12-2003

Gender Differences in Accurate Route Recall in Novice Drivers Using Landmarks in Electronic Maps

Kimberly K. Brantley
Embry-Riddle Aeronautical University - Daytona Beach

Gender Differences In Accurate Route Recall In Novice Drivers Using Landmarks In Electronic Maps

by

Kimberly K. Brantley

A Thesis Submitted to the

Department of Human Factors and Systems

in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Human Factors & Systems

Embry-Riddle Aeronautical University

Daytona Beach, Florida

December 2003

GENDER DIFFERENCES IN ACCURATE ROUTE RECALL IN NOVICE DRIVERS

USING LANDMARKS IN ELECTRONIC MAPS

by

Kimberly K. Brantley

This thesis was prepared under the direction of the candidate's thesis committee chair, Christina Frederick-Recascino, Ph. D., Department of Human Factors & Systems, and has been approved by the members of her thesis committee. It was submitted to the Department of Human Factors & Systems and has been accepted in partial fulfillment of the Requirements for the degree of Master of Science in Human Factors & Systems

THESIS COMMITTEE:

Christina Frederick-Recascino, Ph. D., Chair

Shawn Doherty, Ph. D., Member

Maria Franco, Member

MS HFS Program Coordinator

Department Chair, Department of Human Factors & Systems

Associate Chancellor of Academic Affairs

Acknowledgements

The author wishes to express special thanks to the Thesis Chair, Dr. Christina Frederick-Recascino, whose support, encouragement and guidance made the outcome of this thesis successful. Gratitude is also due to Dr. Shawn Doherty and Maria Franco, thesis committee members, for their assistance, advice and support during this research project.

Appreciation also due to my father, Dr. Gerald Gamache whose love and support I couldn't have done without and for sharing his passion for Human Factors with me. I also wish to express my deepest gratitude and love to my mom, Elaine Gamache, for her unconditional love and for always believing in me. To my s/mom, Dr. Mili Koger, your love, support and encouragement has meant the world to me. To Sarah, Terry, my family and friends, words cannot express the gratitude and appreciation of the love, support and encouragement I have received from everyone during this journey. This acknowledgement would not be complete without expressing my love, thanks and appreciation to my daughter, Jessica Erin who stood by me while I accomplished my dreams.

Abstract

Author: Kimberly K. Brantley

Title: Gender Differences in Accurate Route Recall in Novice Drivers Using Landmarks in Electronic Maps

Institution: Embry-Riddle Aeronautical University

Degree: Master of Science in Human Factors & Systems

Year: 2003

Past literature has found a link between gender and accuracy of route recall in traditional paper maps using landmarks. Research also suggests that what is already known about wayfinding behavior in the physical world can be applied to computer-generated environments. The goal of this study is to merge these two conclusions to determine if gender and route recall differences remain constant for global, electronic maps. Analysis of gender by accuracy as measured by number of trials showed that males required fewer trials ($M = 3.63$) than females ($M = 4.09$), $F(1,99) = 7.29$, $p < .05$ and accuracy as measured by number of errors in trial 1 also showed that males had fewer errors ($M = 3.33$) than females ($M = 4.09$), $F(1,99) = 5.79$, $p < .05$. Analysis of landmarks by accuracy as measured by number of trials showed participants viewing Landmark High Maps required fewer trials ($M = 3.64$) than those viewing Landmark Low Maps ($M = 4.12$), $F(1,99) = 7.68$, $p < .05$. Accuracy as measured by number of errors in trial 1 showed participants viewing Landmark High Maps had fewer errors in trial 1 ($M = 3.16$) than those viewing Landmark Low Maps ($M = 4.33$), $F(1,99) = 11.87$.

Table of Contents

List of Figures

List of Tables

Introduction

Mankind, from very early ages, has felt the need to make maps to let others know the whereabouts of locations of importance. The earliest maps from 450 BC, show continents that were misshaped, drawn from the way the mapmaker perceived the world. Christopher Columbus was the first sailor of record who kept a detailed log of his first voyage, describing early techniques of wayfinding.

Prior to the development of celestial navigation, sailors navigated by "deduced" (or "dead") reckoning (DR) (Pickering, n.d.). The navigator finds his position with DR by measuring the course and distance he has sailed from some known point. Starting from a known point, such as a port, the navigator measures out his course and distance from that point on a chart, marking each new position on the chart with a pin. Each day's ending position would be the starting point for the next day's course-and-distance measurement.

In order for this method to work, the navigator needs a way to measure his course, and a way to measure the distance sailed. Course was measured by a magnetic compass and distance was determined by a time and speed calculation; the navigator multiplied the speed of the vessel (in miles per hour) by the time traveled to get the distance (Pickering, n.d.).

Since the early days of wayfinding, techniques have changed drastically. Gone are the days of pushpin route marking and celestial navigation. Today's world inundates us with new forms of technology. We are capable of sending a message across the globe in a matter of seconds rather than days or weeks; we manage databases with a fraction of manpower than previously required; and we download an electronic map for any location in the world in a matter of seconds.

Statement of Problem

It is the recent advancement of electronic maps that is the topic of this research study. Early map research focused on the use of colors to differentiate landmarks, roads & terrain. This early research focused on the making of the map and not on how the map-reader processed the information acquired. Cognitive mapping and spatial decision-making soon evolved, beginning in Kevin Lynch's publication of *The Image of the City* (1960). Cognitive mapping is defined as how people think about space and how these thoughts are used in spatial behavior. Cognitive mapping research seeks to comprehend how we come to understand spatial relations that we gain through both primary experience and secondary media (paper maps, photos or videos) (Kitchin & Freundschuh, 2000).

In the last few years, studies involving virtual environments have begun to emerge. Virtual environments are large worlds that cannot be viewed from a single vantage point and require extensive movement to navigate. Darken & Sibert (1996) convey that problems associated with wayfinding and navigation are predictably encountered in every large virtual world. Navigators of virtual environments often become disorientated and rarely revisit a virtual world, this gives the navigator limited opportunity to develop a usable cognitive map of the environment. Darken & Sibert's research, which measured participant performance on complex searching tasks in virtual environments with differing environmental cues, concluded that what is already known about wayfinding in the physical world is independent of the type of space. This finding can be applied to computer-generated environments.

The goal of this study is to test Darken & Sibert's (1996) conclusions to determine if gender differences and route recall as found in Galea & Kimura (1993) study hold true in using electronic maps.

Theory

Reading a map is a series of processes that moves information perceived in the environment into memory to be recalled at a later date. A process known as the Information Processing Theory explains this event. Information processing theorists uses a computer as a model for human learning. Like the computer, the human mind takes in information, performs operations on it to change its form and content, stores and locates it and generates responses to it (Searleman & Herrmann, 1994). Thus, the processing involves gathering and representing information, or encoding; holding information or retention; and getting at the information when needed, or retrieval (see figure 1).

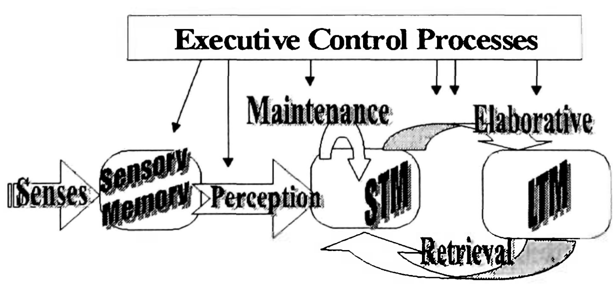


Figure 1
Information Processing Theory.

