1-1-2014

Wayfinding in a City Environment: Driver Experience and Strategies

Katherine King

Wayfinding in a city environment: Driver experience and strategies

By

Katherine Marie King

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Industrial Engineering
in the Department of Industrial and Systems Engineering

Mississippi State, Mississippi

August 2014

Wayfinding in a city environment: Driver experience and strategies

By

Katherine Marie King

Approved:

Lesley Strawderman
(Major Professor)

Kari Babski-Reeves
(Committee Member/Graduate Coordinator)

Daniel W. Carruth
(Committee Member)

Jason Keith
Interim Dean
Bagley College of Engineering

Name: Katherine Marie King

Date of Degree: August 15, 2014

Institution: Mississippi State University

Major Field: Industrial Engineering

Major Professor: Lesley Strawderman

Title of Study: Wayfinding in a city environment: Driver experience and strategies

Pages in Study: 49

Candidate for Degree of Master of Science

The following study aimed to understand pure wayfinding search strategies and identify the most efficient strategy when discovering a new environment. Participants performed one drive in a simulated city environment within a driving simulation lab. Their objective was to locate a target within the city, without any navigational aids (maps, GPS, etc.). Efficiency measures, such as number of road segments covered between origin and target, were evaluated. Experience and gender were also analyzed. There was a significant difference of efficiency between search strategies. Experience did not impact a driver's efficiency. The knowledge from this study can be used in city planning of high tourist areas or major facilities.

DEDICATION

I dedicate my thesis work to my family and many friends. A special dedication goes to my parents Mary and Michael King, for always encouraging me to chase my goals and giving me the confidence to do so. Also to my friends who have been there to support me every day, being my personal cheerleaders each step of the way.

ACKNOWLEDGEMENTS

This project would have not been possible without the support of many people. I owe many thanks and appreciation to my advisor, Lesley Strawderman, who provided the means for me to complete this project, has guided me through the process, read through my countless revisions and helped clear up some of the confusion. Also I would like to thank my committee members, Daniel W. Carruth and Kari Babski-Reeves whose expertise and support helped complete this project. Finally, a special thank you goes to my fellow graduate students who were beside me during this journey and whom made this time more enjoyable.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

1.1 Introduction

Wayfinding is a strategy applied by people every day. Whether wandering around an unknown environment on vacation or exploring different areas of a familiar city, all of these types of tasks rely on one's ability to wayfind. While the techniques for navigating have been studied multiple times (Heuten, Henze, Boll, & Pielot, 2008; Ishikawa, Okabe, Fujiwara, & Imai, 2008; Montello & Sas, 2006), pure wayfinding techniques, with no direction, has not been as thoroughly explored. Vehicular navigation is a well-researched topic area. These studies are generally aimed at evaluating navigational aids, instead of purely assessing wayfinding strategies (Ishikawa et al., 2008; Lee & Cheng, 2008).

Thus, there is a need to investigate pure wayfinding techniques without the use of navigational aids. Once these strategies are identified, it is important to assess which are the most and least efficient. The factors which influence one's wayfinding strategy choice should also be considered. An understanding of how different people go about finding their way in a new environment is necessary to improve navigational aids. A person's experience of an environment influences the type of wayfinding strategies he/she executes. This work aims to investigate and understand pure wayfinding strategies and identify the most efficient strategy, in hopes to improve city planning of high tourist areas as well as general facilities layout (i.e., hospital). Furthermore, it will add to the body of research focused on wayfinding.

1.2 Background

1.2.1 Defining Wayfinding

Wayfinding is a term not clearly defined. It is a complex process that will vary due to individual differences and outside factors.

Possible definitions include:

- A cognitive psychological process for finding a pathway from a point of origin to some specified destination (Arrowsmith, Cartwright, Jackson, & Xia, 2008).
- The "cognitive ability to assimilate spatial information, make maps to find one's way, make decisions, and execute these decisions" (Chebat, Therrien, & Gélinas-Chebat, 2005)
- A process involving the determination of a path and the following of this path or route (Golledge, 1999).

In the study conducted by Arrowsmith et al. (2008), wayfinding was further defined as a purposeful and directed act for traveling from a known origin to destination. Although there is some variation in the terminology used to describe wayfinding, key features exist which all definitions identify.

Some of these common themes include a known origin and destination, decision making process, and the formation/use of a cognitive map during direction-seeking. However, there is no agreement on whether a pre-planned route from origin to destination is a key point in wayfinding; or if there is a significant difference in the process of wayfinding versus navigating. The latter point is discussed more in the following section.

1.2.2 Wayfinding versus navigation

One issue in comparing wayfinding research is the relation between wayfinding and navigation. According to Montello and Sas (2006), navigation involves very directed movements with a specific destination in mind. They go on to describe wayfinding as a process which includes many decision-making steps before reaching the destination (Montello & Sas, 2006). In this study, wayfinding was described as a component of navigation; noting that some researchers use these terms interchangeably. Wayfinding involves taking in real time information from one's surroundings as well as relying on memory to move along one's unknown path from point A to point B. Navigating implies there is a set route from point A to point B and the user must follow this path using some form of direction (physical map, GPS, etc.).

Brunye et al make a distinction between wayfinding and navigation on the basis of the information used it either case. They state that wayfinding draws on existing spatial knowledge of an environment (Brunyé, Taylor, & Taylor, 2008). Therefore, the greater the spatial understanding of an environment, the more extensive and comprehensive the mental model becomes (Brunyé et al., 2008). Navigation does not rely on these spatial representations, but rather involves memory of physical movements or a navigational aid (Brunyé et al., 2008).

One key feature which describes wayfinding is the development and use of a cognitive map. This map can be viewed as a hierarchy of levels of reasoning (Stoffel, Schoder, & Ohlbach, 2008; Timpf, Volta, Pollock, & Egenhofer, 1992). Timpf et al asserted that people employ default reasoning, or commonsense, when managing an unknown situation. At lower levels this reasoning is more detailed and at higher levels this default reasoning is more of a generalization of the lower level (Timpf et al., 1992). Thus wayfinding may be seen as a more general, higher level of reasoning, while navigating may be described as a more detailed, lower level of reasoning. For the purposes of this study, the distinction between wayfinding and navigation is defined in Table 1. Furthermore, Patel and Vij described wayfinding as the cognitive piece of navigation (Patel & Vij, 2010). Whereas they include physical motion along with wayfinding in their description of navigation (Patel & Vij, 2010).

Table 1.1 Chararcteristics of wayfinding and navigating

Factor	**Wayfinding**	**Navigation**
User Goal	Reach destination	Reach destination along a specified route
Cues used	Memory	Aids (e.g. maps, GPS, signage)
Number of paths/routes	Infinite	Finite, typically one
Mental Map	Incomplete	Complete

1.2.3 Pedestrian vs. Vehicular Wayfinding

Many studies have evaluated wayfinding from a pedestrian point of view. It has been studied in a range of environments including shopping malls, city streets, business offices, and more. One such study analyzed the effectiveness of different pedestrian sign systems in central London (Fendley, 2009). Fendley identified some key effects of wayfinding, including the negative feeling associated with realizing one is lost. He stated further the emotions and actions this feeling can lead to is indicative of any tourist visiting a new environment for the first time (Fendley, 2009). Furthermore, Fendley and his team also identified an important aspect they called the principle of awareness, or the lack of knowledge of what one does not know (Fendley, 2009).

