
<td>11.3%</td>
</tr>
<tr>
<td>Directional Signs</td>
<td>110980</td>
<td>9.4%</td>
</tr>
<tr>
<td>Maps</td>
<td>85678</td>
<td>7.3%</td>
</tr>
<tr>
<td>Functional Clusters</td>
<td>78456</td>
<td>6.7%</td>
</tr>
<tr>
<td>Other Design Elements</td>
<td>65453</td>
<td>5.6%</td>
</tr>
<tr>
<td>Interior Elements Pairing</td>
<td>62345</td>
<td>5.3%</td>
</tr>
<tr>
<td>Safety and Regulatory Signs</td>
<td>35678</td>
<td>3.0%</td>
</tr>
<tr>
<td>Furniture</td>
<td>17895</td>
<td>1.5%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1177840</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Major visual elements of Wayfinding Signage: 62.3%
Visual Environmental Attributes/Elements of Wayfinding in Unfamiliar Healthcare Environments

Research Findings - Comparison with previous study

<table>
<thead>
<tr>
<th>Feature</th>
<th>Hospital</th>
<th>College</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying Signs</td>
<td>29,1</td>
<td>20,4</td>
</tr>
<tr>
<td>Informational Signs</td>
<td>20,8</td>
<td>11,3</td>
</tr>
<tr>
<td>Architectural Features</td>
<td>11,3</td>
<td>14,2</td>
</tr>
<tr>
<td>Directional Signs</td>
<td>9,4</td>
<td>8,4</td>
</tr>
<tr>
<td>Maps</td>
<td>7,3</td>
<td>8,4</td>
</tr>
<tr>
<td>Functional Clusters</td>
<td>6,7</td>
<td>3,4</td>
</tr>
<tr>
<td>Other Design Elements</td>
<td>5,6</td>
<td>5,3</td>
</tr>
<tr>
<td>Interior Elements Painting</td>
<td>5,3</td>
<td>5,3</td>
</tr>
<tr>
<td>Safety and Regulatory Signs</td>
<td>3</td>
<td>6,6</td>
</tr>
<tr>
<td>Furniture</td>
<td>1,5</td>
<td>2,6</td>
</tr>
</tbody>
</table>
**Research Findings - Age Differences**

**Time of Navigation:**

**Post hoc** Tests: Tukey HSD: Young age group \((M = 826.5, SD = 83.2)\) was significantly different than the elderly group \((M = 945.8, SD = 84.2)\).

**Eye-fixations on Visual Environmental Attributes:**

No significant difference.
Time of Navigation:

Results of the independent sample t-test show that mean time of navigation differed between males ($M = 834.3$) and females ($M = 899.3$).

Eye-fixations on Visual Environmental Attributes:

No significant difference between males and females.
Eye-tracking Limitations

- Captures a 90 degree field-of-view not peripheral vision
- Calibrating and tracking only the right eye (monocular eye-tracking) instead of the both eyes (binocular eye-tracking).

Other variables

- Noise, smell, number, and type of people in the environment.
Success in Wayfinding:

The more the destination was indicated by environmental attributes/elements, the easier the participants could find their destinations.

Age and Gender Differences:

Males were faster than females in finding the destinations.

Young age groups (20-29) were faster than the elderly group (60-69) of the participants.

Health Impact?
Conclusion

Health Outcome impact?
THANK YOU!

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