When a map reader studies a map, spatial information (road outlines, landmarks, distance and terrain) is absorbed by the reader into sensory memory. From sensory memory, information is transferred to short-term memory where it is simplified and 'chunked' together to form manageable pieces of information. The information is rehearsed until it is automatic and stored away for later recall from long-term memory. When the information is stored as long-term memory, similar spatial information previously learned is grouped together in memory, forming a cognitive map.

Review of the Literature

A review of research has shown that there are differences in gender and route memory for traditional paper maps. One of the earliest differences studied is that men and women process visual-spatial information differently. Men have been shown to be superior in tasks of mental-rotation and location of geographical features on a map. Also, research conducted with traditional paper maps, show males prefer Euclidian maps or maps that give direction and distance, while women found topographic maps or using landmarks more useful (Beatty, 2002; Rovine & Weisman, 1989; Ward, Newcombe & Overton, 1986).

In virtual environments, Jansen-Osmann (2002) studied landmarks, creating imaginary environments in which landmarks were placed. Jansen-Osmann concluded that routes with landmarks aided in orientation in wayfinding tasks and routes with landmarks are learned faster than ones without landmarks. Additional research projects in virtual environments support the use of landmarks in learning relative direction in artificially created environments (Albert, W.S., Rensink, R.A., Beusmans, J.M, 1999), but do not address whether these findings apply for virtual maps of real locations or if there are gender differences in route recall in the synthetic environment.

Traditional Map Research

Maps are two- or three-dimensional displays representing and conveying information about the environment (Lloyd, 2000). Maps are different than photographs. The display has been organized into spatial information for the convenience of the map-reader. Spatial information from the map then becomes spatial knowledge when the patterns are learned. This process is referred as the cartographic communication model (see Figure 1) (Lloyd, 2000).

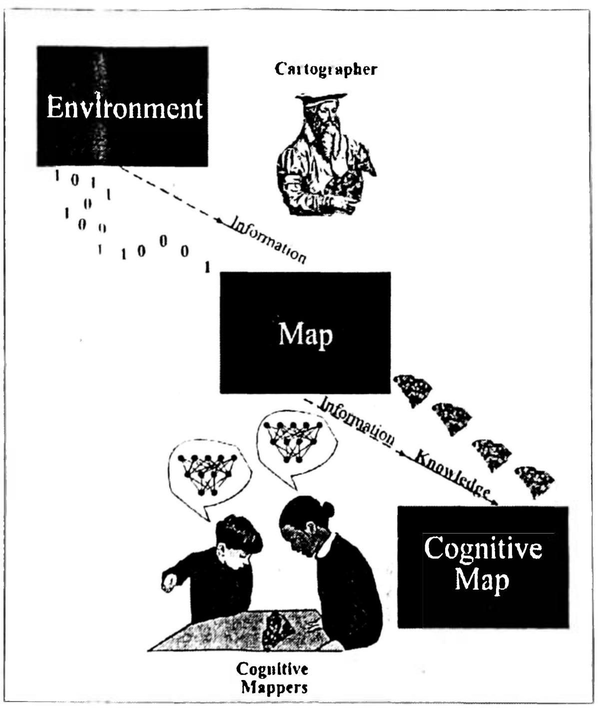


Figure 2
The cartographic communication process. The cartographer transforms spatial data into spatial information and cognitive mappers transform spatial information into spatial knowledge.

A map is a display, which can be thought of as an expression of the cartographer's ideas with a mechanism for storing spatial information providing a source of knowledge for the reader. Lloyd (2000) states that fundamental changes occur when the cartographer transfers spatial data into spatial information and other changes occur when the map-reader transforms spatial information into spatial knowledge. Cartographers categorize, generalize and symbolize to enhance important information and eliminate any non-essential information. The map-reader further simplifies the information when the spatial information is encoded from the cartographers map. In other words, the map-reader processes the spatial information from short-term memory into long-term memory forming a cognitive map. Tversky (1981) reports that most cognitive maps fail to reflect all the details of the environment they represent, and that they also have systematic errors caused by the processes that encode them into memory.

Early map research focused on the use of color and the readability of type in traditional paper maps. As cited by Lloyd (2000), Arthur Robinson, one of the first researchers to study colors in maps, argued that color is a great simplifying and clarifying element. It can be used to differentiate between terrain, water and landmarks making the map easier to understand. People also have an emotional reaction to color. People are more sensitive and react faster to some colors than they do to others (Lloyd, 2000). Robinson argued that the legibility of the lettering and the reader's ability to distinguish details in the map could be affected by the colors used. His research showed that reds tend to advance, while blues recede into the background, and there is a contrast effect that causes hues to appear different when they are adjacent or separated from each other. Distinguishing between terrain and landmarks aids in visual search and processing of information. Keates (1982) states “Whatever task is concerned, the initial stage depends on the two processes of detection and discrimination. At the most basic level, the map user must be able to respond to what is there: that is, the symbols on the map must be a sufficient stimulus to make them detectable” (p.10).

People generally read maps because they need information. They may want to know where a particular place is located, how close it is to a general reference point or what a place is like. Map reading is an integration of knowledge. It requires both bottom-up information (the map) and top-down information (information stored in memory by the reader). The bottom-up information contains the lines, colors, shapes and text the cartographer has put on the map. The top-down information is the prior knowledge of the reader such as meaning of words, judgment of distances between objects, comparison of sizes of objects, or common symbols (North arrow, contour lines etc.), and use of shapes and colors (stars for capital cities, blue for water).

Spatial Cognition and Cognitive Mapping

Kitchin & Freundschuh (2000) state that cognitive mapping research seeks to understand how people learn, process and use spatial information that relates to their environment. Several studies have investigated correlations between subject variables (age, gender, culture, etc) and accuracy of recall using the subjects’ hand-drawn map of the environment (Dabbs, Chang, Strong & Milun, 1998; Allen, 2000; Chang & Antes, 1987; Choi & Silverman, 2002; Galea & Kimura, 1993; Ward et al., 1986). These studies concluded that the type and amount of spatial knowledge individuals have changes with increased familiarity with their environment. Other studies have investigated the accuracy of spatial knowledge acquired through navigational experience (Haq & Zimring, 2003;

Rieser, 1989; Presson & Hazelrigg, 1984; Thorndyke & Hayes-Roth, 1982). These studies demonstrated that the subject's knowledge of the locations of objects in the environment becomes more accurate with increased experience.

Spatial knowledge is generally acquired either by direct navigation or by viewing a map. Studies contrasting map learning with learning by more direct, navigational experience have shown that spatial information is not always stored in a specific orientation (Thorndyke & Hayes-Roth, 1982, Presson & Hazelrigg, 1984). Thorndyke and Hayes-Roth (1982), compared spatial learning from maps with direct navigation. Participants learned the layout of a building, either by studying a map or by direct navigation. Map learners estimated route distances and straight-line distances equally well, but navigation learners estimated route distance more accurately than straight-line distances. Map learners were also less accurate in pointing to unseen locations in the building but were more accurate in placing locations on a map, relative to locations in the building. Thorndyke & Hayes-Roth concluded that after studying a map, people have a survey, or bird's eye representation of the environment, which aids in estimation of straight-line distances. However, they make more errors in pointing to unseen locations in the building because of the difficulty of translating the survey view to a horizontal view. In contrast, they proposed that after navigating in a building, people have procedural (sequential) knowledge of routes between locations, which adds error to estimates of straight-line distances.