The dynamics of pedestrian wayfinding has been an important aspect in the study of evacuation strategies and models (Pelechano, 2006; Zhu, Liu, & Tang, 2008). A great challenge for this research domain is simulating realistic pedestrian behavior, both on the crowd and individual level. Despite the obvious need for modeling pedestrian wayfinding strategies in an emergency situation, there is also the need to understand pedestrian behavior in "normal" settings. Knowledge of this normal behavior has a major impact on infrastructure designs: such as urban planning and traffic operations (Antonini, Bierlaire, & Weber, 2006). All of the above studies were focused on analyzing pedestrian wayfinding in different environments with an aim to accurately model these behaviors.

One major point researchers investigating pedestrian wayfinding make, is that it differs greatly from vehicular wayfinding (Gaisbauer & Frank, 2008; Hoogendoorn & Bovy, 2004). This is due predominantly to the difference in traffic conditions and travel levels. Whereas vehicular travel is restrained to the street level, pedestrians have a higher degree of freedom of movement (Gaisbauer & Frank, 2008). An additional difference between pedestrian and vehicular wayfinding is the amount of available cognitive resources when directing one's path. Drivers have much more stimuli, such as changes that occur with the vehicle and changes in traffic in the surrounding environment, which require more and constant attention that a pedestrian navigating a street (Gaisbauer & Frank, 2008).

Thus, when considering wayfinding in a driving environment, multiple factors can affect one's wayfinding ability. For example, possessing a general poor sense-of-direction may predispose someone to experience disorientation on a regular basis in different environments (Montello & Sas, 2006). Small occurrences of this can cause great emotional responses such as frustration, anxiety, and emotional response. In the setting of vehicular wayfinding, disorientation can have more severe affects such as traffic congestion and accidents (Montello & Sas, 2006). Another aspect affecting one's wayfinding ability in a vehicle is environmental complexity. This was pointed out by Brunye et al where they assert that different landmark sizes and shapes can cause one to have a greater need for navigational assistance (Brunyé et al., 2008).

1.2.4 Wayfinding Strategies

Although the strategies used for wayfinding in driving conditions haven't been highly examined, it has been evaluated in other environments. Most studies have evaluated wayfinding strategies in pedestrian environments, such as multi-level buildings (Hölscher, Meilinger, Vrachliotis, Brösamle, & Knauff, 2006). In his study, Hölscher et al. defined three wayfinding routes for moving through a multi-level building. For example, one search strategy was the central-point-strategy, which involved "finding one's way by sticking…[to] the main entry hall and main connecting corridors, even if this requires considerable detours" (Hölscher et al., 2006). Furthermore, when wayfinding outdoors, one is more likely to maintain as straight a path toward a destination as possible, minimizing turns or deviations (Dalton, 2003). Although wayfinding is a predominantly exploratory action, there are some underlying organizational strategies commonly used in this process. A couple of these identified strategies include a cyclic and back and forth pattern (Kallai, Makany, Karadi, & Jacobs, 2005). An example of a cyclic pattern is circling an entire city block, then moving to the next and circling it, and continuing this pattern on. A back and forth pattern is similar to a zig-zag pattern. For example, driving an entire road until it ends, then turning the block and driving the adjacent road back toward the initial direction. Another search strategy is a perimeter search which involves very little exploration as one tends to stay near the boundaries of an object (Kallai et al., 2005). Two closely related strategies are network and random. Network search involves more exploration, moving from the center of an object and exploring out from a start point. Random strategy involves moving from object to object without much connection between all objects (Kallai et al., 2005). These strategies can be applied and examined in a driving wayfinding condition.

1.2.5 Contributing Factors

Multiple studies have been conducted aimed at understanding the differences, if there are any, gender can have on how we think and perceive. In relation to wayfinding, many studies have looked at how gender affects one's spatial orientation/ability. Lawton and company and have thoroughly studied wayfinding techniques and gender differences in this task. In one such study, he noted that numerous studies have reported that men are more likely to prefer survey perspectives (cardinal directions/precise distances). Women prefer route perspectives (landmarks) (Lawton, 1994). In that particular study Lawton and his colleagues did not find any differences in wayfinding performance for women and men (Lawton, 1994).

A more recent study conducted by Lin and Chien noted women and men use different cues when navigating an environment. Men utilize position and distance information while women are more concerned with landmarks when attempting to navigate (Lin & Chien, 2010). Yet, according to both of these studies, there is more evidence that the difference, if any, between genders and wayfinding ability is still largely inconclusive.

Driving experience is another factor which affects how one visually searches while wayfinding in a new environment. In one similar visual attention study, it was reported that a driver's visual search skills/strategies and effectiveness is directly linked to their driving experience (Underwood, 2007). Underwood further suggested that experienced driver's adapt their visual search strategies depending on the conditions of their environment, unlike inexperienced drivers (Underwood, 2007). Another study conducted by Konstantopoulos et al supported these ideas. They measured drivers' eye movements throughout a simulated driving scene. Their results showed the number of fixations and sampling rate of experienced drivers to be greater than inexperienced drivers. (Konstantopoulos, Chapman, & Crundall, 2010). Thus suggesting experienced drivers required less processing time of their surroundings.

Experience or familiarity with an environment could have an effect on a driver's ability to find their way better than a stranger to the environment. The more experience a navigator has with an environment, the better their mental representation (Brunyé et al., 2008). Although finding one's way requires knowledge of the environment, it may be in the form of specific facts about a particular environment *or* it may be in the form of general relationships held between a bigger classification of environments (Freksa, 1999) Freksa goes on to say this general spatial knowledge is typically gained through making inferences about general patterns and spatial configuration (Freksa, 1999).

In the study carried out by Timpf et al, they assessed their multi-level concept model in a driving environment: the U.S. Interstate Network (Timpf et al., 1992). They state that drivers' experience with the transportation system and it's real world objects help create more general conceptual models (Timpf et al., 1992). These become distributed within the hierarchy of reasoning depending on the detail level. Higher levels are more generalized concepts of real world objects. Thus, one's familiarity with driving in an urban environment versus a rural environment should provide them with a greater cognitive map of what a city structure looks like. Their ability to find their way around this generally familiar environment should be great than that of a stranger to an urban environment.

CHAPTER II

METHODOLOGY

2.1 Objective

The major objective of this study is to understand the strategies drivers use when wayfinding without the use of navigational aids. Three search patterns were compared in this study: long pattern, short pattern, and no pattern. Specifically, the efficiency of these wayfinding search patterns outlined above was evaluated and the effect of urban driving experience on the type of pattern used was analyzed. Furthermore, the effects of gender were evaluated. For this specific work, these hypotheses were proposed:

- Experienced urban drivers will choose a long pattern
- Inexperienced, more rural, drivers will use no organized search pattern
- The most efficient strategy will be long pattern
- No search pattern will be the least efficient.

2.2 Methods

2.2.1 Experimental Design

This study was performed in the driving simulator lab at the Center for Advanced Vehicular Systems (CAVS) at Mississippi State University. The simulator is a full sized vehicle. The automatic Nissan Maxima has all of the original interior components needed to safely and comfortably operate the vehicle. It sits atop a motion base which allows for six degrees of freedom to simulate the physics of a real-car drive. The visual environment is provided via three projector screens surrounding the simulator.

The simulated environment is a large city environment, 4X4 blocks wide. The city is very detailed, including small shops, bus terminals, as well as office-style skyscrapers placed throughout the city. Within the city there is a salient fast food restaurant (i.e. KFC). The participants will be instructed to locate this target within the city and park in the lot in front. Figures 2.1 and 2.2 show varying views of the simulated environment.

