Influences on pedestrian bi-directional route within exhibition spaces

Jennifer Claudia Haywood
Iowa State University

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Influences on pedestrian bi-directional route within exhibition spaces

by

Jennifer Claudia Haywood

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Major: Interior Design

Program of Study Committee:
Frederic Malven, Major Professor
Jihyun Song
Paul Bruski

Iowa State University

Ames, Iowa

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ABSTRACT

Besides signage, other physical cues exist which appear to influence pedestrian bi-directional choice. This research hypothesizes that deflection of cues within an interior exhibit setting can directly influence visitor navigation. The implications are that some exhibits are viewed while others are ignored and more importantly the visitors’ overall experience and education are affected.

A study, conducted on adult participants, was used to determine the affect of physical cues on directional choice. Observation of bi-directional route preference with cues of varying angle degrees was conducted. Additionally, a survey was performed to determine visitor perception of wall panels and their effect on navigational choice. The analysis from the methodology was used to reveal the influence of these angled walls on pedestrian route. Results from this study illustrate how visitors respond to spatial cues and how exhibit spaces can be designed to influence pedestrian behavior.
CHAPTER I. INTRODUCTION

Statement of the Problem

Pedestrian navigation has received much study and focus throughout the years, particularly with respect to exterior, public navigation. Little research has been performed on the influences of pedestrian navigation within interior spaces. Of particular interest is the pedestrian navigation occurring within exhibition spaces. For the purposes of this study, exhibition refers to museums and art galleries. Navigation within exhibition space directly equates to the sum of a visitor’s education and learning. “Informal education in museums is structured through movement in space” (Wineman and Peponis, 2009). Wineman and Peponis (2009) argued that the spatial layout of exhibition space directly influences visitor exploration, engagement, and understanding of that space. The implications are that some exhibits are viewed while others are ignored.

Behavior within different interiors can vary depending on the tasks and functions occurring within the space (Tversky, 2003). Exhibitions serve the general public through their function as an informal learning environment. Because there is not a single landmark or target that the visitors to a museum are seeking, the navigation occurring looks very different than in other exterior or interior settings. The primary mode of activity occurring within these educational settings is exploration (Bell et al., 2001). The layout of exhibition spaces can be used to differentiate and control possible experiences of visitors while still allowing for visitor exploration (Choi, 1998).
**Purpose**

The purpose of this study was to analyze the physical cues influencing pedestrian navigation within interior exhibition spaces. Much study has been done on pedestrian movement with exterior and public space. The most available information exists within panic situations and the ability to predict movement of pedestrians within this context is valuable. However, panic situations are extreme and do not indicate pedestrian movement under other circumstances. Equally important is to understand pedestrian movement under ‘normal’ situations (Beirlaire et al., 2003). Within exhibitions, directional cues may serve two functions: direct visitor movement and provide graphical information in the form of signs, artifacts or information. Of particular interest for this study was how physical cues could be used to influence and even direct visitor movement. Designers of exhibition space and any interior setting for that matter can manipulate the space by altering the elements within. Any number of views can be created to tell a desired narrative or story (Brooker and Stone, 2008).

The studies of Melton (1933) and Robinson (1933) provided unique insight into the route behaviors of visitors to a museum or gallery space. They proved there is a distinct preference for right-sided navigation pathways. This is important for curators and museum staff to concern themselves with as so many exhibits are laid out in direct opposition to their findings.

It is important to mention that while this study serves the purpose of beginning a dialogue on the influences of pedestrian movement, it does not attempt to make any conclusive theories to this effect. “The validation of pedestrian walking models is a difficult task, and has not been extensively reported in the literature” (Robin et al., 2009).
Objectives

The objectives of this study include the following:

1. Determine elements influencing pedestrian route within interior and exhibit spaces.
2. Measure the effect environmental elements have on influencing directional choice.
3. Define observed theories relating to pedestrian navigation and behavior.

![Figure 1. Research Objectives](image)

By understanding how pedestrians navigate within exhibition spaces, designers and curators can directly influence, if not control, the movement within these spaces. Unlike exterior space, in which navigation is much more varied and difficult to control entirely, interior spaces offer a huge advantage of being able to direct the movement occurring within their walls.
Research Questions

Cullen (1971) described the term ‘deflection’ as an alternative to a closed vista in which an object is “deflected away from the right angle, thus arousing the expectation that it is doing this to some purpose.” Figure 2 shows an image of Cullen’s concept of ‘deflection.’

![Deflection as defined by Cullen (1971)](image)

Figure 2. Deflection as defined by Cullen (1971)

The central aim of this study focused on the influences of pedestrian directional choice within exhibition spaces. Using Cullen’s concept of ‘deflection,’ this study examined the influences of deflected surfaces on pedestrian navigation. An observational experiment and survey were used to investigate three main research questions:

1. To what extent (if any) does the concept of deflection influence pedestrian route?
2. To the extent that deflection is a significant influence, what are the variables that influence direction? (angle, color, texture, outer walls, etc.)
3. Of the variables that influence direction, which is the most significant?
The conclusions drawn from the literature review and research questions will aid those involved within exhibition spaces better understand how interior layout influences pedestrian route and more importantly, the experiences that are resulting from that route.
CHAPTER II. LITERATURE REVIEW

The review of literature includes a summary of the major environmental elements influencing directional choice and their level of affect, the role of signage in wayfinding, and pedestrian behavior theories. A discussion on general wayfinding principles are first introduced, followed by the models of Passini (1996), Brunswik (1952), Gibson (2009), Talbot et al (1993) and Lynch (1960).

Environmental Influences

Humans understand their world three-dimensionally based on relationships such as head and feet, front and back, and left and right axes. These relationships serve as directional cues aiding in our understanding of an environment’s spatial arrangement (Kopec, 2006). The term ‘wayfinding’ was introduced in the 1970’s to describe an individual’s representation of space and all mental processes involved in movement (Passini, 1996).

Within the literature there exists two types of individuals: those who know their destinations and those who do not have a precise destination. Pedestrians within an exhibition setting are typically the latter. Bierlaire et al (2003) referred to these individuals as ‘explorers.’ The same wayfinding principles in most interior settings can be applied to museums. The nature of exhibition spaces is to display as many exhibits as possible. If an exhibition space becomes too complex, confusion can occur. When this happens, visitors tend to seek out directional aids such as maps or signs in assisting them through the space (Bell et al., 2001).

Exhibition spaces are often new, unfamiliar spaces to the visitors navigating within them. Humans understanding of an environment is influenced by their perceptions and familiarity with its individual parts. Within these unfamiliar spaces, visitors may come to incorrect conclusions
about the size, height, color, or angle (Brunswik, 1952; Kopec, 2006). These environmental cues can directly influence behavior without conscious thought. The visitors within these spaces are often unaware of the environmental influences on their behavior (Kopec, 2006).

The Austrian-American psychologist, Egon Brunswik, developed a theory known as the ‘lens model.’ He argued that humans perceive individual features or cues within their environments in order to understand it. American psychologist, J.J. Gibson introduced the ‘affordances’ theory that states the world is composed of substances, surfaces, and textures, which provide environmental cues through various arrangements or layouts. In contrast to Brunswik, J.J. Gibson argued that rather than perceiving individual components, humans “respond to an ecologically structured environment” (Kopec, 2006).