Presson & Hazelrigg's (1984) research supported Thorndyke & Hayes-Roths' findings and also concluded that learning from a map (secondary learning) results in figural representation that has great precision, but a specific orientation. Learning the route more directly (primary learning) results in a representation that is less precise, but one that can be used in more flexible ways. Presson & Hazelrigg (1984) also state the location of landmarks on a route were more difficult to point out if the subjects were aligned with the route opposite the way they initially learned it. Alignment effects for remembered maps are similar to those found when subjects use a physical map to locate a landmark or to guide navigation. When physical maps are aligned with the surrounding space, they are much easier to use then if they are not aligned. Presson & Hazelrigg concluded a map that is seen from a single vantage point is later easily used only in the same orientation. However, navigation typically provides multiple vantage points, making it easier to use later on because the spatial information has been learned in a variety of orientations.

Route Learning and Wayfinding

People use wayfinding throughout their lives. It is a natural skill that is learned by the young child and develops as people grow older. People navigate from place to place, relying on knowledge acquired from the environment around them. It takes place in many different situations, such as driving, walking in a city or navigating through a building (Raubal & Egenhofer, 1998). Wayfinding, as defined by Lynch (1960) is "a consistent use and organization of definite sensory cues from the external environment (p.12)". The goal of wayfinding is to find the way from one place to another and normally takes place in a large-scale area. Cornell and Heth (2000) state that route knowledge can be characterized as a series of procedural descriptions. The descriptions begin with an anchor point, a place that defines the beginning of the route. Route performance then depends upon successful application of procedures that incorporate appropriate sources of geographical information, such as path borders, estimation of duration and distance of travel.

Rovine and Weisman (1989) report that people acquire and store information about their surroundings in some schematized but structured form, described variously as an environmental image, mental representation or cognitive map. They note that it is further "assumed that 1) mental representations or cognitive map is shaped, in part by the environment from which it evolves, and 2) the cognitive map in turn has at least some limited impact upon subsequent behavior within that environment" (p. 217). In the earlier example of specific orientation learning, a map learned only in one orientation is 'valid' for that orientation, it is difficult but not impossible to locate objects from another orientation.

Raubal & Egenhofer (1998) describe wayfinding as relying on spatial knowledge that consists of three levels: 1) landmark knowledge of relevant points of reference in the environment, 2) route knowledge puts two landmarks in a sequential order and 3) survey knowledge that allows people to locate landmarks and routes within a general frame of reference. They further note that cognitive abilities depend on the task on hand. Finding one's way in a building uses different cognitive abilities than navigating streets.

People use clues in their environment and representations of spatial knowledge to perform wayfinding tasks successfully (Raubal & Egenhofer, 1998). Raubal & Egenhofer describe a cognitive map as a 'mental representation that corresponds to people's perception of the real world' (p. 897). A cognitive map develops from a mental landmark map to a mental route map, which then develops into a mental survey map. For example, landmarks are perceived in the environment, and as more landmark memories are added, a perception of the route taken develops. People will eventually venture off the route, adding more information to develop a route map. The combination of several route maps of the same area creates an extensive view, developing a survey map. The mental survey map is the closest to a cartographic map, but contains errors and distortions (Tversky, 1981). People develop cognitive maps based on their perception, language and clues in the environment. A complex environment can lead to slower development of cognitive maps and to more errors (Raubal & Egenhofer, 1998). Cornell & Heth (2000) also state that known routes minimize cognitive effort and the process of wayfinding becomes easier and automatic as the result of repeated use of the route.

Gender Differences

Past research has shown that males outperform females in tests of spatial ability in tasks involving rotation of objects or disembedding of figures from a background, while women are better at remembering object locations and finding lost objects. (Galea & Kimura, 1993; Dabbs et al., 1998). Galea and Kimura tested ninety-seven subjects on gender differences in strategies for route-learning while controlling for visual item memory using a hand-drawn map (see appendix A). The research results showed males were more efficient at learning routes than females and used more Euclidean measures. They also reported that females recalled more landmarks than males, and this recall was not related to time spent learning the route. Galea and Kimura also remarked that males and females seemed to incorporate a spatial strategy to solve the route, but differed in the effectiveness of the strategy. Dabbs et al. suggested that these basic spatial skills contributed to both navigation strategy and geographic knowledge. They suggested that object location memory promotes the use of landmarks in navigation, while three-dimensional visualization promotes the use of abstract Euclidian navigation.

One theory suggested by Gaulin & FitzGerald (1986) is that evolution plays a part in gender differences of spatial abilities. Early men traveled and hunted, taking a wandering path as they hunted ignoring much of what they passed and processing little information about potential landmarks. In returning home, a direct path was preferred, thereby allowing the men to develop a 'birds-eye' view of their environment. Women, on the other hand stayed closer to home, encountering fewer new objects, processing more information about these known objects for use of monitoring activities around them.

In wayfinding activities, past research showed that men were more accurate in placement of buildings on a map, locating direction of landmarks, estimating distance traveled and using north/south, east/west references when giving directions (Beatty, 2002; Galea & Kimura, 1993; Ward et al., 1986). The literature also stated that men were more accurate in computer wayfinding tasks and made fewer errors and required fewer trials in learning new routes than women (Self & Golledge, 2000; Galea & Kimura, 1993; Ward et al., 1986). However, women were more likely to recall landmarks and to refer to landmarks when reciting directions than men (Galea & Kimura, 1993; Ward et al., 1986). Self & Golledge (2000) found that men used distance reference points to keep track of their location, while women used step-by-step instructions to determine their progress along a route.

Virtual Environments

Research conducted on route accuracy and wayfinding have largely concentrated on environments, either by direct navigation or viewing a traditional paper map. Another way to research spatial knowledge is through the use of videos, simulations or virtual environments (VE). VE is a means of simulating real world places and can be described as a computer-generated simulated space in which an individual interacts by controlling what they experience by moving their head or limbs (Witmer, Bailey, Knerr, & Parsons 1996). Richardson, Montellow & Hegarty (1999) stated that "learning from a VE is similar to learning from navigation, since the interface preserves many of the visual-spatial characteristics experienced during real navigation and the learner takes a horizontal perspective in the environment, building up a spatial representation over time, through movement within the environment" (p. 743).

Ruddle, Payne & Jones (1997) simulated Thorndyke & Hayes-Roth's (1982) research on wayfinding in an office building using VE and showed that participants were initially disorientated when navigating using VE's, but ultimately developed accurate route-finding abilities. Ruddle et al. also reported findings similar to Thorndyke & Hayes-Rothe findings in the ability to judge directions and distances. Their research also suggests that participants were more accurate in route finding when familiar objects were used as landmarks than when no landmarks were used.

Transfer of training from a VE to a real environment depends of the level of similarity between the two environments (Richardson, et al. 1999). Computer-simulated environments can vary depending on whether the interaction is passive or learner controlled, if information presented is multimodal (i.e. visual, auditory) and by the degree of submersion into the environment (Richardson, et al. 1999). A few studies have attempted to learn how VE spatial knowledge is developed. In the study by Witmer et al. (1996), participants studied route directions and landmarks and then rehearsed the route using a VE model, the actual building or symbolic representations (photographs & verbal directions) of the environment. Participants were successful in learning routes in VE, but with slower rehearsal times than with real or symbolic participants. The participants were also able to transfer routes learned from a VE to a real environment, although they made more errors in route-finding than participants trained in real settings. Another study compared direction estimates in real environments and VE, with participants in the real environment making more accurate direction estimates. These studies suggest either that spatial knowledge is more quickly acquired in a real setting, or that accuracy of spatial knowledge is lower in VE environments (Ruddle et al. 1997).