Figure 2.1 Street view of city environment

Figure 2.2 Overhead view of city environment

There are a total of 36 road segments within the 4x4 city grid. The starting point of each participant and the location of the park within the city can be seen in figure 2.3 below. The red car denotes the starting point and the red “X” denotes the location of the target.

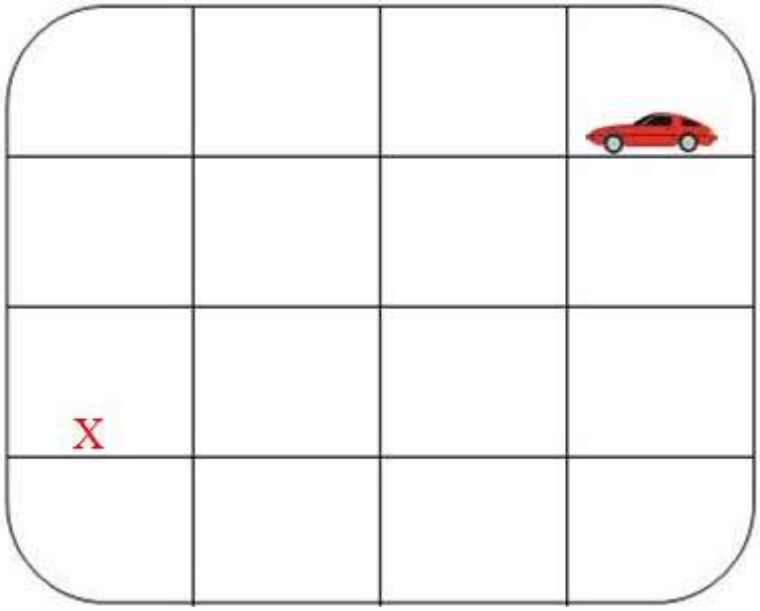

Figure 2.3 Grid view of the city environment

2.2.2 Dependent Variables

Wayfinding strategy efficiency was measured via three dependent variables. The dependent variables consisted of: number of road segments, road segments duplicated, and drive time within the city. Road segments are defined as one block within the city, from corner to corner. There are a total of 36 road segments. Therefore, the maximum unique road segments a participant can cross between the starting point and the park is 36. The minimum is five. Each segment is uniquely numbered from 1 to 36. Thus, road segments and duplicate segments covered were captured in the data collection. Target identification was also acquired during the data collection and analyzed in the results. In addition to these, performance data including speed, lane position, driving time, and video were collected for each participant. These measures have been utilized multiple times in previous literature as proper measures for assessing wayfinding and navigating techniques (Ishikawa et al., 2008; Lee & Cheng, 2008; Pielot & Boll, n.d.).

2.2.3 Independent Variables

Independent variables include the user's wayfinding strategy, gender, and urban driving experience. The wayfinding data collected per driver was evaluated. Wayfinding strategy was categorized into three search patterns: long, short, and no pattern. Long patterns were those that resembled the perimeter and back and forth searches previously defined. This involves driving a greater number of road segments before turning. Short patterns were those paths that resembled a network or cyclic search; thus including more turns and less road segments covered before turning, than a long search pattern. No pattern is a lack of a search strategy, or no discernible pattern. Examples of these strategies can be seen in Appendix A and the categorization is described in detail in section 2.2.7.

Urban driving experience and gender was assessed via a prescreening and demographics survey. Specifically, the question used to assess urban driving experience asked: "Do you feel comfortable driving in a big urban city environment (i.e., Atlanta, Dallas, etc.)?" This was a yes or no question. It was assumed that having more experience equates to more comfort when driving in a big city, compared to inexperience.

2.2.4 Participants

A total of 35 participants were involved in this study. However, due to either a technical malfunction or participants' discomfort or sickness with the driving simulator, valid data was available for 30 participants. Of those 30 participants, 8 did not locate the target. Therefore, only 22 participants' data were analyzed. The average age was 23.1 years (SD= 2.5). A total of 16 males and 6 females participated in the study. Regarding experience, 18 participants reported being comfortable when driving in an urban environment. The participants were recruited from the Mississippi State University campus. All had a valid driver's license and met the screening survey requirements described in the procedures below.

2.2.5 Experimental Task

In total the participants were asked to complete two drives for this experiment. The initial drive was a familiarization drive. This allowed the participant to become comfortable with the driving simulator and its controls. The environment was a city, similar to the one used in the main drive. The familiarization drive lasted approximately five minutes. Following that drive, participants completed the data collecting drive. The big city environment contained one target building. The participant's goal was to locate the target within the city. No maps, navigational aids, or any other material was supplied to the participant. Each participant's movements were recorded in data collection.

2.2.6 Procedures

A screening survey was used in the recruitment of participants to assess any existing health risks that might exclude them from operating the driving simulator. These include vision, hearing, history of epilepsy, and history of motion or simulator sickness. Furthermore, in an effort to recruit a balanced number of participants with or without city driving experience, there was a screening question concerning this information. This was completed using SurveyMonkey and scheduling was handled via email and telephone contact.

Upon entering the lab, participants were handed a copy of the consent form and the researcher answered any questions. Once the consent form was signed, a demographic survey including a driving behavior questionnaire (DBQ) (Appendix A) was filled out. Finally, a baseline motion/simulator sickness questionnaire (MSSQ) was completed. The participant was then shown the driving simulator and related equipment (i.e. projector screens, steering, etc.).

Participants completed the five minute familiarization drive followed by another MSSQ. The new MSSQ score compared to the baseline values and the decision to continue or terminate made between the researcher and participant. If responses markedly increased, such as a "severe" response, or participants voiced any discomfort or desire to stop, the experiment was discontinued.

Participants re-entered the simulator and were instructed to complete the experimental task. During this time, the researcher again closely monitored the participant looking for signs of discomfort. Once the participant located the target, he/she was informed to park in the lot in front of the target building. Upon exiting the vehicle the participant filled out a final MSSQ.

2.2.7 Data Analysis

Performance data, such as velocity and lane position, along with wayfinding data, such as path taken, were recorded in the simulator. Efficiency measures collected consist of: number of road segments, duplicated road segments, and driving time. These data sets were collected post task completion in Excel. A map of each participant's path through the driving simulator scenario was traced onto a copy of the city grid shown in Figure 2.3. These paths were then evaluated and fit to one of the three wayfinding search stratetgy categories using the following criteria:

- If a driver covered three or more road segments before turning, this was defined as utilizing a long search pattern. For example, if a driver covered four road segments around the perimeter, turned, covered four more road segments, turned, and covered four more road segments, this would be classified as long search pattern. Figure 1 in Appendix A.6 shows an example of long pattern.
- If a driver covered less than three road segments before turning, this was defined as utilizing a short pattern. For example, if a driver made a series of right turns, to complete circling one block, then moved to the next city block and made a series of turns to circle it, and so on, this would be classified as short pattern. Figure 2 in Appendix A.6 shows an example of short pattern.
- The number of times a driver utilized each pattern was counted. The dominant pattern for each driver was defined as the one pattern used the most during the drive.
- No search pattern was defined as an unclear mix of both long and short. For example, if a driver covered two road segments, turned, covered three more road segments, turned, covered another road segment, turned, and covered three more road segments again, that would be classified as no search pattern. Figure 3 in Appendix A.6 shows an example of no pattern.