Urban planner, Kevin Lynch (1960) researched human perceptions of their environments. Within his studies, he developed terms to describe features of the ‘cognitive map.’ The term ‘cognitive map’ describes the spatial representation within our memory (Bell et al., 2001). Lynch (1960) defined the following terms, which encompass the urban environment: path, edges, districts, nodes, and landmarks.

Lynch’s factors relating to cognitive maps can also be adapted to directional influences. Edges serve as boundaries between two places (Lynch, 1960). Edges are used within regions to close off, seam, relate, or join space. Lynch (1960) defined landmarks as “simply defined physical object(s).” Landmarks within a cityscape differ from landmarks within an interior. More subtle possibilities can include accent walls, art pieces, and special displays. Landmarks allow navigators to become oriented within a space while at the same time contributing to the experience and expression of space (Rengel, 2007).
The directional cues chosen for this study were large wall panels. According to Rengel (2007), “walls do more than just enclose rooms.” Walls serve several functions in space including: contain, enclose, separate, as object, and as a function. Because walls have two sides, they are often angled. Calori (2007) described many attributes of walls and signage, which aid in pedestrian navigation and wayfinding. These signs may be in the form of an unlimited number of shapes and can be rotated to the vertical to form “powerful stylistic connotations.” Rengel (2007) discussed the importance of ‘arrangements’ in influencing directional choice. Space can be manipulated to “lead the moving person in a desired direction.”

**Pedestrian Behavior Theories**

Within the built environment, humans prefer legibility. An individual’s environment is better understood with a regular, rectilinear floor plan and visually distinguishable parts rather than an irregular ambiguous layout (Weisman, 1979). Another finding of pedestrian preference includes floor plans that are relatively linear and require little displacement. Humans are efficacious and will often choose the simplest ways to perform tasks. Pedestrians will choose paths, which “minimize the need for angular displacement” (Turner and Penn, 2002). Peponis et al (1990) categorized the following ‘rules of navigation:’

1. Avoid backtracking
2. If all else is equal, continue in the same direction.
3. Divert from the current heading when a new view allows you to see more space and/or activity (that is, other people).

In their research, Dalton et al (2011) found that pedestrians prefer straighter routes and do not like many changes in their direction. In addition, shallow changes in angled turning are
preferred to sharp turns. Angles greater than 90 degrees can lead pedestrians to become disoriented. Changes in trajectory are more favored when they are gradual or smooth rather than linear and acute (Bierlaire et al., 2003). Moussaid et al (2010) defined cognitive heuristics for movement which state “pedestrians seek an unobstructed walking direction, but dislike deviating too much from the direct path to their destination.”

Similarly, Hochmair (2004), introduced the ‘Least-Angle Strategy’ theory, which states that pedestrians will always “proceed in the direction of the target.” Under this model, pedestrians do not perform much cognitive effort in making navigational decisions. This model works particularly well in situations where pedestrians must make navigation choices quickly and where no other detailed information is available. Assuming a forward approach, the research introduced another term ‘deviation angle.’ If the pedestrians were approaching a specified landmark, then the streets on either side of the target axis would be called deviation angles. The closer the deviation angle to the target axis (less than 90˚), the more likely that street would be chosen to proceed to their destination. Figure 3 shows the application of the Least-Angle Strategy where D is the target destination, P is the pedestrian’s location, s₁ and s₂ are the streets on either side of the target axis (dotted line), and x₁ and x₂ are the deviation angles (Hochmair, 2004). In situations where the pedestrian is familiar with the space or where other environmental information exists such as a map or verbal route instructions, the Least-Angle Strategy theory may not apply in and of itself. It may instead function as an ingredient within the entire wayfinding process (Hochmair, 2004).
Figure 3. Application of Least-Angle Strategy (Hochmair, 2004).

A study performed by Kalff et al (2010), researched the spatial layout of a virtual supermarket and the effects of shelving turned at a 45° angle. The differences in exploration between two conditions and environmental features were analyzed. It was discovered that the minus 45° angle condition, in which shelving is pointed away from the main aisle, was easier for participants to navigate and find their target destination: food section. It was concluded that the orientation of the shelves functioned as a directional cue, which ‘deflects’ participants.

The studies of Hochmair (2014) and Kalff et al (2010) demonstrate the strong influence environmental cues such as side streets and shelves have on pedestrians navigating within their proximity. These studies both showed that angled cues can have a significant influence on pedestrian route.
Another pedestrian behavior, related to gender, shows that there appears to be differences between males and females within navigation and wayfinding tasks. The studies of Kim et al. (2007) proved that gender differences in spatial navigation were present. Based on specific tasks, males and females responded differently to their physical environment and performed spatial navigational tasks differently.

**Right-side Bias**

Within exhibition settings, there tends to be a ‘right-handed’ bias. Upon entering an exhibition space, visitors would turn right and follow the direction of the room on the right side (Melton, 1933). In his experiments, Melton (1933) discovered that only 10% of visitors would complete an entire navigation throughout the exhibit. Visitors tend to engage with exhibits initially and then they view fewer and are more selective as they continue to explore. The likelihood of visitors exploring and engaging with a particular exhibit element is called its ‘attraction gradient’ (Melton, 1933).

At the same time as Melton, Edward S. Robinson, professor of Psychology at Yale University was testing his own theory of right-sided biasness within various museums in different cities. “We have found that under ordinary circumstances – that is in relatively symmetrical buildings and rooms – there is a strong tendency for the public to bear to the right” (Robinson, 1933). Robinson found that around 75 percent of visitors favored the right side while 25 percent favored the left.

The research of Stephen Bitgood (1995) stated that in the absence of landmarks, open doors, and inertia, visitors tend to turn right when entering a gallery. His research also found that
a right-turn bias is not the only element that influences visitor circulation. Visitors have a tendency to “remain on a main pathway rather than select a secondary one” (1995).

Humans have a ‘right-side’ bias, which extends to memory. Placing information graphics such as labels in the right corner of exhibits will tend to be better remembered (Kopec, 2006; Melton, 1935). Literature on human behavior within museum settings indicates that pedestrians have a natural preference towards the right side of their navigational approach. If this is so, how can museums utilize this information to persuade or even control movement within their spaces? What exactly is the measure of influence on bi-directional route?

**Wayfinding & Signage**

While this study did not test the influences of graphical information or signs, this is still an important topic to consider as signs’ physical properties can serve as cues within navigation.

Signage is often overused and when used, is an afterthought, put in place long after the design and building phases have been completed. Designers should work together unifying graphics and architecture rather than consulting proponents of graphic information shortly before ‘opening day’ (Passini, 1996). Nasar and Hong (1999) researched the effectiveness of signage within urban landscapes and found that there was a preference for the use of signs to be reduced within these settings. “The strategic placement of a few well-designed signs within a legible environment will have greater positive effects than signs posted at every turn and intersection” (Kopec, 2006). Good architectural design should minimize the necessity for signage through the use of coherent floor plans, visible access points, and interconnecting pathways and should only be used when other forms of environmental cues are unavailable (Dalton, 2011; Kopec, 2006).
Another reason that signage should not solely be relied on for successful wayfinding is due to user error and/or poor signage design. In their research, Warren et al (1990) studied the accuracy of specifying pedestrian location within a two-dimensional floor plan. The findings from this study aided in understanding the perceptual and cognitive factors involved with map design. It was determined that accuracy was greatly improved when the floor plan and building view were aligned than when they were misaligned. The implications from these findings are that the design of the map (i.e. signage) is a major influence on the success of wayfinding and understanding of the space. If the signage is designed poorly or if the pedestrians cannot understand how to use the signage (which also may be due to poor design), then “a higher error rate is the result” (Warren et al., 1990).