Is there a difference in how spatial knowledge is acquired in desktop VE and real environments? Ruddle et al. (1997) states that in the process of obtaining spatial knowledge in real world environments, people acquire spatial knowledge by moving through their environment, obtaining several orientation views. This process is controlled over time by head, eye and body movements. Desktop VE environments do not permit kinesthetic or vestibular feedback since movement is controlled by the interface (i.e., mouse, keyboard), and information is affected by a restricted field of view, the lack of or the low fidelity of landmarks and by cues of direction and position. Richardson et al. (1999) also stated that another difference is that in a desktop VE, the participates must make a scale translation from the display to the real environment and there is some evidence that distance and size of the environment is normally underestimated.

Primarily, the VE studies previously discussed have involved a complete or a partial submersion into a 3-D virtual environment, for the purpose of studying simulators, Global Positioning System (GPS) and military training. A limited number of studies have focused on low fidelity or non-immersive virtual environments. Ruddle, Payne & Jones (1999) researched the use of maps as navigational aids in conjunction with VE. In this study, maps with small amounts of detail (a global map) or one with greater detail (a local map) were used to locate objects/landmarks. The study concluded that the use of global and local maps simultaneously was most effective, but with repeated searching, global maps on their own were equally effective. By using both types of maps, subjects learned positions of landmarks in a global or survey view but landmarks were also detected once subjects were in the local or general vicinity of the landmark. When global and local maps were directly compared, global map subjects located landmarks in less time. Ruddle et al. explained that global maps present information in a fixed, world-referenced position and orientation while local maps used a fixed, world-referenced orientation but an ego-referenced position (at any time it showed the immediate surroundings). The combination of world-referenced orientation and ego-reference position required the subjects to incorporate information from different positions, delaying the development of spatial knowledge than in global conditions (Ruddle et al.).

Technology and Gender Differences

Another issue addressed in computer simulated, navigational research is the effect of technology and gender differences. VE is a computer related skill, which requires competence with technology. The use of technology has been perceived as a masculine activity (Schumacker & Marahan-Martin, 2001). Males have more experience with computers, have higher skill levels with the Internet and are less likely to have anxiety with their computer skills (Schumacker & Marahan-Martin, 2001). In a study reported by Self & Golledge (2000), correlations between maze performance and psychometric tests of spatial ability were examined. Participants were asked to rate their experience playing computer games that navigated through simulated 3-D environments. Males, who reported a higher experience in maze games, also were faster in all trials and were more accurate than females in maze wayfinding.

In object location memory, Postma, Izendoorn & De Hann (1998) conducted a study that involved finding objects on a computer screen. In this study, the objects appeared for a short time on the display and then disappeared. The task involved the subject relocating the objects back to their original position either with or without cues of the original location. Results showed that females were less efficient in positioning objects without cues than males, but no difference was found when cues were provided.

Statement of Hypotheses

A majority of route recall, route memory, and landmark studies focused on the use of direct navigation, either in buildings or cities, on traditional paper maps of hand-drawn imaginary places or in virtual environments of 3-D design. In studies of gender and route accuracy and recall, males prefer maps that give direction and distance, while women recall more landmarks (Beatty, 2002; Rovine & Weisman, 1989; Ward, Newcombe & Overton, 1986). In regards to VE, research suggested that wayfinding is independent of the type of space (Darken & Sibert, 1996). This present study focuses on global maps available to the public from navigation websites. For this purpose, paper and electronic maps will be tested for accuracy of route recall using methodology outlined in Galea & Kimura (1993) study. Gender will also be analyzed to determine if these factors also influence route recall and route memory.

There are 7 hypotheses for this study:

- H_1: Accuracy, as measured by error, will be significantly better (p=.05) using paper or electronic landmark high maps.
- H_2: Accuracy, as measured by trials, will be significantly better (p=.05) using paper or electronic landmarks high maps.
- H_3: Females will be significantly better (p=.05) than males using paper or electronic landmark high maps on the variables of accuracy and number of trials.
- H_4: Females will be significantly better on accuracy and number of trials needed to reach proficiency (p=.05) using landmark high maps versus landmark low maps.
- H_5: Females will be significantly better (p=.05) than males in recall of landmarks.
- H_6: No main effect will be found between paper and electronic maps on either accuracy or number of trials needed to reach proficiency.
- H_7: No main effects for accuracy or number of trials will be found between males using landmark low and landmark high maps.

Method

Participants

One hundred and nine participants were used in this study. Participants included seventy-six students currently enrolled at Flagler College undergraduate psychology courses in St. Augustine, Florida and thirty-one students enrolled at Embry-Riddle Aeronautical University undergraduate psychology courses in Daytona Beach, Florida. Composition of these groups included male and female participants. Past research has suggested a correlation between driving experience and route memory. Until the 5th or 6th decade of life, people accumulate more experience and geographical knowledge which aids in route memory (Beatty, 2002). In Beatty's study, three age groups were used: under 16, 16 to 29 and 30 to 60. In a study of wayfinding in children and adults, the age groups consisted of: 8 yr old, 12 yr olds and 18-30 yr olds, with a mean age of 25.3 (Cornell, Heth, & Alberts, 1994). To control for driving experience, the participants in the present study were between 18 and 23 years of age. Each participant had a valid driver's license and a minimum of two years and a maximum of eight years of driving experience, including a learners' permit. Participants were randomly divided into two groups, paper or electronic map and further divided into two groups, without landmarks and with landmarks, with males and females in each group.

Previous research in route learning and wayfinding tasks used sample sizes as few as 10 participants, (Jansen-Osmann, 2002) to 176 participants, (Ward et al., 1986). The sample size was determined through review of the two previous stated research projects and four additional research articles: Albert et al., (1999) utilized 32 participants, Ruddle et al. (1997) utilized 24 participants, Galea & Kimura (1993) utilized 97 participants, and Rovine & Weisman (1989) utilized 45 participants. Post-hoc power analysis was run on two of the previous studies. Jansen-Osmann study was a with-in subject, 2X2 design with 5 subjects in each condition. The power for 'number of trials until criterion was reached' $p = .57$. Power for 'number of wrong turns per trial' was $p = .35$. When subjects were increased to 10 for the learning trial, $p = .89$. When subjects were increase to 15 for wrong turns, $p = .81$. Galea & Kimura study was a between-subject 2X2 design with n=48 in condition A, and n=49 in condition B. The power was computed for route learning composite score, $p = .71$. According to Galea & Kimura route learning composite scores is a calculation of z-scores from each of the three measures – number of trials, total errors, and time. They stated a composite score was calculated because 'aggregate scores tend to have better reliability due to a decrease in error variance'. A pilot study was conducted for this study and it was determined that 107 participants were needed to achieve power of at least .8 for the independent variables. This placed 53 participants in the paper map group and 54 in the electronic map group.