Descriptive statistics and analysis were performed in SPSS. The mean, standard deviation, minimum, and maximum values are shown in the descriptive statistics of the different variables assessed. Analysis of Variance (ANOVAs) and independent t-tests were used to evaluate the efficiency of each strategy and the impact of experience and gender on efficiency. Furthermore, Fisher's exact tests were run to test if experience or gender significantly affected strategy choice.

CHAPTER III

RESULTS

3.1 Descriptive Statistics

The following three wayfinding strategies were evaluated: long pattern, short pattern, and no pattern. The utilization frequency of each strategy is shown in Table 3.1. The environment contained a total of 36 unique road segments. The shortest distance between the starting point and the target was five road segments. Results show, the shortest distance covered to the target was seven unique road segments and the longest was 58 with 18 duplicated.

Table 3.1 Percentage of utilization for each strategy, level of experience, and gender

		Strategy		
	N	Long Pattern	Short Pattern	No Pattern
Overall	22	14 (40.0%)	3 (8.6%)	5 (14.3%)
Experience				
Yes	18	11 (61.1%)	2 (11.1%)	5 (27.8%)
No	4	3 (75.0%)	1 (25.0%)	0 (0.0%)
Gender				
Male	16	9 (56.3%)	3 (18.8%)	4 (25.0%)
Female	6	5 (83.3%)	0 (0.0%)	1 (16.7%)

The efficiency measures include: driving time, total road segments, and total duplicated road segments. Descriptive statistics for all efficiency measures are shown in Table 3.2.

Table 3.2 Descriptive statistics for efficiency measures

	N	Mean	SD	Max	Min
Road Segments	22	28.1	17.4	58	7
Duplicated Road Segments	22	6.6	6.7	20	0
Driving Time (seconds)	22	556.3	320.1	1148.1	166.7

To evaluate efficiency in subsequent analyses, the relation between the three efficiency variables was examined. Correlation between the efficiency variables was analyzed. Correlation values are shown in Table 3.3. Based on the correlation analysis results, the three measures used to analyze efficiency are highly correlated.

Table 3.3 Correlation values of efficiency measures

	Road Segments	Duplicated Road Segments	Total Driving Time in Seconds
Road Segments	1	.970**	.956**
Duplicated Road Segments	.970**	1	.933**
Driving Time (seconds)	.956**	.933**	1

**. Correlation is significant at the 0.001 level (2-tailed).

3.1.1 Wayfinding Strategy

Descriptive statistics per variable, per strategy are displayed in Table 3.4. Short pattern had the highest mean of road segments covered and no pattern had the lowest.

Table 3.4 Descriptive statistics for efficiency measures by wayfinding strategy

Efficiency Measure	**Wayfinding Strategy**	**N**	**Mean**	**SD**	**Max**	**Min**
Road Segments	Long Pattern	14	28.6	16.2	56	8
	Short Pattern	3	50.7	8.7	58	41
	No Pattern	5	13.0	5.6	21	7
Duplicated Road Segments	Long Pattern	14	6.5	5.9	18	0
	Short Pattern	3	16.3	4.7	20	11
	No Pattern	5	1.2	1.8	4	0
Driving Time (seconds)	Long Pattern	14	596.1	308.2	1148.1	201.2
	Short Pattern	3	868.6	238.0	1130.3	665.2
	No Pattern	5	257.6	103.3	383.2	166.7

A one-way analysis of variance (ANOVA) was performed on the number of road segments covered and strategy used. There was a significant effect of strategy on the number of road segments covered, $F(2,19) = 6.902$, $p = .006$. Furthermore, a post-hoc Tukey analysis showed a significant difference between short pattern and no pattern ($p = .004$), with short (M=50.7) having a significantly higher number of road segments than no pattern (M=13.0). Furthermore, there was a significant difference between strategies for number of duplicated road segments, $F(2,19)=8.028$, $p=.003$, and for drive time, $F(2,19)=5.198$, $p=.016$.Tukey analysis showed a significant difference between long pattern and short pattern for duplicated road segments ($p=.020$) and between short and no pattern ($p=.002$). Short pattern had the highest mean duplicated road segments (M=16.3). Finally, for drive time, there was a significant difference between short and no pattern ($p=.016$). The no pattern strategy had the shortest mean drive time (M=257.6).

3.1.2 Urban Driving Experience

The efficiency measures were evaluated according to urban driving experience. Descriptive statistics are shown in Table 3.5. Those with urban driving experience had a lower mean number of road segments covered than those without urban driving experience.

Table 3.5 Descriptive statistics for efficiency measures by urban driving experience

Efficiency Measure	Urban Driving Experience	N	Mean	SD	Max	Min
Road Segments	Yes	18	24.7	16.2	56	7
	No	4	43.3	16.0	58	28
Duplicated Road Segments	Yes	18	5.6	6.4	20	0
	No	4	11.3	6.8	18	4
Driving Time (seconds)	Yes	18	502.2	325.3	1148.1	166.7
	No	4	800.2	144.7	1000.5	680.1

An independent t-test was performed on urban driving experience and total number of road segments covered. Urban driving experience did not significantly impact the number of road segments covered, t(20) = 2.073, *p*= .051. The mean number of road segments covered for those with no urban driving experience was 43.3 (SD=16.0) and 24.7 (SD=16.2) for those who reported having urban driving experience. Neither drive time, t(20)=1.768, *p*=.092, nor number of duplicated road segments, t(20)=1.579, *p*=.130, was impacted by experience.

Although a long search strategy, on average, was used by both inexperienced and experienced drivers most, according to Fisher's exact test there was no significant difference in the use of strategy based on urban driving experience (*p*=.490).

3.1.3 Gender

Efficiency values were also evaluated according to gender. These descriptive statistics are shown in Table 3.6. Overall, the mean duplicated road segments between male (M=7.4) and female (M=4.7) drivers were not significantly different. Furthermore, the mean driving time for males and females were similar, with males having a slightly longer drive on average (M=482.3) compared to females (M=486.7).

Table 3.6 Descriptive Statistics of efficiency measures by gender

Efficiency Measure	Gender	N	Mean	SD	Max	Min
Road Segments	Male	16	29.8	18.6	58	7
	Female	6	23.5	14.1	45	9
Duplicated Road Segments	Male	16	7.4	7.3	20	0
	Female	6	4.7	4.8	13	0
Driving Time (seconds)	Male	16	582.3	330.4	1148.1	166.7
	Female	6	486.7	308.0	960.3	170.2

An independent t-test was also performed on gender and total number of road segments covered. Males, on average, covered a greater number of road segments than females, with a mean of 29.8 (SD=18.6) compared to 23.5 (SD=14.1).However, gender did not have a statistically significant impact on the number of road segments covered, t(20) = 0.750, *p*= .462. Furthermore, the number of duplicated road segments, t(20)=0.840, *p*=.411, and drive time, t(20)=0.616, *p*=.545, were not impacted by gender.

Males and females, on average, utilized the long search pattern the most. According to Fisher's exact, there was no statistically significantly difference in the use of strategy based on gender (*p*=.585).

3.1.4 Target Identification

As stated before, eight participants did not identify the target. Descriptive statistics for those participants are shown in Table 3.7. The mean number of road segments covered was 34.1 (SD=18.5), compared to the mean of those who did identify the target 28.1 (SD=17.4), shown in Table 3.2. Of the participants who failed to identify the target, only one was inexperienced. There were six males and two females. The minimum and maximum number of duplicated road segments is the same for both groups, those who did and did not identify the target.