Exhibition spaces present a unique problem in that the directional cues might also serve as the displays of precious artwork or artifacts. Within these settings wayfinding difficulties can double. When wayfinding is not successful it may be due to a number of reasons: inadequate signage, deficient architecture, confusing layout, etc. (Passini, 1996). Passini (1996) argued that the implementation of wayfinding cues should be “easy” and are “essential features of architectural composition and should not require signage support.” A designer’s primary goal for developing successful wayfinding is to be a facilitator for effortless movement through space (Gibson, 2009). Within exhibition settings, visitors cannot begin their experience until they have a clear understanding of direction. When used, signage should be “simple, short, and consistent” (Locker, 2011).

Designers have a responsibility to consider the preferential routes of visitors first before any sign is erected. Robinson (1933) argued that signage should serve as a supplementary navigational tool after the visitors’ natural tendencies within wayfinding have been accounted
for. Mollerup (2005) argued that building signs often display what should have been demonstrated by the building itself. Calori (2007) argued that wayfinding is an active process, which relies on signage and “other visual wayfinding cues” that can help people “navigate their environment when there’s no one to ask.”

The literature suggests that signs themselves may not be the most important element in directing pedestrian movement. Instead, how can physical cues (free of graphical information) be used to direct pedestrian movement?

**Conclusion**

The literature reviewed for this study included a summary of the major environmental elements influencing directional choice, the role of signage in wayfinding, and a review of pedestrian behavior theories. The literature reviewed addresses many of the theories and beliefs held about interior navigation and influences on pedestrian behavior. Understanding the influences on pedestrian route choice serves to identify the subtle environmental cues influencing navigation within specified settings. In the case of exhibition spaces, where navigation is more exploration than destination-focused, the influences on pedestrian route are of particular importance. Within an exhibit, experiences of an exhibit can vary from person to person in very subtle ways. If the goal of the curator is to control or influence movement (for example, clockwise navigation), they will have a greater challenge than in any other interior setting. It is important to note that other directional cues besides visual elements exist which aid in wayfinding. Non-visual cues like sound, textures, smell, and kinesthesia “can be used to learn about and guide effective action in the environment” (Warren, 1990). For the purposes of this research, only visual cues were examined. The use of cues to direct pedestrian movement is
significantly influential because the necessity of additional signage gets called into question. Within the research of O’Neill (1991), it was discovered that “the wayfinding performance of participants with access to signage in the most complex settings remained equivalent to, or significantly poorer than, those in the simplest settings with no signage.”

Because of exhibits’ ‘attraction gradient,’ it becomes plausible for designers to have a greater influence on directing pedestrian movement within exhibition spaces (Melton, 1993). As visitors will view fewer elements the longer they navigate, the exhibit displays can be used as directional cues to influence where they go next.

While Calori (2007) touches on the possibility of 3D forms communicating information, the study does not delve into what that communication might be. Instead, Calori explores the importance of sign graphics in further detail. This study attempts to start an inquiry into how 3D shapes (i.e. cues) acting within wayfinding environments may be influencing visitors to those spaces. Void of information graphics, what are the influences and effects of 3D shape, form, and position?
CHAPTER III. METHODOLOGY

Within exhibition spaces, visual cues may serve two purposes: to direct and to present exhibit information. For the purposes of this study, the latter was ignored. The visual cue was analyzed on the basis of its function as a directional influence and not as a source of information or intrigue for pedestrians. The methodology for this thesis was based on the review of literature. The literature review discussed the role of physical elements as being a navigational tool and the general behavior of pedestrian movement through space. For the purposes of this study, the influence of angled walls on pedestrian navigation was observed. Rengel (2007) states ‘diagonal arrangements . . . favoring one direction are effective.’ In addition, differences in navigational patterns amongst demographics were observed based on the research of Kim et al (2007).

Using Hochmair’s research on deviation angles within decision situations, this study tested two deviation angles (45° vs. 60°). This study was based on an observational experiment and supplemental survey. This approach allowed for quantitative and observational research to be statistically analyzed. This section begins with the research questions and hypotheses that were used to look at pedestrian behavior and perceptions. A discussion of the research methods follows along with the research findings and analysis.

Research Questions

1. To what extent (if any) does the concept of deflection influence pedestrian route?

2. To the extent that deflection is a significant influence, what are the variables that influence direction? (angle, color, texture, outer walls, etc.)

3. Of the variables that influence direction, which is the most significant?
Hypotheses

The following hypotheses, based off the literature review, were made prior to the study:

1. Other things being equal, when confronted with walls or other barriers in the pedestrian’s line of travel, a participant’s route through the gallery space is most influenced by the angle of the wall panel.

2. There is a significant difference between male and female navigational behaviors and perceptions (Kim et al., 2007).

3. The smaller angle (45°) will be more significant in influencing bi-directional choice, as it is closer to the target axis in a forward approach. The target axis within this study was assumed to be the east wall located at the end of the pathway.

4. Pedestrians will statistically follow a right-side approach due to the ‘right-handed’ bias (Melton 1933; Bitgood, 1995).

Participant Demographics

Participants included undergraduate design students from the Interior Design program at Iowa State University. A verbal invitation to participate in the study was presented to students within Interior Design courses (Appendix E). The details of the study, length, benefits, compensation, etc. were discussed and a sign-up sheet for interested participants was collected. In total, 32 students participated and completed the study. The study was run over the course of three days but individual participants chose one of those three days to participate. Total participation time was approximately 20 minutes. Participants included mostly female students due to the current enrollment of students within the Interior Design program. The
disproportionate amount of male to female participants is a factor that is discussed within 
Chapter 5. All participants within the study were over the age of 18.

**Observational Experiment**

The ‘Angular Deviation Experiment’ was conducted with the purpose of better understanding the subtle influences of angled wall panels on pedestrian navigation. An observational experiment occurred over the course of three days at Iowa State University’s College of Design. The location for the experiment was at the first floor gallery space, an exhibit-like setting of approximately 1500 square feet.

Within the gallery space, a hallway of wall panels with four directional (center) wall panels was positioned. Figure 4 shows the floor plan and positioning of the wall panels, which allowed participants to choose a bi-directional path towards the end of the gallery.

Individually, participants were instructed to navigate through the gallery space as ‘natural’ as possible. While inside, 2 video cameras were set at opposite ends of the space (one at the entrance and another at the exit). Video footage was used to observe and summarize pedestrian and navigational behaviors as the principal investigator was outside of the gallery space while the navigation occurred.

The principal investigator waited outside of the gallery space and provided consent forms and instructions to the participants prior to the study. At the conclusion of their navigation through the space, the participants returned to the principal investigator and completed the survey.