Materials

A Dell Inspiron 3800 Series laptop computer with a 12.1 display, 256 ram and Microsoft Windows 2000 was used in this study. For the electronic maps of this study, two maps, Map A and Map B were used. The maps were identical except for the inclusion of landmarks. The Landmark Low Map (LL) included road outlines and street names, while the Landmark High Map (LH) included road outlines, street names and color representations of landmarks (buildings, shops, parks, stoplights, etc.) Map A was downloaded from Yahoo! Maps and saved. Map A was then altered in Photo Shop to delete landmarks such as parks & colors. Map A was then used to add relevant landmarks to create Map B. Each map covered five square miles and provided a legend for scaled mileage and cardinal direction. On Map B, the total number of landmarks was 23 with 11 landmarks on the route and 12 landmarks off the route. The total number of traffic lights used was 37 on the route and 28 lights off the route. Routes were identical in each map containing oblique and right-angled turns, with 8 left hand turns and 5 right hand turns. For the paper maps, printed versions of Map A and Map B were used. The maps were mounted in order to place maps in the same position on the desktop as the electronic maps. All landmarks, routes, and turns in the paper condition were identical to the electronic maps.

Design

This study was a 2 X 2 X 2 between subjects factorial design with map type (paper and electronic), landmarks (low and high landmarks), and gender (male and female) as the independent variables. This experiment replicates the methodology of Galea & Kimura (1993) research on sex differences in route learning using the map learning with traditional paper maps experiment as discussed in the literature review. Participants were tested individually.

Procedure

Participants were asked to complete a consent form. The consent form included a summary of the study, task they were required to accomplish and a questionnaire that was used to obtain information about age, years of driving experience, gender, miles driven per week, how often any type of navigation aid was used, confidence in mapping ability, familiarity with Burbank, CA area, major and contact information. Based on completion of the consent form and questionnaire, participants were randomly assigned to one of four conditions: paper map, without landmarks – Map A (N=26, Males N=13, Females N=13) and with landmarks – Map B (N=27, Males N=12, Females N=15), electronic map, without landmarks – Map A (N=26, Males N=13, Females N=13) and with landmarks – Map B (N=28, Males N=13, Females N=15). Two participants of the 109 surveyed were disqualified from the study because of familiarity of the Burbank, California area.

The participant was seated in front of the monitor and chair height adjusted so that each participant viewing angle is 20° above the center of the monitor. The monitor was then adjusted so that each participant viewing distance is 24 inches from the center of the monitor. The experimenter then brought the map onto the screen and as replicated in Galea & Kimura (1993) research gave the following directions: "This is a map of a town. I want to point out to you that this direction is north. I am going to take you on an imaginary Sunday afternoon drive that someone took and I want you to remember the drive." The experimenter then slowly indicated the route with the cursor on the map using an equivalent time of 2 minutes for all participants. The directions were tape recorded to ensure accuracy of directions. In landmark high maps, landmark legend was reviewed when North is pointed out for the participant. For paper map experiments, identical procedures were followed, except a paper copy of the map was presented in place of the monitor.

Immediately following the presentation of the route, participants played a game of solitaire, either with a deck of cards or on the computer to control for short term memory recall. The map was then refreshed and the participant was required to trace the route given by the experimenter to a criterion of two successive correct trials. Upon making an error, the participant was immediately corrected and then continued with the trial and the experimenter recorded the number of errors per trial. Two measures of accuracy as used by Galea & Kimura (1992), was recorded: a) total errors made on the first testing trial, and b) total number of trials need to reach criteria.

Once the participant completed two successive trials and scores recorded by the experimenter, the participant was debriefed to determine if they had any questions and informed that they will be contacted on the outcome of the study if contact information was supplied on the consent form.

Results

Descriptive Information

Number of trials participants needed to reach criteria in route recall was between two and eight trials with mean of 3.87 ($SD = 1.0$). Participants had between two and eight years of driving experience with a mean of 4.41 ($SD = 1.5$). The average number of errors made in trial 1 was 3.73 ($SD = 1.8$) and the average total errors across all trials was 5.36 ($SD = 3.7$), the average response to 'how often do you use any type of navigational aids' was sometimes (monthly) ($M = 3.60$, $SD = .8$) and the average miles driven per week were 26-75 miles ($M = 2.10$, $SD = .9$). Participants' perception of their mapping ability was average to good with a mean of 2.50 ($SD = .7$). A significant negative correlation between driving experience and error in trial 1 was found, $r(107) = -.20$, $p < .05$. Participants who had more driving experience made fewer errors made in trial 1. A positive correlation was found between errors in trial 1 and number of trials needed to reach criteria, $r(107) = .49$, $p < .05$. Higher error rate in trial 1 resulted in the more trials needed to complete criteria of two consecutive error free trials.

Results for the Dependent Variable: Number of Trials

For number of trials needed to reach criteria, a Univariate ANOVA model was run using the independent variables: gender, type of map and type of landmarks ($F(7,106) = 2.92$, $p < .05$, power = .91). Results of this analysis indicated that there was a significant main effect of gender. Analysis of gender by accuracy as measured by number of trials showed that males required fewer trials (M = 3.63, SD = .7) than females (M = 4.09, SD =1.1), F (1,99) = 7.29, p < .05, power =. 76. There was also a significant main effect of landmark type. Analysis of landmarks by accuracy as measured by number of trials showed participants in Landmark High Maps required fewer trials (M = 3.64, SD = 1.0) than Landmark Low Maps (M = 4.12, SD = 1.0), F (1,99) = 7.68, p < .05, power = .78. Results of this analysis also indicated a significant interaction effect between map type and type of landmark, F (1,99) = 3.742, p < .05, power = .48. Using a one-way ANOVA, there was no difference in number of trials taken by females to reach criteria based on whether or not they viewed Low or High landmark maps. For males, those in the Landmark High group (M = 3.40, SD = 8) needed fewer trials than those in the Landmark Low group (M = 3.85, SD = .7), (F = 4.90, p < .05). See Table 1 for means and standard deviations associated with this analysis.