Table 3.7 Descriptive statistics of participants who did not identify target

	N	Mean	SD	Max	Min
Road Segments	8	34.1	18.5	59	11
Duplicated Road Segments	8	9.0	8.6	20	0
Driving Time (seconds)	8	618.3	329.1	1125.9	254.1

CHAPTER IV

DISCUSSION

Pure wayfinding is a process used daily when observing a new environment. However, one still executes an organized search strategy in this situation. Furthermore vehicular wayfinding is a unique process more limited in path selection than pedestrian wayfinding. Overall, the participants in this study utilized a long search pattern more than a short or no search pattern. This follows previous studies, which noted that when outdoors, one tends to keep as straight a path as possible, minimizing turns (Dalton, 2003). Short pattern was the least efficient search strategy. Drivers exhibiting short pattern behavior drove a higher number of road segments and duplicated more road segments. Drivers exhibiting long pattern behavior had the lowest number of duplicated road segments. The difference found between these patterns may be due to the nature of the patterns. A short search pattern involves a lot of turns and therefore has a higher chance of duplicating road segments. As stated previously, a long search pattern is one that resembles a perimeter or back and forth searches. These searches are very organized and not very exploratory (Kallai et al., 2005). Therefore duplicating road segments are not an inherent property of this search pattern. A network or cyclic strategy is an example of a short search pattern. This type of search is a much more exploratory search strategy (Kallai et al., 2005). Duplicating road segments is a more inherent quality of this type of search pattern. However, the no pattern strategy resulted in the lowest drive time of the three wayfinding search strategies. This result may be explained by how no pattern was defined. Some of the participants completed the experiment quickly, by chance. Therefore, it was hard to identify what strategy they were using. The strategy of these participants was classified as no pattern, which may have skewed the results.

Although there was no statistically significant difference, urban driving experience appeared to be practically significant for impacting the number of road segments covered, though no statistical significance was found; therefore, this result should be further examined. Previous studies have found a clear difference in visual search strategies based on experience (Konstantopoulos et al., 2010; Underwood, 2007). Experienced drivers have been studied and shown to have more efficient visual search strategies. Therefore, further research should be done with this study to evaluate in more detail the effect of experience on vehicular wayfinding search strategies. However, strategy utilized was not affected by experience. Inexperienced drivers, on average, covered more road segments than experienced drivers. In this respect, experienced urban drivers are more efficient than inexperienced. This is similar to previous studies which found someone's familiarity with an environment impacts their ability to navigate within a similar environment (Freksa, 1999). The effects of gender on strategy and efficiency were also analyzed. There was no statistically significant difference between genders on number of road segments covered. This follows the findings of previous literature results which note that there are insignificant differences in wayfinding techniques between genders (Lawton, 1994; Lin & Chien, 2010). Furthermore, the differences that have been found are still high inconclusive. It is clear that strategy, more than gender or experience, affected efficiency.

The group of participants who did not identify the target was also analyzed. Their mean number of road segments was similar to those of the participants who did identify the target. Of this group, only one was inexperienced. This further supports the results that urban driving experience doesn't affect one's strategy or target identification skills.

Initially, the intent of this study was to get two balanced pools of participants: half with urban driving experience and the other with none. However, upon actual data analysis only four out of 22 were inexperienced. This may account for the lack of significance shown between experience and strategy choice. Even so, experienced drivers were more efficient in their search on average. However, in general, a long search pattern was utilized by both groups the most. As stated previously a long pattern consists of search strategies similar to a perimeter or back and forth searches. These are less exploratory approaches compared to a short pattern. This result follows common thought; that if someone is new to an environment, he/she would be more cautious than exploratory.

CHAPTER V

CONCLUSION

Although pure wayfinding is a process not utilized as much today, due to the increase in advanced navigational technology, it is still a needed process for when that technology fails. Whether a driver is trying to navigate to a specific building on a main street in a big city, or attempting to find their way on a college campus, a lack of accuracy with advanced navigational aids can hinder this process. Therefore, research into how people wayfind and what factors contribute to how that process is executed in these situations need to be studied. In conclusion, it is clear a long search pattern is more efficient than a short or no search pattern when attempting to wayfind in a new urban environment. Urban driving experience does affect how efficiently a person finds their way in a new city. However, it is not clear how significant this effect is. Furthermore, neither experience nor gender has an effect on the type of wayfinding strategy a driver executes. This study shows that it is hard to predict where new visitors will move throughout a new urban environment.

Some limitations of this study include the sample. A convenience sample of the first 35 was taken. An expansion of this study, to include a larger sample size and equal group sizes, should be performed in the future to gain greater insight into pure wayfinding techniques. This would also give insight into the difference of efficiency between the three strategies identified. Furthermore, the experimental environment could be enlarged to include more details (such as interstate connections, etc.) of a big urban city environment.

The results from this study inform city planners to create multiple salient signs, extending from entrance to any popular destination, in an effort to control and direct visitor/tourist traffic. Knowing the paths commonly taken by different groups of drivers can aid major businesses, tourist attractions, or general needs facilities (i.e. hospitals) should aid in the location decisions for these places.

REFERENCES

Antonini, G., Bierlaire, M., & Weber, M. (2006). Discrete choice models of pedestrian walking behavior. *Transportation Research Part B: Methodological*. doi:10.1016/j.trb.2005.09.006

Arrowsmith, C., Cartwright, W., Jackson, M., & Xia, J. (Cecilia). (2008). The wayfinding process relationships between decision-making and landmark utility. *Tourism Management*. doi:10.1016/j.tourman.2007.05.010

Brunyé, T. T., Taylor, S. T., & Taylor, H. A. (2008). Spatial Mental Representation: Implications for Navigation System Design. *Reviews of Human Factors and Ergonomics*. doi:10.1518/155723408X342835

Chebat, J.-C., Therrien, K., & Gélinas-Chebat, C. (2005). Lost in a mall, the effects of gender, familiarity with the shopping mall and the shopping values on shoppers' wayfinding processes. *Journal of Business Research*. doi:10.1016/j.jbusres.2004.02.006

Dalton, R. C. (2003). The Secret Is To Follow Your Nose: Route Path Selection and Angularity. *Environment & Behavior*, *35*(1), 107–131. doi:10.1177/0013916502238867

Fendley, T. (2009). Making sense of the city: A collection of design principles for urban wayfinding. *Information Design Journal*. doi:10.1075/idj.17.2.03fen

Freksa, C. (1999). Spatial aspects of task-specific wayfinding maps. In *Visual and Spatial Reasoning in Design* (pp. 15–32).

Gaisbauer, C., & Frank, A. U. (2008). Wayfinding model for pedestrian navigation. In *11th AGILE International Conference on Geographique Information Science* (pp. 1–9).

Golledge, R. G. (1999). Wayfinding Behavior: Cognitive Mapping and Other Spatial Processes. In *Wayfinding behavior: Cognitive mapping and other spatial processes* (pp. 5–45).