Controlling for all other elements including lighting, temperature, etc. held constant, the only variable manipulated within this study was the angle of the directional wall panels as seen
in figure 5. The first angled wall panel was positioned 45° from the perpendicular (to the forward axis). The second wall panel was angled perpendicular. This angle served as the control where a bi-directional path around it held a statistically equal choice for pedestrians. The third panel was angled 60° from the perpendicular (in a forward approach). Both the first and third angled panels favored a left-side approach to test against the ‘right-handed’ bias researched within the literature. Panel Z (shown in figure 4) was angled towards the right to encourage movement around the center wall panels and away from the perimeter. This positioning eliminated bi-directional navigation, as the participants’ only choice (without moving or repositioning) was to travel on the right side of the wall panel.

\[\text{Figure 4. Angular Deviation Experiment floor plan}\]
Figure 5. Angles of directional wall panels

The panels measured 4’ wide by 6’ high. Panels were positioned 6’ apart in a forward approach and sidewalls measured 12’ spanning distance of navigational space. Figure 6 shows a perspective of the first center wall panel, which required the participants to navigate around. Figure 7 shows a female participant navigating through the gallery space. On average participants spent 36 seconds within the gallery space navigating from the entrance to the exit. Results are summarized in Chapter 5.

Figure 6. Photograph of wall panel at a 45° angle from the target axis (in a forward approach)
Figure 7. Photograph of participant navigating through the gallery space

Survey

A survey was distributed to student participants after the completion of their navigation through the College of Design gallery space (Appendix D). The purpose of the survey was to collect statistical information on navigational influences and perceptions from a sample of undergraduate students within the Interior Design program. Students from this program are assumed to be familiar with 3D space and environments as a result of their courses and curriculum and thus were ideal participants for a study within this discipline. A survey is an ideal method for this study because it allows for responses to be collected in a timely manner and for statistical software to be used for data analysis.
The survey consisted of 17 questions in total (11 Likert Scale questions, three categorical and three open-ended). Three questions asked about demographics such as gender, age, and year in school. The survey was distributed as a physical copy to participants who completed the tasks within the gallery space and took approximately 5-10 minutes to complete. Questions asked about navigational influences such as wall panel angle, color, texture, and surrounding walls. A 5-Level Likert Scale was used on questions asking about the participant’s level of agreement to statements such as: *I was able to easily navigate around the directional wall(s).* Another 5-Level Likert Scale was used to determine the significance of the aforementioned factors on their navigation through the gallery space.

Data analysis of the survey was conducted using IBM SPSS software and Microsoft Excel. Microsoft Excel was used to organize the survey responses for import into the statistical software. SPSS software was used to support or refute the hypotheses from the study. Frequencies, averages, correlations, and t-tests were used to analyze the data collected from both the survey and observational experiment. Results from the analysis are discussed in Chapter 4.
CHAPTER IV. RESULTS

Overview

The goals and objectives for this study were to understand the role of physical cues on influencing pedestrian navigation within exhibition spaces. Specifically, this study attempted to understand the elements influencing pedestrian route, the measure of influence, and how perceptions and behaviors influence navigation. The research methodology for this study included an observational experiment and survey.

Results for the survey included: descriptive frequencies, correlations, t-tests, and case specific analysis. Results for the experiment included: descriptive frequencies, correlations, t-tests, case specific analysis, and video correlations with survey answers. These results helped to support or refute the hypotheses mentioned in Chapter 3:

1. Participants’ route through the gallery space is most influenced by the angle of the wall panel.
2. There is a significant difference between male and female navigational behaviors and perceptions (Kim et al., 2007).
3. The smaller angle (45˚) will be more significant in influencing bi-directional choice as it is closer to the target axis in a forward approach.
4. Pedestrians will statistically follow a right-side approach due to the ‘right-handed’ bias (Melton 1933; Bitgood, 1995).

Descriptive Frequency: All Survey Questions

The most influential factor in determining route through the College of Design gallery space is the directional wall panels, as 23 percent of survey respondents stated. For the purposes
of this study, the directional wall panels refer to the panels located in the center of the gallery space (See Appendix D). Other top influences on pedestrian navigation include: panel angle, curiosity, and the sidewalls framing the gallery space. Table 1 shows the mean value for all quantitative survey questions.

*Table 1. Mean responses for survey Q1-Q12*

<table>
<thead>
<tr>
<th>Question</th>
<th>N</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>32</td>
<td>4.13</td>
</tr>
<tr>
<td>Q2</td>
<td>32</td>
<td>4.00</td>
</tr>
<tr>
<td>Q3</td>
<td>32</td>
<td>1.84</td>
</tr>
<tr>
<td>Q4</td>
<td>32</td>
<td>4.00</td>
</tr>
<tr>
<td>Q5</td>
<td>32</td>
<td>4.00</td>
</tr>
<tr>
<td>Q6</td>
<td>32</td>
<td>3.56</td>
</tr>
<tr>
<td>Q7</td>
<td>32</td>
<td>2.44</td>
</tr>
<tr>
<td>Q8</td>
<td>32</td>
<td>3.91</td>
</tr>
<tr>
<td>Q9</td>
<td>32</td>
<td>2.28</td>
</tr>
<tr>
<td>Q10</td>
<td>32</td>
<td>2.28</td>
</tr>
<tr>
<td>Q11</td>
<td>32</td>
<td>4.03</td>
</tr>
<tr>
<td>Q12</td>
<td>32</td>
<td>2.03</td>
</tr>
</tbody>
</table>

*Hypothesis 1*

Hypothesis 1 states participants’ route through the gallery space is most influenced by the angle of the wall panel. The hypothesis was analyzed using results from the frequencies of three
survey questions and correlations amongst survey questions. The first survey question asked, *what influenced your route through the gallery?* The data results compared percentage totals of respondents’ open-ended answers to the relevant question (see figure 8). Due to the qualitative nature of this survey question, the only statistical analysis available included comparing frequencies of answers.

**Figure 8.** Survey open-ended question asking: *What influenced your route through the gallery?*

Figure 8 displays a bar graph showing the responses for what influences navigation through the gallery space. For this question, 23 percent of participants perceived the directional
wall panel as the most influential factor for their route through the gallery space. 18 percent of participants did not respond to this question. 13 percent of respondents listed angle, curiosity, or sidewall panels as additional factors influencing their route. The data suggests that angle is not the most influential factor of route through the gallery space, although angle is a characteristic of the directional walls. Additional data analysis conducted below was used to determine the influence of wall panel characteristics such as angle, color, and texture on route choice.

An additional survey question asked participants to use a 5-Level Likert Scale to answer: *My navigation was influenced by the angle of the directional wall(s).* Participants responded 1 (strongly disagree) to 5 (strongly agree). Results are summarized in Figure 9.

*Figure 9. Survey Likert Scale Question: My navigation was influenced by the angle of the directional wall(s).*
The results from this question indicate a strong influence related to angle of the directional wall. 84.5 percent of respondents (sum of agree and strongly agree responses) indicated they agree with the statement that their navigation was influenced by the directional wall angle.

Another survey question (figure 10) asked participants to think about the significance of specific wall panel characteristics such as angle, color, and texture on their navigation. 87.6 percent of respondents (sum of significant and very significant responses) believe the angle of the directional wall was a significant influence on directing their navigation through the gallery. This analysis shows a strong relationship between angle and navigation.

**Figure 10.** Survey Likert Scale Question: Rate the level of significance each of the following factors had on influencing your navigation through the gallery: Angle of directional wall(s).
Correlation between Survey Questions

The following table shows significant correlations between questions asking about specific directional influences. The correlations were performed to answer hypothesis 1:

Participants’ route through the gallery space is most influenced by the angle of the wall panel.

Conclusions from the correlations on various survey questions are summarized in table 2.

Table 2. Correlations between survey questions regarding influences on pedestrian route.