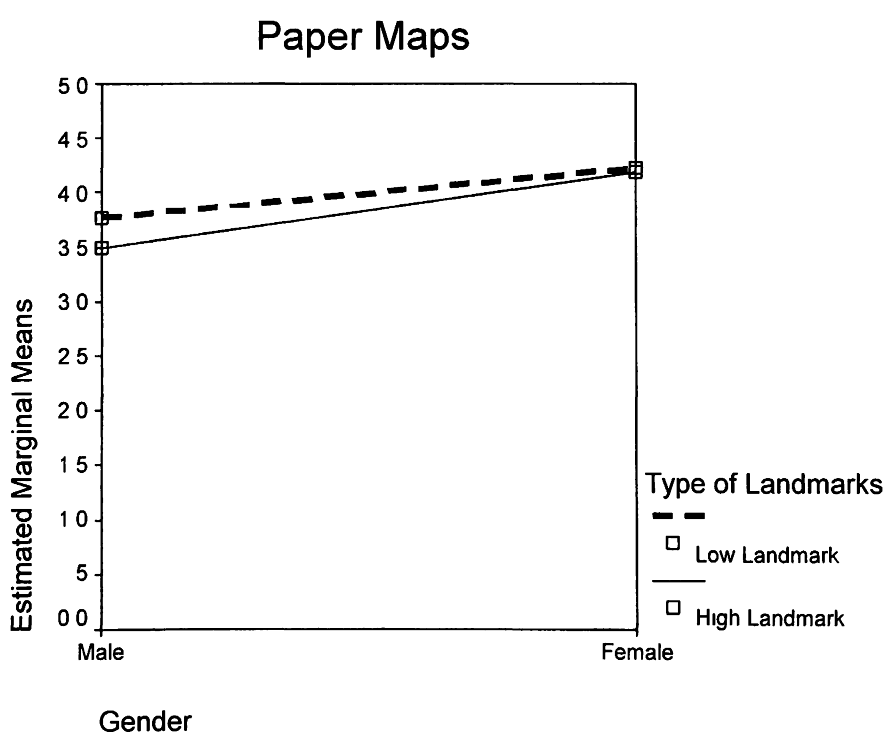


Figure 3
Univariate ANOVA plot for number of trials by map type

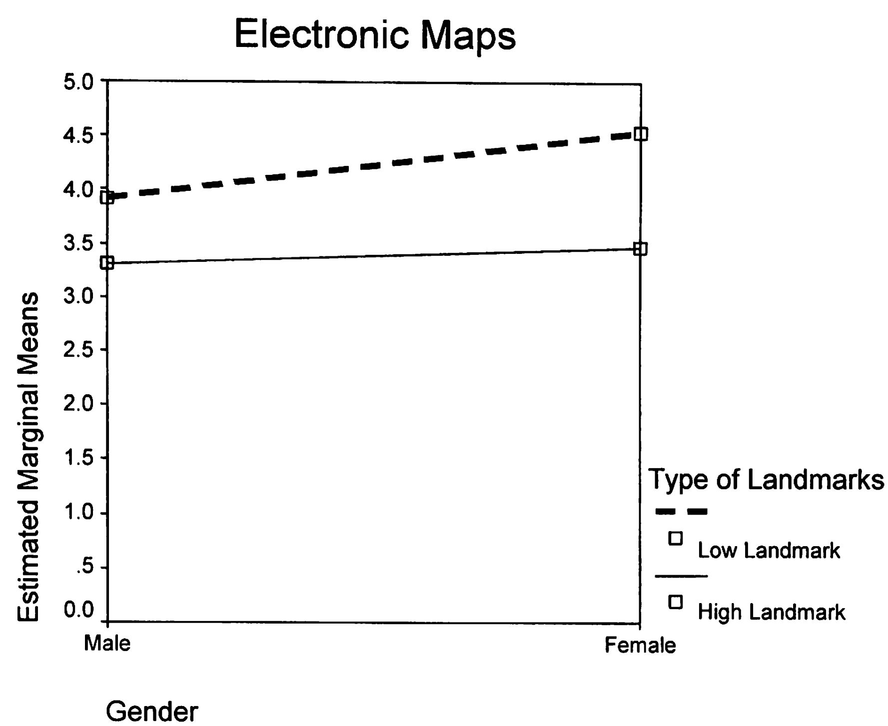


Figure 4
Univariate ANOVA plot for number of trials by map type

Table 1
Number of trials

Variable	μ	SD	N
Paper Maps	3.94	.9	53
Electronic Maps	3.80	1.0	54
Males	3.63	.7	51
Females	4.09	1.1	56
Landmark Low Map	4.12	1.0	52
Landmark High Map	3.64	1.0	55

Results for the Dependent Variable: Number of Errors in Trial 1

For number of errors in trial 1, a Univariate ANOVA model was run using the independent variables: gender, type of map and type of landmarks ($F(7,106) = 3.30$, $p < .05$, power = .95). Results of this analysis indicated that there was a significant main effect of gender. Analysis of gender by accuracy as measured by number of errors in trial 1 showed that males had fewer errors ($M = 3.33$, $SD = 1.9$) than females ($M = 4.09$, $SD = 1.8$), $F(1,99) = 5.79$, $p < .05$, power =. 66. There was also a significant main effect of landmark type. Analysis of landmarks by accuracy as measured by number of errors in trial 1 showed participants in Landmark High Maps had fewer errors in trial 1 ($M = 3.16$, $SD = 1.7$) than Landmark Low Maps ($M = 4.33$, $SD = 1.9$), $F(1,99) = 11.87$, $p < .05$, power = .93. In a gender specific, one-way ANOVA, females made significantly fewer errors in trial 1 on Landmark High Maps ($M = 3.30$, $SD = 1.5$) than on Landmark Low Maps ($M = 5.00$, $SD = 1.8$) ($F = 15.28$, $p < .01$). There was no significant mean difference in number of errors in trial 1 by males in Landmark High or Low groups. See Table 2 for means and standard deviations associated with this analysis.