Heuten, W., Henze, N., Boll, S., & Pielot, M. (2008). Tactile wayfinder: A non-visual support system for wayfinding. In *Proceedings of the 5th Nordic conference on Human-computer interaction: building bridges* (pp. 172–181). doi:10.1145/1463160.1463179

Hölscher, C., Meilinger, T., Vrachliotis, G., Brösamle, M., & Knauff, M. (2006). Up the down staircase: Wayfinding strategies in multi-level buildings. *Journal of Environmental Psychology*. doi:10.1016/j.jenvp.2006.09.002

Hoogendoorn, S. P., & Bovy, P. H. L. (2004). Pedestrian route-choice and activity scheduling theory and models. *Transportation Research Part B: Methodological*. doi:10.1016/S0191-2615(03)00007-9

Ishikawa, T., Okabe, A., Fujiwara, H., & Imai, O. (2008). Wayfinding with a GPS-based mobile navigation system: A comparison with maps and direct experience. *Journal of Environmental Psychology*. doi:10.1016/j.jenvp.2007.09.002

Kallai, J., Makany, T., Karadi, K., & Jacobs, W. J. (2005). *Spatial orientation strategies in Morris-type virtual water task for humans. Behavioural brain research* (Vol. 159, pp. 187–196). doi:10.1016/j.bbr.2004.10.015

Konstantopoulos, P., Chapman, P., & Crundall, D. (2010). Driver's visual attention as a function of driving experience and visibility. Using a driving simulator to explore drivers' eye movements in day, night and rain driving. *Accident; Analysis and Prevention*, *42*(3), 827–34. doi:10.1016/j.aap.2009.09.022

Lawton, C. A. (1994). Gender differences in way-finding strategies: Relationship to spatial ability and spatial anxiety. *Sex Roles*. doi:10.1007/BF01544230

Lee, W.-C., & Cheng, B.-W. (2008). Effects of using a portable navigation system and paper map in real driving. *Accident; Analysis and Prevention*, *40*(1), 303–8. doi:10.1016/j.aap.2007.06.010

Lin, P.-C., & Chien, L.-W. (2010). The effects of gender differences on operational performance and satisfaction with car navigation systems. *International Journal of Human-Computer Studies*. doi:10.1016/j.ijhcs.2010.06.006

Montello, D. R., & Sas, C. (2006). Human Factors of Wayfinding in Navigation. Retrieved from http://eprints.comp.lancs.ac.uk/2103/1/MontelloSas.pdf

Patel, K. K., & Vij, S. K. (2010). Spatial Navigation in Virtual World, *1*(1948), 101–125.

Patten, C. J. D., Kircher, A., Ostlund, J., Nilsson, L., & Svenson, O. (2006). Driver experience and cognitive workload in different traffic environments. *Accident; Analysis and Prevention*, *38*, 887–894. doi:10.1016/j.aap.2006.02.014

Pelechano, N. (2006). *MODELING REALISTIC HIGH DENSITY AUTONOMOUS AGENT CROWD MOVEMENT : SOCIAL FORCES ,COMMUNICATION, ROLES AND PSYCHOLOGICAL INFLUENCES*. *Cell*. Retrieved from http://www.cis.upenn.edu/grad/documents/pelechano_000.pdf

Pielot, M., & Boll, S. (n.d.). Tactile Wayfinder : Comparison of Tactile Waypoint Navigation with Commercial Pedestrian Navigation Systems, 1–18.

Stoffel, E.-P., Schoder, K., & Ohlbach, H. J. (2008). *Applying hierarchical graphs to pedestrian indoor navigation*. *Proceedings of the 16th ACM SIGSPATIAL international conference on Advances in geographic information systems - GIS '08* (p. 1). doi:10.1145/1463434.1463499

Timpf, S., Volta, G., Pollock, D., & Egenhofer, M. (1992). A conceptual model of wayfinding using multiple levels of abstraction. In *Theories and Methods of Spatio-Temporal Reasoning in Geographic Space* (Vol. 639, pp. 348–367). doi:10.1007/3-540-55966-3_21

Underwood, G. (2007). Visual attention and the transition from novice to advanced driver. *Ergonomics*, *50*, 1235–1249. doi:10.1080/00140130701318707

Zhu, B., Liu, T., & Tang, Y. (2008). Research on Pedestrian Evacuation Simulation Based on Fuzzy Logic, 1024–1029.

APPENDIX A

PARTICIPANT MATERIALS

A.1 Screening Survey

1. Which of the following best describes your eye sight?

20/20

20/20 Corrected with glasses

20/20 Corrected with contact lenses

Less than 20/20

2. Do you have any hearing problems?

Yes No

3. Do you have a history of epilepsy?

Yes No

4. **Do you have a history of simulator-induced motion sickness?**

Yes No

5. **Are you comfortable driving in a big urban city environment (i.e. Atlanta, Dallas, etc.)?**

Yes No

A.2 Demographics Survey

Part 1. Participant Information

1. What is your age? ____________

2. What is your gender?

   [ ] Male [ ] Female

3. What is your level of education?

   [ ] 8th grade or less [ ] Some college or 2-year degree

   [ ] Some high school [ ] 4-year college degree

   [ ] High school grad or GED [ ] More than 4-year degree

4. Which of the following best describes your eye sight?

   [ ] 20/20 [ ] 20/20 corrected with contact lenses

   [ ] 20/20 corrected with glasses [ ] Less than 20/20

5. Do you have any hearing problems?

   [ ] Yes [ ] No

6. Do you have a history of epilepsy?

   [ ] Yes [ ] No

7. Do you have a history of simulator-induced motion sickness?

   [ ] Yes [ ] No

Part 2. Driving History

8. How old were you when you received your first driver's license? ____________

9. On average, how much do you drive on a given day?

[ ] 30 minutes or less

[ ] One to two hours

[ ] 30 minutes to one hour

[ ] More than two hours

10. How often do you drive for extended periods of time (one hour or more)?

[ ] Daily

[ ] A few times a week

[ ] Once a week

[ ] Once a month

[ ] A few times a year

[ ] Once a year or less

11. Consider all driving that you do. What percentage of your driving is rural, urban, or interstate? Your answers must sum to 100%.

Rural (country roads, highways)	______
Urban (city streets)	______
Interstate	______
Total:	100%

12. For your primary vehicle, what is the level of technology?

[ ] High (ex: touch screen dash system, bluetooth capability, safe driving alarms)

[ ] Medium (ex: cruise control, 6-CD changer, steering wheel controls)

[ ] Low (ex: no cruise control, no steering wheel controls, single CD/tape player, no extra safety alarms)

13. When traveling via vehicle in an unfamiliar environment, do you predominantly use a GPS device (no including maps or paper directions)?

[ ] Yes [ ] No

A.3 Driving Behavior Questionnaire (DBQ)

For each type of item listed below, choose the response that corresponds to how often you engage in that type of behavior.

Driving Behavior	Never	Hardly Ever	Occasionally	Quite Often	Frequently	Nearly All the Time
1. Check your speedometer and discover that you are unknowingly travelling faster than the legal limit.						
2. Become impatient with a slow driver in the outer lane and overtake on the insider.						
3. Drive especially close or 'flash' the car in front as a signal for that driver to go faster or get out of your way.						
4. Stuck behind a slow-moving vehicle on a two-lane highway, you are driven by frustration to try to overtake in risky circumstances.						
5. Take a chance and cross on lights that have turned red.						
6. Angered by another driver's behavior, you give chase with the intention of giving him/her a piece of your mind.						
7. Deliberately disregard the speed limits late at night or very early in the morning.						
8. Forget when your road tax/insurance expires and discover that you are driving illegally.						
9. Drive back from a party, restaurant, or pub, even though you realize that you may be over the legal blood-alcohol limit.						
10. Have an aversion to a particular class of road user, and indicate your hostility by whatever means you can.						
11. Lost in thought or distracted, you fail to notice someone waiting at a marked crossing, or a crossing light that has just turned red.						
12. Park on a double-yellow line and risk a fine.						
13. Overtake a slow-moving vehicle on the inside lane or hard shoulder of a motorway.						
14. Cut the corner on a left-hand turn and have to swerve violently to avoid an oncoming vehicle.						
15. Fail to yield when a bus is signaling its intention to pull out.						
16. Ignore 'yield' signs, and narrowly avoid colliding with traffic having right of way.						