<table>
<thead>
<tr>
<th>Questions</th>
<th>N</th>
<th>Correlation</th>
<th>Value</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1 &amp; Q2</td>
<td>32</td>
<td>Positive**</td>
<td>.676</td>
<td>Participants, who were influenced by the directional wall panels, were also influenced by its angle.</td>
</tr>
<tr>
<td>Q1 &amp; Q3</td>
<td>32</td>
<td>Negative**</td>
<td>-.733</td>
<td>Participants responded they were influenced by the directional wall panels.</td>
</tr>
<tr>
<td>Q1 &amp; Q5</td>
<td>32</td>
<td>Positive*</td>
<td>.391</td>
<td>Participants, who were influenced by the directional wall panels, were also directed towards the left or right.</td>
</tr>
<tr>
<td>Q1 &amp; Q8</td>
<td>32</td>
<td>Positive*</td>
<td>.441</td>
<td>Participants, who were influenced by the directional wall panels, were also significantly influenced by its angle.</td>
</tr>
<tr>
<td>Q2 &amp; Q3</td>
<td>32</td>
<td>Negative**</td>
<td>-.757</td>
<td>Participants responded they were influenced by the angle of the directional wall panels.</td>
</tr>
<tr>
<td>Q2 &amp; Q8</td>
<td>32</td>
<td>Positive**</td>
<td>.553</td>
<td>Participants responded they were influenced by the angle of the directional wall panels.</td>
</tr>
<tr>
<td>Q3 &amp; Q8</td>
<td>32</td>
<td>Negative**</td>
<td>-.547</td>
<td>Participants, who were influenced by the directional wall panels, were influenced by its angle.</td>
</tr>
<tr>
<td>Q6 &amp; Q11</td>
<td>32</td>
<td>Positive**</td>
<td>.618</td>
<td>Participants, who were influenced by their natural walking tendencies, were also influenced by the sidewall panels.</td>
</tr>
<tr>
<td>Q9 &amp; Q10</td>
<td>32</td>
<td>Positive**</td>
<td>.794</td>
<td>Participants who were influenced by the color of the wall panels were also influenced by the texture.</td>
</tr>
</tbody>
</table>
** Correlation is significant at the 0.01 level. *Correlation is significant at the 0.05 level.

The data analysis for hypothesis 1 (between the frequencies and correlations) indicates that angle might not be the first element that participants perceive as they think about their navigational influences but of the elements, angle is a strong influence.

**Gender Significance for Q5**

_Hypothesis 2_

Hypothesis 2 states there is a significant difference between male and female navigational behaviors and perceptions. This hypothesis was analyzed using results from a t-test performed on participant demographics and survey questions.

A t-test was run to analyze survey questions with student demographics of: gender, school year (classification), and age. The t-test showed no significant difference amongst classification (freshman, sophomore, junior, and senior students). Table 3 shows frequencies for these demographics. However, the t-test showed a significant difference between Q5 and gender (male versus female). The t-test resulted in a 2-tailed p-value of 0.001. This data shows that there is significance between male and female responses for Q5: _The directional wall(s) directed me towards either the left or right_. A 95 percent confidence interval showed that the number of males who agree with the statement was significantly lower than the number of females. On average, male respondents were uncertain whether they agreed with the statement while female respondents were more likely to agree with the statement. However, it should be noted that the n for males was only 5 compared to n=27 for female respondents.

This hypothesis cannot be supported nor refuted due to the small number of male participants included within the study. There appears to be a difference in gender pertaining to
perception of bi-directional influences but the measure of difference should be considered for future studies.

**Case Specific Analysis: Frequency and Most Influential Factor**

One categorical question (Q12) within the survey asked about the single most influential factor in route navigation. The question was then analyzed for differences in demographics. The question asked, *what physical factor MOST influenced your path around the directional wall(s)?* Angle had the highest value out of all the factors: angle, color, texture, surrounding sidewalls, unknown, or other. Table 3 shows the values of participant demographics for all who selected ‘angle’ for this question.

**Table 3.** Frequency of participant demographics who selected ‘angle’ for Q12.

<table>
<thead>
<tr>
<th>Demographics</th>
<th>Frequency</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-20:</td>
<td>8</td>
<td>36.4%</td>
</tr>
<tr>
<td>21:</td>
<td>7</td>
<td>31.8%</td>
</tr>
<tr>
<td>22 and up:</td>
<td>7</td>
<td>31.8%</td>
</tr>
<tr>
<td>Classification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sophomore/Junior:</td>
<td>10</td>
<td>45.5%</td>
</tr>
<tr>
<td>Senior/Graduate:</td>
<td>12</td>
<td>54.5%</td>
</tr>
</tbody>
</table>

This question showed no significant differences in frequencies between age and classification of student respondents. Overall, this study cannot support nor refute hypothesis 2 (indicating a difference in perception of navigational tendencies related to gender). However, this study indicates there is no significant difference with age or classification of respondents.
Video & Survey Correlations

Hypothesis 3

Hypothesis 3: The smaller angle (45˚) will be more significant in influencing bi-directional route, as it is closer to the target axis in a forward approach. Figure 11 shows the percentage of participants who navigated either left or right of the three wall panels. In total, the study included four wall panels but the initial wall panel has been excluded from the data analysis frequencies because it was positioned directly next to the sidewalls (Panel Z in figure 4).

The images in figure 11 relate to the first, second, and third directional wall panels positioned within the gallery space. Two wall panels (the first and third) acted as the variable panels while the middle panel served as the control. With the second wall panel, participants had the option to navigate bi-directionally without an angular influence. The direction (left/right) that participants chose while navigating through the gallery space are shown as percentages.

![Figure 11](image_url)

Figure 11. Varied positioned wall panels (45˚, perpendicular, and 60˚) with bi-directional route choices shown as percentages.
Hypothesis 3 was analyzed based off the frequencies of participants who navigated left or right of the positioned wall panels. As figure 11 illustrates, 68.8 percent of participants navigated to the right of the wall panel, which was positioned at a 45° angle favoring the left side in a forward approach. This data refutes the hypothesis that the smaller angle (45°) will be more significant in influencing route as it is closer to the target axis in a forward approach. Instead of following the angle of the wall panel to the left, almost 70 percent of participants (7 out of 10 students) navigated to the right of the panel.

The control panel in this study was positioned perpendicular to the participants’ navigational route in a forward approach. The data shows that 50 percent of participants navigated to the left of this wall panel while the other 50 percent navigation to the right. This data is characteristic of a control in which the sample size is split evenly between two choices.

The ‘larger’ positioned angle (60°) was navigated on the left side by 71.9 percent of participants. 28.1 percent of participants navigated around the panel on the right side. This data also refutes the hypothesis that the smaller angle (45°) will be a greater influence on pedestrian route. With the 60° angled wall panel, almost 72 percent of participants followed the angle of the wall panel to the left, while only 31 percent of participants followed the angle of the 45° angle to the left.

**Hypothesis 4**

Hypothesis 4: Pedestrians will statistically follow a right-side approach due to the ‘right-handed’ bias (Melton 1933; Bitgood, 1995). Hypothesis 4 was analyzed based off the same analysis as hypothesis 3: using the frequencies of participants who navigated left or right of the positioned wall panels. As figure 11 illustrates, 68.8 percent of participants navigated to the
right of the wall panel, which was positioned at a 45° angle favoring the left side in a forward approach. This data supports the hypothesis that pedestrians will follow a right-side approach due to the ‘right-handed’ bias. This indicates that regardless of wall panel angle, pedestrians will continue to navigate on the right side due to their natural tendencies.