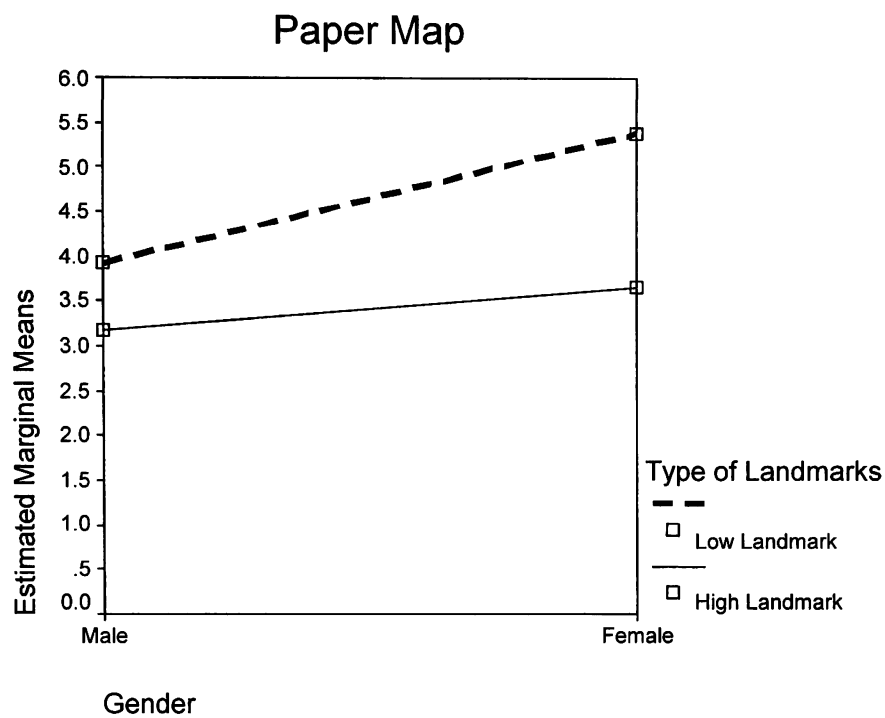


Figure 5
Univariate ANOVA plot for number of errors in trial 1 by map type

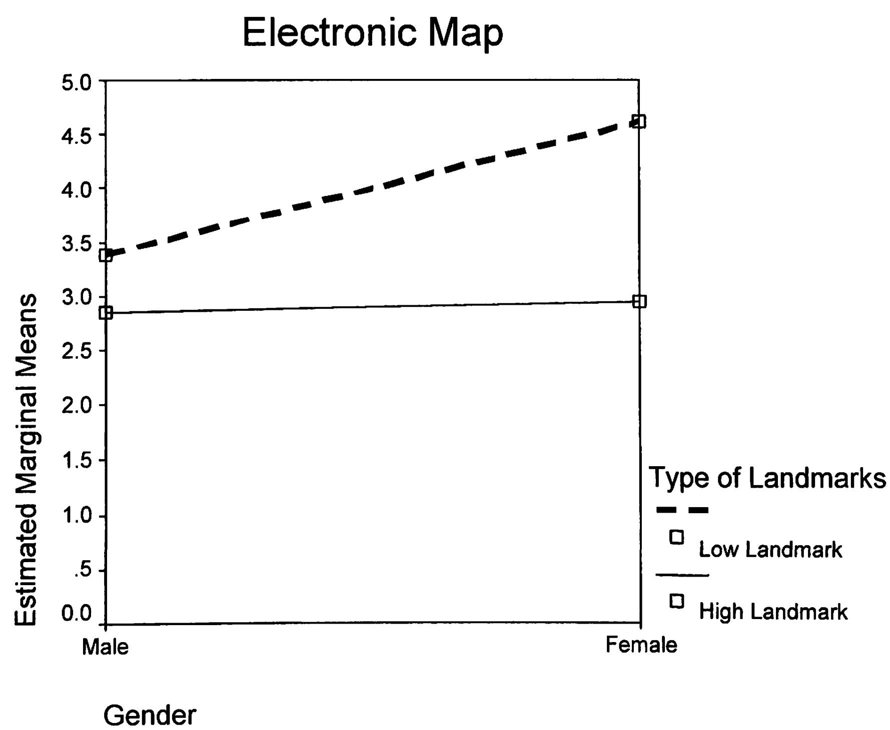


Figure 6
Univariate ANOVA plot for number of errors in trial 1 by map type

Table 2
Number of errors

Variable	μ	SD	N
Paper Maps	4.04	1.9	53
Electronic Maps	3.43	1.7	54
Males	3.33	1.9	51
Females	4.09	1.8	56
Landmark Low Map	4.33	1.9	52
Landmark High Map	3.16	1.7	55

Results for Recall of Landmarks

For recall of landmarks, a t-test was run between gender and the number of landmarks recalled on Landmark High Maps. Results of this analysis indicated that there was no significant main effect in the number of landmarks recalled between males (M = 16.16, SD = 10.5) and females (M = 13.00, SD = 10.3), t (53) = .27, p > .05.

Discussion

The data provide support for previous research conducted on the use of landmarks in wayfinding tasks. The analysis of accuracy as measured by error showed that participants who studied landmark high maps made fewer errors in trial 1 than those who studied landmark low maps. Analysis of accuracy as measured by trials also showed that those individuals who studied landmark high maps required fewer trials to reach criteria than those exposed to landmark low maps. These analyses supported the hypotheses that maps, which included landmarks, would be recalled more accurately than maps without landmarks. This is possibly due to landmarks aiding in the formation of a cognitive map by giving the map-reader more information creating a more accurate cognitive map.

No interaction effects were found between the use of landmarks and gender, thereby leading the researcher to reject the hypotheses that females would be significantly better than males in using Landmark High Maps. However females were significantly better using Landmark High Maps than Landmark Low Maps on the variable of accuracy as measured by errors in trial 1.

Analysis of recall of landmarks across gender shows no significant main effect. Therefore, the results of the present study do not support Galea & Kimura (1993) research that females recalled more landmarks than males. However, Galea & Kimura's research also tested for visual memory. In this task, participants were shown objects and were tested in one of two conditions, immediate or delayed. No difference was found in the immediate condition, but females recalled more objects in the delayed condition. In this present study, landmark recall was given immediately following the recall of the route, which could explain why no difference between genders was found.

Analysis between the two forms of map presentation (electronic versus paper), showed no relationship between either measure of performance and type of map presentation. This finding supported the hypothesis that no significant main effect would be found. Past research in Virtual 3-D environments show that issues of wayfinding in the real world are applicable to the virtual world, but little research has been conducted on flat, two-dimensional monitors. This study supports past findings that it is not an issue in the type of media the map is presented in whether it is paper, 3-D or two dimensional.

Finally, significant main effects of gender were found for males using Landmark Low and Landmark High maps on accuracy for total number of trials needed for proficiency only. Since males use cardinal direction and three-dimensional visualization in wayfinding activities, it is likely that they tend to ignore the additional information that landmarks provide.

Conclusions

This study supported Darken & Sibert's (1996) conclusions that what is known about wayfinding in the physical world is independent of the type of space but does not confirm evidence as found in the Galea & Kimura (1993) study that found gender differences in route learning and landmark recall. Differences were found in accuracy and the college the participants attended. However, with 76 of the participants from Flagler College and 31 from Embry-Riddle Aeronautical University, the unequal sample sizes made these findings inconclusive. Future research should focus on individual differences, mainly the use of technology or technology-based learning compared to more creative or liberal arts learning and whether wayfinding is more prevalent in right brain or left brain participants.

Another aspect of this research that should be considered is the use of wayfinding, landmarks and route accuracy in the use of a GPS system. Are there differences in the cueing of routes and landmarks in a GPS compared to the use of a map displayed on a monitor? Would these same differences apply to cell phone displays? Does the size of the display make a difference in what the map-reader processes? These potential research areas deserve attention in future studies.

References

Allen, G. (2000). Men and women, maps and minds. In Nuallain (Ed.), *Spatial cognition: Foundations and applications* (pp 3-18). Amsterdam/Philadelphia: John Benjamins Publishing Company.

Albert, W., Rensink, R., Beusmans, J. (1999). Learning relative directions between landmarks in a desktop virtual environment. *Spatial Cognition and Computation, 1*, 131-144.

Beatty, W. (2002). Sex difference in geographical knowledge: Driving experience is not essential. *Journal of the International Neuropsychological Society*, 8, 804-810.

Chang, K., & Antes, J. (1987). Sex and cultural differences in map reading. *The American Cartographer, 14*, 29-42

Choi, J., & Silverman, I. (2002). The relationship between testosterone and route-learning strategies in humans. *Brain and Cognition, 50*, 116-120.

Cornell, E., & Heth, D. (2000). Route learning and wayfinding. In R. Kitchin & S. Freundschuh (Eds.), *Cognitive mapping* (pp. 66-83). New York: Routledge.

Cornell, E., Heth, C., Alberts, D (1994). Place recognition and wayfinding by children and adults. *Memory & Cognition. 22*, 633-643.

Dabbs, J., Chang, E., Strong, R., & Milun, R. (1998). Spatial ability, navigation strategy and geographic knowledge among men and women. *Evolution and Human Behavior*, *19*, 89-98.

Darken, R., & Sebert, J. (1996). Navigating large virtual spaces. *International Journal of Human-Computer Interaction.* 8, 49-71.

Galea, L., Kimura, D. (1993). Sex differences in route-learning. In Galea & Kimura (Ed.), *Personality and individual differences* (pp53-65). New York: Pergamon.

Gaulin, S. & FitzGerald (1986).Sex differences in spatial ability: an evolutionary hypothesis and test. *American Naturalist, 127*, 74-88.

Gillner, S., & Mallot, H. (1998). Navigation and acquisition of spatial knowledge in a virtual maze. *Journal of Cognitive Neuroscience. 10*, 445-463.

Goldin, S. & Thorndyke, P. (1982). Simulating navigation for spatial knowledge acquisition. *Human Factors. 24*, 457-471.

Haq, S., & Zimring, C. (2003). Just down the road a piece: The development of topological knowledge of building layouts. *Environment and Behavior, 35*, 132-160.

Jansen-Osmann, P. (2002). Using desktop virtual environments to investigate the role of landmarks. *Computers in Human Behavior*, *18*, 427-436.