17. Deliberately drive the wrong way down a deserted one-way street.						
18. Disregard red lights when driving late at night along empty roads.						
19. Get involved in unofficial ‘races’ with other drivers.						
20. ‘Race’ oncoming vehicles for a one-car gap on a narrow or obstructed road.						

A.4 Motion Sickness/ Simulator Sickness Questionnair (MSSQ)

Pre-exposure/Post-exposure Simulator and Motion Sickness Questionnaire

Please circle the appropriate items below according to your CURRENT feelings with respect to the symptoms listed.

You will be asked to answer this questionnaire again after each scenario.

1. General Discomfort	None	Slight	Moderate	Severe
2. Fatigue	None	Slight	Moderate	Severe
3. Boredom	None	Slight	Moderate	Severe
4. Drowsiness	None	Slight	Moderate	Severe
5. Headache	None	Slight	Moderate	Severe

6. Eyestrain	None	Slight	Moderate	Severe
7. Difficulty Focusing	None	Slight	Moderate	Severe
8. Salivation Increase	None	Slight	Moderate	Severe
Salivation Decrease	None	Slight	Moderate	Severe
9. Sweating	None	Slight	Moderate	Severe
10. Nausea	None	Slight	Moderate	Severe
11. Difficulty Concentrating	None	Slight	Moderate	Severe
12. Mental Depression	None	Slight	Moderate	Severe
13. "Fullness of the Head"	None	Slight	Moderate	Severe
14. Blurred Vision	None	Slight	Moderate	Severe
15. Dizziness (eyes open)	None	Slight	Moderate	Severe
Dizziness (eyes closed)	None	Slight	Moderate	Severe

16. Vertigo	None	Slight	Moderate	Severe
17. Visual Flashbacks	None	Slight	Moderate	Severe
18. Faintness	None	Slight	Moderate	Severe
19. Aware of Breathing	None	Slight	Moderate	Severe
20. Stomach Awareness	None	Slight	Moderate	Severe
21. Loss of Appetite	None	Slight	Moderate	Severe
22. Increased Appetite	None	Slight	Moderate	Severe
23. Desire to Move Bowels	None	Slight	Moderate	Severe
24. Confusion	None	Slight	Moderate	Severe
25. Burping	None	Slight	Moderate	Severe
26. Vomiting	None	Slight	Moderate	Severe

Other (please describe)	None	Slight	Moderate	Severe

A.5 Consent Form

Mississippi State University
Informed Consent Form for Participation in Research

Title of Research Study: Evaluating Impact of Infrastructure and In-Vehicle Technologies on Driver Behavior

Study Site: Center for Advanced Vehicular Systems (CAVS) Driving Simulation Lab

Researchers: Dr. Daniel Carruth, Dr. Lesley Strawderman, & Katherine King, Mississippi State University

Purpose

The purpose of this research is to investigate driver behavior in simulated municipal environments. The goal of the study is to assess how changes to environments affect driver behavior in ways that may impact safety of all road users.

Procedures

If you participate in the study, you will be asked to complete a series of drives in the CAVS driving simulator. The CAVS driving simulator consists of a Nissan Maxima body mounted on a six degrees of freedom motion base with three forward screens, one rear screen, and two LCD screens acting as side view mirrors. The driving simulator motion base will move during the study to create realistic motions during the simulated drive. During the driving scenarios, you will be asked to drive on simulated highways, take exits into simulated urban areas, and explore the simulated urban areas to find a specified target (i.e. a park) while driving normally and respecting traffic safety regulations (i.e. maintaining a normal speed, respecting traffic signals, etc.).

During the drives, the driving simulator will record driver performance data including, but not limited to, the speed of the car and position in the lane. Audio and video will also be recorded during the drive. A pair of cameras on the dash will also monitor and record your head orientation and your eye movements to determine what you are looking at while you drive.

You will be asked to drive through two urban areas. You will be asked to perform two drives in which you will visit an urban area. The first drive will be a familiarization drive to give you a chance to get used to driving the simulator. After this drive, you will be given a five minute break and asked to complete a short questionnaire that will help detect motion and/or simulator sickness. The second drive you will be asked to locate the target (i.e. a park). In total the experiment should take no more than one hour.

Risks or Discomforts

You must be at least 18 years of age and less than 65 years of age with normal vision and hearing and no history of epilepsy or simulator-induced sickness. You should be aware that there is a possibility of simulator sickness due to motion cues provided by the motion base and the simulator display. Please inform the experimenter if you experience any discomfort or other symptoms. The experimenter will stop the simulation immediately. During the study, we will ask you to complete a short motion and simulator sickness questionnaire. The questionnaire includes questions that may seem embarrassing or strange, including questions about bodily functions. These questions are asked in order to minimize discomfort or other adverse effects due to the simulator system. Any responses to these questions will be kept confidential. NOTE that refusal to complete the motion and simulator sickness questionnaire will discontinue your participation in the study.

Additionally, when exposed to any form of video display, there is a possibility that individuals may experience an epileptic reaction. For this reason, we regret that we cannot accept volunteers with a past history of epilepsy. We do not wish to aggravate any physical or psychological conditions. Please discuss any concerns with the researcher.

Benefits

Your participation in this study will provide information on how features of the environment or in-vehicle technologies impact driver behavior and may provide methods for improving safety for all road users.

Incentive to participate

You will receive course extra credit as compensation for your participation. If the study must be terminated for technical issues, the experimenter determines that the study should be terminated for your health or safety, or you choose to withdraw your consent at any time prior to completion of the experiment, you will also receive course extra credit in compensation for your time.

Confidentiality

Individual identities will be protected and all participant responses will be kept confidential. To protect the confidentiality of this information, each participant will be assigned a code number that will only be known to the researcher who collects the data. The purpose of the code number is to link all pieces of a participant's data (performance data, eye tracking data, audio/video data) together. All of the information provided to the research project members will be marked with the code number except this informed consent form. This code number will never be put on the informed consent form or be linked to the informed consent form in any manner. Video and audio data will be collected and transcribed to a file with only the participant code as identification. Any personal details (names, etc.) mentioned will be removed. No identifying information will be included in resulting transcripts.

All video information (eye tracking, over-the-shoulder, foot well, external vehicle) will be stored confidentially on a password-protected computer. In order to pursue external funding or disseminate descriptions of procedures or results, some videos may be released publicly or to specific government or private agencies. When possible, identifying items or features, such as jewelry, will be removed prior to recording or will be rendered illegible using video editing tools prior to release. Faces and other identifying features will be rendered unidentifiable using editing tools. If, for any reason, identifying features cannot be removed, the video will not be released.

Please note that these records will be held by a state entity and therefore are subject to disclosure if required by law. Research information may be shared with the MSU Institutional Review Board (IRB) and the Office for Human Research Protections (OHRP).

The sponsor of this study National Center for Intermodal Transportation for Economic Competitiveness and the U.S. Department of Transportation may also have access to the records of the research.

Questions

If you have any questions about this research project, please feel free to contact Dr. Daniel Carruth at 662-325-5446 or dwc2@cavs.msstate.edu. You may also contact Katherine King at 228-209-0500 or kk266@msstate.edu for further questions.

For questions regarding your rights as a research participant, or to express concerns or complaints, please feel free to contact the MSU Regulatory Compliance Office by phone at 662-325-3994, by e-mail at irb@research.msstate.edu, or on the web at http://orc.msstate.edu/participant/.