The ‘larger’ positioned angle (60°) was navigated on the right side by 28.1 percent of participants. This data refutes hypothesis 4. However, the exit was located on the left side of the navigational path, so it is possible that participants chose the shortest route to the exit as the literature reviewed supports.

When the overall navigational behaviors of participants were observed, as seen in figure 12, the top two routes (RLL, RRR) indicate that pedestrians initially chose a right-side approach in their navigation. The first route varied by turning to the left side and continuing on the left side of the gallery. The second route continued on a right-side approach throughout the entire navigation.

Overall, the combined data from the observational experiment shows a strong support for hypothesis 4, related to a ‘right-handed’ bias. Further studies could review the influences of the exit on the left (north) wall in explaining the behavior observed at the third center panel (60°).

**Video Observations**

From the video footage, the overall paths chosen by student participants were observed. Figure 12 shows the six different paths student participants chose to navigate. Table 4 corresponds to figure 12 and shows the frequencies of participants who navigated through the gallery space using one of the six bi-directional routes around three center wall panels.
Table 4. Overall routes around three center wall panels

<table>
<thead>
<tr>
<th>Bi-directional Path (L=Left, R=Right)</th>
<th>Participants #</th>
<th>Percentage of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>RLL</td>
<td>10</td>
<td>31%</td>
</tr>
<tr>
<td>RRR</td>
<td>7</td>
<td>22%</td>
</tr>
<tr>
<td>LRL</td>
<td>6</td>
<td>19%</td>
</tr>
<tr>
<td>LLL</td>
<td>4</td>
<td>13%</td>
</tr>
<tr>
<td>RRL</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>RLR</td>
<td>2</td>
<td>6%</td>
</tr>
</tbody>
</table>

Figure 12. Chosen paths by student participants during the observational experiment
The majority of participants (10 students) used the path: RLL. The second most frequently chosen route was: RRR. It should be mentioned that panel Z may have influenced the overall routes (seen in table 4) chosen by the participants of this study. However, this study cannot conclusively say what is that influence.

Additional observations made upon review of the video footage include pedestrian behaviors and correlations between duration of the study and answers made on the survey. On average, participants spent 36 seconds in total navigating through the gallery at the College of Design.

Figure 13 shows the correlation between survey answers and duration of total time spent in the gallery space. The open-ended survey question asked: what influenced your route through the gallery? Survey responses were categorized into 8 categories: angle, line of sight, directional wall panels, destination, wall panels, curiosity, spacing, and sidewall panels.

**Figure 13.** Correlation between average navigation duration (measured in seconds) and open-ended survey question asking: What influenced your route through the gallery?
The correlations seen in figure 13 show that participants who responded that curiosity, spacing between wall panels, and sidewall panels were the most influential factor in their navigation, spent the longest time within the gallery space. Those participants, who responded that angle was the most influential factor, spent the least amount of time within the gallery space. This indicates that angled wall panels may help to direct movement through space faster than other influences.

Additional pedestrian behaviors were observed with the video footage. Eight of the participants within the study turned around or glanced behind them towards the previous wall panel. Figure 14 shows a still image of a male participant that physically turned around to look at the wall panel he had just moments before walked around prior to exiting the gallery space.

*Figure 14.* Photograph of participant looking at wall panel.
Figure 15 plots out the locations of where students were standing when they turned around within the gallery space. Five out of the eight students who physically turned around listed ‘curiosity’ as the main influence directing their route. The demographics of the five students are summarized in table 5. Four out of the five participants were seniors. Of those five students, three followed the route: LRL, 1 followed the route: RLL, and 1 followed the route: LLL. The route LRL could be defined as being one of the most ‘exploratory’ route options within the experiment as it required multiple changes in trajectory. Choosing a left path goes against the right-handed bias found within the research. In addition, changing trajectory not once but twice within the LRL path corresponds to a behavior of exploration and curiosity.

**Figure 15.** Diagram showing points of ‘curiosity’
Figure 15 shows that the majority of participants (6 out of 8) physically turned around towards the end of the gallery space, closest to the exit. The other two participants turned around after walking past the first center wall panel (45°). None of the participants walked in a reverse path or retraced their steps back towards the west wall. Instead, these participants turned around to glance at or view the panels and then they continued on their route towards the exit.

Table 5. Participants who listed ‘curiosity’ as the most influential element and who also physically turned around

<table>
<thead>
<tr>
<th>Bi-directional Path (L=Left, R=Right)</th>
<th>Gender</th>
<th>Classification</th>
<th>Length of navigation (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRL</td>
<td>Female</td>
<td>Senior</td>
<td>32</td>
</tr>
<tr>
<td>LRL</td>
<td>Male</td>
<td>Senior</td>
<td>28</td>
</tr>
<tr>
<td>LRL</td>
<td>Female</td>
<td>Senior</td>
<td>65</td>
</tr>
<tr>
<td>RLL</td>
<td>Female</td>
<td>Senior</td>
<td>26</td>
</tr>
<tr>
<td>LLL</td>
<td>Female</td>
<td>Sophomore</td>
<td>34</td>
</tr>
</tbody>
</table>

**Result Conclusions**

The following hypotheses based on the literature review and methodologies were established, followed by the conclusions derived from this study.

1. Participants’ route through the gallery space is most influenced by the angle of the wall panel. *Hypothesis supported*
2. There is a significant difference between male and female navigational behaviors and perceptions (Kim et al., 2007). *Hypothesis neither supported nor refuted*

3. The smaller angle (45°) will be more significant in influencing bi-directional choice as it is closer to the target axis in a forward approach. *Hypothesis rejected*

4. Pedestrians will statistically follow a right-side approach due to the ‘right-handed’ bias (Melton 1933, Bitgood, 1995). *Hypothesis supported*

The limitations of analyzing data such as correlations between duration and participants who traveled right or left of individual wall panels, include the shortcoming that navigation is the sum of many different factors, actions, and choices. It is difficult to make conclusions on navigational behavior as a whole based on only one or two factors.

It should be noted that the results discovered with hypothesis 3, more participants followed the wall panel with the larger angle (60°) versus the smaller angle (45°), could have been due to the location of the exit. The exit door in this study was used as the ‘destination’ for pedestrian navigation. In the College of Design gallery, the exit is located on the north wall, which for this study, was also located on the left side of the participants’ navigational path.
CHAPTER V. SUMMARY & CONCLUSIONS

This study’s hypotheses and various observations collected from the experiment and survey analysis are discussed below.

Major Themes Identified

*Angle is a significant influence on pedestrian navigation*

The data analysis performed for hypothesis 1 indicated that angle might not be the first element that participants perceive as they think about their navigational influences but of the elements, angle is a strong influence. The majority of student respondents did not list ‘angle’ as the most influential element affecting their navigation through the gallery space. Instead, the wall panels were mentioned as the most influential element. However, when specifically asked whether angle was an important element, respondents overwhelmingly said it was influential in affecting their route through the gallery.