Research-related injuries

In addition to reporting an injury to Dr. Daniel Carruth at 662-325-5446 and to the Regulatory Compliance Office at 662-325-3994, you may be able to obtain limited compensation from the State of Mississippi if the injury was caused by the negligent act of a state employee where the damage is a result of an act for which payment may be made under §11-46-1, et seq. Mississippi Code Annotated 1972. To obtain a claim form, contact the University Police Department at *MSU UNIVERSITY POLICE DEPARTMENT, Williams Building, Mississippi State, MS 39762, (662) 325-2121.*

Voluntary Participation

Please understand that your **participation is voluntary.** Your **refusal to participate will involve no penalty or loss** of benefits to which you are otherwise entitled. You **may discontinue your participation** at any time without penalty or loss of benefits.

Please take all the time you need to read through this document and decide whether you would like to participate in this research study.

If you agree to participate in this research study, please sign below. You will be given a copy of this form for your records.

______________________________ ____________
Participant Signature Date

______________________________ ____________
Investigator Signature Date

A.6 Wayfinding Search Strategies

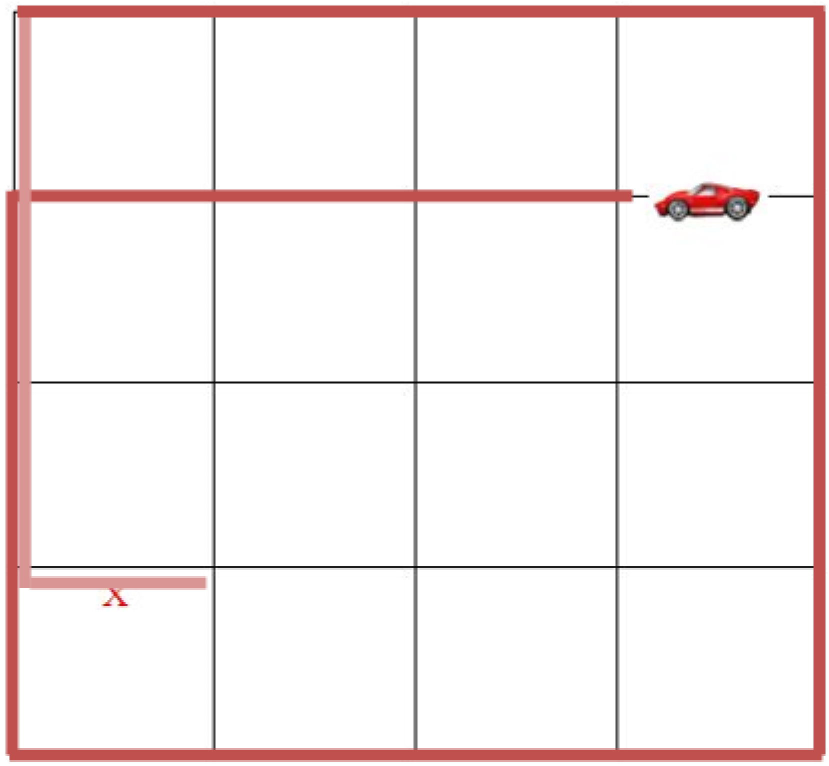

Figure A.1 Example of a long search pattern

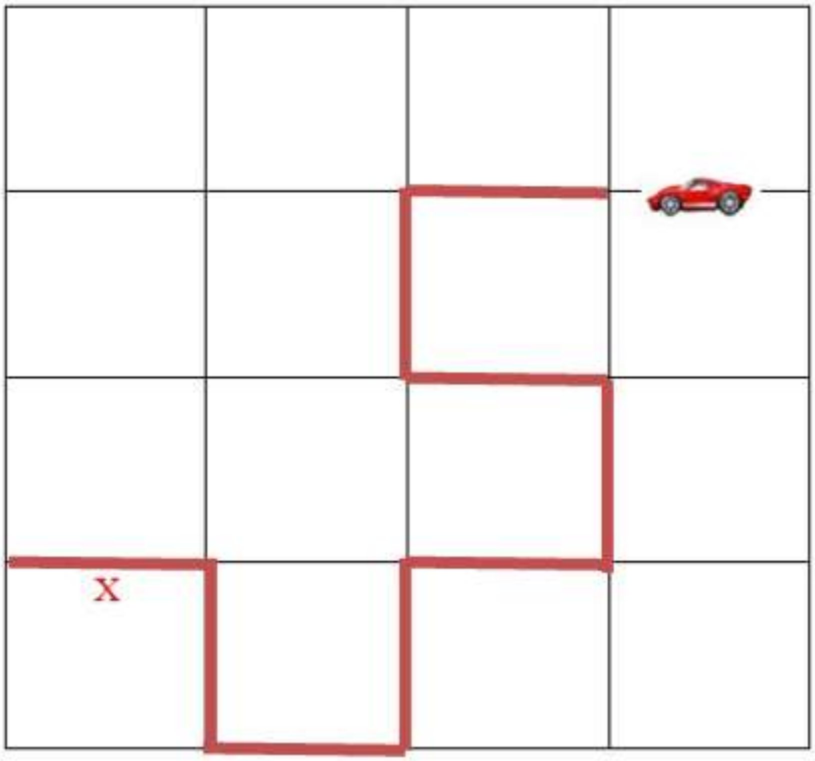

Figure A.2 Example of a short search pattern

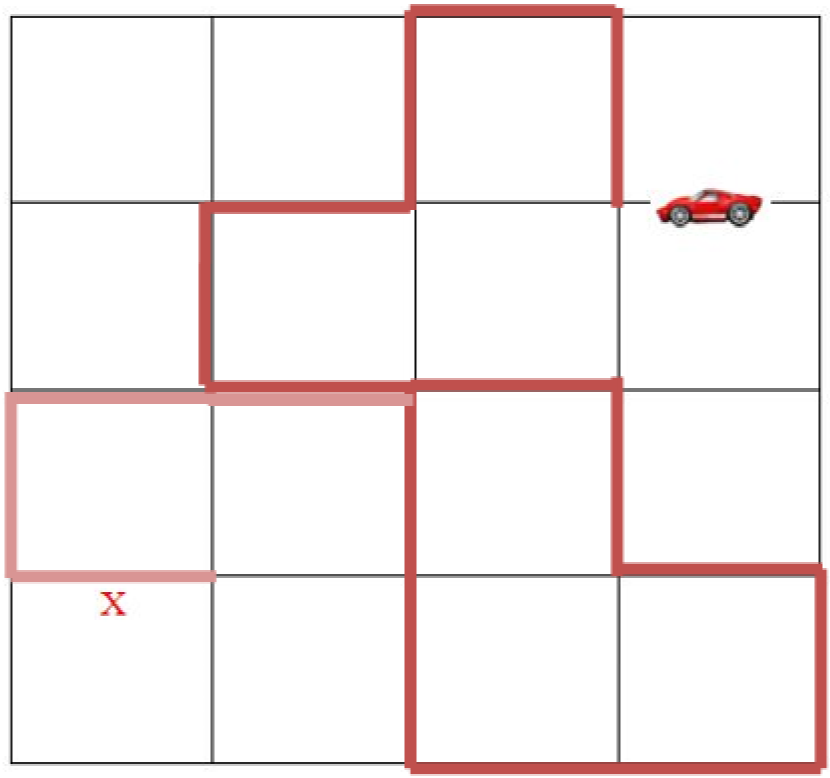

Figure A.3 Example of no search pattern