* Differences in age and classification navigational behaviors are not significant

While differences in gender cannot be supported nor refuted, this study indicates there is no significant difference with age or classification of respondents. The frequencies analyzed from the data showed that behavior is similar amongst participants of varying age and school year. Participants navigated left or right around the center wall panels regardless of demographics.
Angle degree may not be a significant influence on pedestrian navigation

This study refuted hypothesis 3 that the smaller angle (45° vs. 60°) had a stronger influence on pedestrian bi-directional choice. The majority of participants chose the left side for the 60° angled wall panel more than the 45° panel. However, it was observed that pedestrians had a tendency to follow the shortest route to the exit, altogether ignoring the wall panels. Future studies should do more testing of various angles to determine if angle degree is an important element at all.

Curiosity is an important element in influencing pedestrian navigation

Curiosity was listed as a top factor in influencing pedestrian route. 13 percent of participants listed curiosity as the single element that influenced their route through the gallery. Participants, who responded that curiosity was the most influential factor in their navigation, spent the longest time within the gallery space. Also, it was observed through the video footage (figure 14) that eight participants physically turned around to look behind them at previous wall panels. One interpretation of their behavior may be that they were curious and wanted to scan their environment to better understand it. The implication of this is that curiosity could be a significant influence on pedestrian navigation, more so than angle or other elements.

Limitations of the Study

The methodology within this study had many shortcomings, which are explained below. First, additional study layouts should be considered. Second, participant demographics could be more varied in future studies. The limitations of this study included having a disproportionate
number of female students to males due to the nature of the selected major: Interior Design. Future studies could include a larger sample of male and female adults.

Additional limitations to this study included:

- The linear space with openings at both ends proved to be useful for the study. However, the number of panels available at the time of the study limited the independence of exposure to each consecutive panel orientation. A more ideal arrangement is shown in figure 16.

![Diagram showing alternate experiment layouts](image)

**Figure 16.** Diagram showing alternate experiment layouts

- This study only tested three center wall panels in which participants could navigate around. The data collected was limited to navigation around only three panels, which is not necessarily representative of a full-scale exhibition space. Repeating this study with more center wall panels in which pedestrians choose a path bi-directionally could produce greater significance and correlation results.

- This study looked only at left-favored wall panels. Wall panels favoring the right side were not tested within this study. Repeating this study with more directional
wall panels, which also favor the right side, could produce more balanced results and could help to definitively support or refute hypothesis 4.

- Participants’ behaviors were observed using video footage from two cameras set at either end of the gallery space, which offered only two perspectives of their behaviors navigating through the space. Future studies could include additional cameras or eye-scanning techniques to understand additional behaviors not observed within this study.

**Future Research**

Within this study, a large limitation was the small number of participants collected. Future studies could repeat the observational experiment and survey with a larger sample size. Also, as this study only looked at a specific demographic (Interior Design students), future studies could expand to other disciplines with a more even spread of gender and age.

This study looked specifically at the element of angled wall panels. This was done based on the literature review and studies of Hochmair (2004) and Cullen (1971) which indicated angle is a strong influence on movement through space. Future research can study the effects of additional routes and shaped structures such as zigzag routes, curves, etc.

According to Rengel (2007), curved walls are a significant directional cue that allow for partial views thus arousing the viewer’s curiosity and persuading a forward motion.

Although it was not an element of concern within this study, texture, as a directional influence, could be studied in the future. Rengel (2007) discusses the importance of texture as adding articulation to a space. “If you want to increase users’ spatial awareness momentarily, you can change the floor texture, making it rough and/or bumpy.” Within this study, texture was
not an element that participants perceived as having a strong influence on their route choice. Whether texture is an influence in additional studies, with a larger sample or various participant demographics could be tested.

Another variable that was not researched extensively within this study includes color. Color, like texture, can be used to alert visitors to a change within their environment. “Color coding can also designate function. Color is not only a means to simplify users’ perception of a place and provide prompts to guide them where they are going, but it can also breathe life into an otherwise purely utilitarian design” (Gibson, 2009). This applies to movement through space, as color could be a significant influence on moving pedestrians away from certain elements and towards others.

**Conclusion**

Understanding pedestrian movement and the subtle influences of directional cues on that movement is a crucial step towards a reliable description of pedestrian route choice in real-life situations. This study was performed to begin a dialogue on the influences of pedestrian navigation including the angular effect on bi-directional (left/right) choices. The study looked at pedestrian behaviors, route choices, and perceptions through the use of an observational experiment and corresponding survey. The research provided insight into the subtle influences of physical structures on pedestrian movement within exhibit settings.

The results of observed behaviors in this study were inconclusive. However, the frequency of reference to ‘panels’ in the questionnaire, and attention given to ‘angles’ in follow-up discussion provides support for the potential significance of further research on ‘deflection’ as an interior wayfinding cue.
REFERENCES


APPENDIX A: HUMAN SUBJECTS TRAINING CERTIFICATE

Certificate of Completion
The National Institutes of Health (NIH) Office of Extramural Research certifies that Jennifer Munoz successfully completed the NIH Web-based training course “Protecting Human Research Participants”.
Date of completion: 08/27/2012
Certification Number: 969612
APPENDIX B: IRB APPROVAL FORM

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4167

Date: 8/27/2014
To: Jennifer Munoz Haywood
115 Crystal St Apt 204
Ames, IA 50010

CC: Dr. Fred Malven
283 Design
Jihyun Song
158 College of Design

From: Office for Responsible Research

Title: Influences on Pedestrian Bi-Directional Route

IRB ID: 14-404

Approval Date: 8/25/2014
Date for Continuing Review: 8/24/2016

Submission Type: New
Review Type: Expedited

The project referenced above has received approval from the Institutional Review Board (IRB) at Iowa State University according to the dates shown above. Please refer to the IRB ID number shown above in all correspondence regarding this study.

To ensure compliance with federal regulations (45 CFR 46 & 21 CFR 56), please be sure to:

- Use only the approved study materials in your research, including the recruitment materials and informed consent documents that have the IRB approval stamp.

- Retain signed informed consent documents for 3 years after the close of the study, when documented consent is required.

- Obtain IRB approval prior to implementing any changes to the study by submitting a Modification Form for Non-Exempt Research or Amendment for Personnel Changes form, as necessary.

- Immediately inform the IRB of (1) all serious and/or unexpected adverse experiences involving risks to subjects or others; and (2) any other unanticipated problems involving risks to subjects or others.

- Stop all research activity if IRB approval lapses, unless continuation is necessary to prevent harm to research participants. Research activity can resume once IRB approval is reestablished.

- Complete a new continuing review form at least three to four weeks prior to the date for continuing review as noted above to provide sufficient time for the IRB to review and approve continuation of the study. We will send a courtesy reminder as this date approaches.

Please be aware that IRB approval means that you have met the requirements of federal regulations and ISU policies governing human subjects research. Approval from other entities may also be needed. For example, access to data from private records (e.g., student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. IRB approval in no way implies or guarantees that permission from these other entities will be granted.

Upon completion of the project, please submit a Project Closure Form to the Office for Responsible Research, 1138 Pearson Hall, to officially close the project.
APPENDIX C: INFORMED CONSENT FORM

CONSENT FORM FOR: INFLUENCES ON PEDESTRIAN BI-DIRECTIONAL ROUTE

This form describes a research project. It has information to help you decide whether or not you wish to participate. Research studies include only people who choose to take part—your participation is completely voluntary. Please discuss any questions you have about the study or about this form with the project staff before deciding to participate.

Who is conducting this study?
This study is being conducted by Jennifer Haywood, graduate student in Interior Design at Iowa State University.

Why am I invited to participate in this study?
You are being asked to take part in this study because you are a design student and/or enrolled in design courses at Iowa State University. You should not participate if you are under the age of 18.

What is the purpose of this study?
The purpose of this study is to understand the bi-directional influences on pedestrian navigation through interior spaces.

What will I be asked to do?
If you agree to participate, you will be asked to perform 4 rounds of navigation around directional cues set up in the College of Design gallery. After, you will be asked to complete a survey about your navigational influences.

- Participation in the rounds of navigational tasks will be video recorded.

Your participation will last for 30 minutes (10 minutes to complete the 4 navigational tasks, to be completed all at once, and 20 minutes to complete the survey).

- Survey questions will include categorical, scaled, and open-ended questions related to your navigational influences and directional route choice.

What are the possible risks or discomforts and benefits of my participation?
There are no foreseeable risks or discomforts related to your participation.

Benefits—You may not receive any direct benefit from taking part in this study. We hope that this research will benefit society by aiding designers in understanding the subtle cues in the environment that can influence navigation and wayfinding.

How will the information I provide be used?
The information you provide will be used for the following purposes:

- Data collected will be used to make conclusions about pedestrian directional choice. The results and conclusions drawn from the information may be published within a graduate thesis and professional presentations. Only the research staff will have access to the data and video recordings.
What measures will be taken to ensure the confidentiality of the data or to protect my privacy?

Records identifying participants will be kept confidential to the extent allowed by applicable laws and regulations. Records will not be made publicly available. However, federal government regulatory agencies, auditing departments of Iowa State University, and the ISU Institutional Review Board (a committee that reviews and approves research studies with human subjects) may inspect and/or copy study records for quality assurance and analysis. These records may contain private information.

To ensure confidentiality to the extent permitted by law, the following measures will be taken: Identifying information such as gender, age, and major will be collected. No other identifiers (such as name, address, phone number, etc.) will be collected. All data will be stored within a locked container and data stored digitally will be password protected. Participant’s identities will be kept confidential when results of the study are disseminated.*

*However, you may consent below to have your images released for publication. Please note, that even by consenting, your face will be blurred to maintain confidentiality.

Will I incur any costs from participating or will I be compensated?

You will not have any costs from participating in this study. You will not be compensated for participating in this study.

A drawing for 2 gift cards in the amount of $50 will be listed as an incentive for participation. Participants may provide their email address to be included in the random drawing. Inclusion in the gift card drawing is not contingent on successful completion of the study.

What are my rights as a human research participant?

Participating in this study is completely voluntary. You may choose not to take part in the study or to stop participating at any time, for any reason, without penalty or negative consequences. You can skip any questions that you do not wish to answer.

If you have any questions about the rights of research subjects or research-related injury, please contact the IRB Administrator, (515) 294-4566, IRB@iastate.edu, or Director, (515) 294-3115, Office for Responsible Research, 1138 Pearson Hall, Iowa State University, Ames, Iowa 50011.

Whom can I call if I have questions about the study?

You are encouraged to ask questions at any time during this study. For further information, please contact Jennifer Haywood, (515) 520-1897, or Frederic Malven, (515) 294-6724.

Consent and Authorization Provisions

Your signature indicates that you voluntarily agree to participate in this study, that the study has been explained to you, that you have been given the time to read the document and that your questions have been satisfactorily answered. You will receive a copy of the written informed consent prior to your participation in the study.
Participant's Name (printed) ____________________________________________

Participant's Signature ___________________________ Date ____________

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Check and sign here if you consent to having your video recording images available for 
publication. Please note, that even by consenting, your face will be blurred to maintain confidentiality.

☐  Participant's Signature

________________________________________
APPENDIX D: PEDESTRIAN NAVIGATION QUESTIONNAIRE

Pedestrian Navigation Questionnaire

What influenced your route through the gallery?

I. Please rate your level of agreement to the following questions (1-Strongly Disagree to 5-Strongly Agree)

1. My navigation was influenced by the directional wall(s).
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Uncertain</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

2. My navigation was influenced by the angle of the directional wall(s).
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Uncertain</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

3. My navigation was NOT influenced by the directional wall(s).
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Uncertain</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

4. I was able to easily navigate around the directional wall(s).
   
<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Uncertain</td>
<td>Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>
5. The directional wall(s) directed me towards either the left or right.

|   | 1 | 2 | 3 | 4 | 5 
|---|---|---|---|---|---
|   | Strongly Disagree | Uncertain | Agree | Strongly Agree | Disagree 

6. My navigation was influenced by my tendency to generally walk left or right.

|   | 1 | 2 | 3 | 4 | 5 
|---|---|---|---|---|---
|   | Strongly Disagree | Uncertain | Agree | Strongly Agree | Disagree 

7. I spent a good amount of time deciding which direction to navigate around the directional wall(s) before moving.

|   | 1 | 2 | 3 | 4 | 5 
|---|---|---|---|---|---
|   | Strongly Disagree | Uncertain | Agree | Strongly Agree | Disagree 

II. Please rate the level of significance each of the following factors had on influencing your navigation through the gallery (1-Very Insignificant to 5-Very Significant)

1. *Angle* of directional wall(s)

|   | 1 | 2 | 3 | 4 | 5 
|---|---|---|---|---|---
|   | Very Insignificant | Uncertain | Significant | Very Significant | Insignificant 

2. *Color* of directional wall(s)

|   | 1 | 2 | 3 | 4 | 5 
|---|---|---|---|---|---
|   | Very Insignificant | Uncertain | Significant | Very Significant | Insignificant 

3. *Texture* of directional wall(s)

|   | 1 | 2 | 3 | 4 | 5 
|---|---|---|---|---|---
|   | Very Insignificant | Uncertain | Significant | Very Significant | Insignificant 

4. Surrounding side walls

|   | 1 | 2 | 3 | 4 | 5 
|---|---|---|---|---|---
|   | Very Insignificant | Uncertain | Significant | Very Significant | Insignificant
III. What physical factor MOST influenced your path around the directional wall(s)?
(only select 1)
   a. Angle of the directional wall(s)
   b. Color of the directional wall(s)
   c. Texture of the directional wall(s)
   d. Surrounding side walls
   e. Not known
   f. Other

IV. Demographics
1) Gender:  
   Male
   Female
   Prefer not to answer

2) Age: _______________

3) Year in school:  
   Freshman
   Sophomore
   Junior
   Senior
   Graduate
   Other

3) Major: _______________
Hello,

My name is Jennifer Haywood. I am a graduate student in Interior Design. I am conducting research with Fred Malven. I am here to discuss an opportunity for you to participate in research about pedestrian navigation and directional choice.

I am interested in recruiting design students or those enrolled in design courses over the age of 18. The study will take place over 1 week [exact dates will be listed here] and will require one 20-30 minute visit to the College of Design gallery. Participants will be asked to navigate through the gallery space while walking around wall partitions. Additionally, participants will be asked to complete a survey asking about their route influences.

Participants will be video recorded during the study for the purpose of data collection. Participant's identities will remain confidential.

A random drawing for 2 ($50) gift cards will be conducted. Two participants will have the chance to win one each as compensation for their involvement in the study.

You should not participate in this study if you are younger than 18 years of age.

If you would like to sign up for the study or learn more about the requirements, please feel free to e-mail me (jcmunoz@iastate.edu). Thank you for taking the time to consider participation!

Kind Regards,

Jennifer