Jansen-Osmann, P. & Berendt, B. (2002). Investigating distance knowledge using virtual environments. *Environment and Behavior. 34*, 178-193.

Keates, J. (1982). *Understanding Maps*. New York: Halsted.

Kitchin, R., Freundschuh, S. (2000). Cognitive mapping. In R. Kitchin & S. Freundschuh (Eds.), *Cognitive mapping* (pp. 1-8). New York: Routledge.

Levine, M. (1982). You are here maps: Psychological considerations. *Environment and Behavior, 14*, 221-237.

Lloyd, R. (2000). Understanding and learning maps. In R. Kitchin & S. Freundschuh (Eds.), *Cognitive mapping* (pp. 84-107). New York: Routledge.

Lynch, K. (1960). *The Image of the city.* Massachusetts: MIT Press.

Miller, L. & Santoni, V. (1986). Sex differences in spatial abilities: strategic and experiential correlates. *Acta Psychologica, 62*, 225-135.

Pickering, K. (n.d.) Retrieved October 28, 2003. from http://www1.mon.net/~keithp/dr.htm.

Postma, A., Izendoon, R., & De Hann, E. (1998). Sex differences in object location memory. *Brain and Cognition. 36*, 334-345.

Presson C., & Hazelrigg, M. (1984). Building spatial representations through primary and secondary learning. *Journal of Experimental Psychology: Learning, Memory and Cognition. 10*, 716-722.

Presson, C., DeLange, N., & Hazelrigg, M. (1989). Orientation specificity in spatial memory: what makes a path different from a map of the path? *Journal of Experimental Psychology: Learning, Memory, and Cognition. 15*, 887-897.

Raubal, M., & Egenhofer, M. (1998). Comparing the complexity of wayfinding tasks in built environments. *Environment and Planning B: Planning and Design. 25*, 895-913.

Rieser, J. (1989). Access to knowledge of spatial structure at novel points of observation. *Journal of Experimental Psychology: Learning, Memory, and Cognition. 15*, 1157-1165.

Richardson, A., Montello, D., & Hegarty, M. (1999). Spatial knowledge acquisition from maps and from navigation in real and virtual environments. *Memory & Cognition, 27*, 741-750.

Rovine, M., Weisman, G. (1989) Sketch-map variables as predictors of way-finding performance. *Journal of Environmental Psychology, 9*, 217-232.

Ruddle, R., Payne, S, & Jones, D. (1997). Navigating buildings in "desk-top" virtual environments: Experimental investigations using extended navigation experience. *Journal of Experimental Psychology: Applied. 3*, 143-159.

Ruddle, R., Payne, S., & Jones, D. (1999). The effects of maps on navigation and search strategies in very-large-scale virtual environments. *Journal of Experimental Psychology: Applied. 5*, 54-75.

Sanders, M. & McCormick, E. (1987). *Human factors in engineering and design 6th Edition.* New York: McGraw-Hill.

Schumacher, P. & Morahan-Martin, J. (2001). Gender, internet and computer attitudes and experiences. *Computers in Human Behavior. 17*, 95-110.

Searleman, A. & Herrmann, D. (1994). *Memory from a broader perspective.* Boston: McGraw-Hill.

Self, C., & Golledge, R. (2000). Sex, gender, and cognitive mapping. In R. Kitchin & S. Freundschuh (Eds.), *Cognitive mapping* (pp. 197-220). New York: Routledge.

Thorndyke, P., & Hayes-Roth, B. (1982). Differences in spatial knowledge acquired from maps and navigation. *Cognitive Psychology, 14*, 560-589.

Tversky, B. (1981). Distortions in Memory for Maps. *Cognitive Psychology 13, 407-433.*

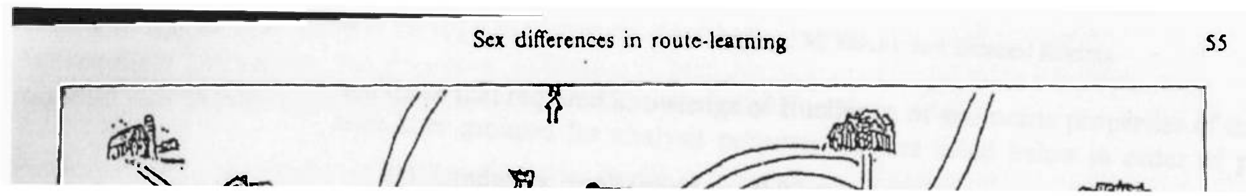
Tversky, B. (2003). Structures of mental spaces: how people think about space. *Environment and Behavior. 35*, 66-80.

Ward, S., Newcombe, N., & Overton, W. (1986). Turn left at the church or three miles north: A study of direction giving and sex differences. *Environment and Behavior, 18*, 192-213.

Witmer, B., Bailey, J, Knerr, B. & Parsons (1996). Virtual spaces and real world places: transfer of route knowledge. *International Journal of Human-Computer Studies. 45*, 413-428.

Appendix A

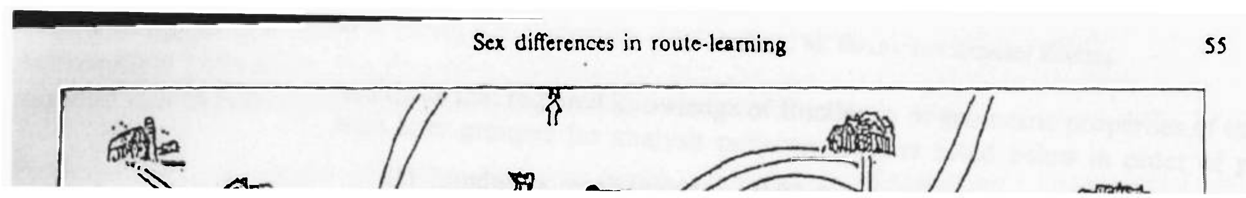
Galea & Kimura's Map



Gender Differences 35

Appendix A

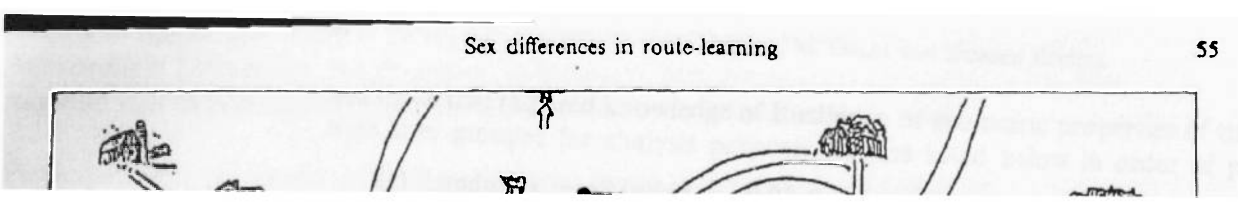
Galea & Kimura's Map



Gender Differences 35

Appendix A

Galea & Kimura's Map



Galea & Kimura's Map Appendix A Gender Differences 35

Appendix B

Consent Form

This study involves a cognitive based experiment designed to test route recall in electronic maps. The study is being conducted by Kimberly Brantley of Embry-Riddle Aeronautical University. No deception is involved, and the study involves no more than minimal risk to participants (i.e., the level of risk encountered in daily life).

Participation in the study typically takes 30 minutes and is strictly anonymous. Participants begin by answering a series of questions about driving history, after which they will be seated in front of a monitor. A map will be presented at which time the experimenter will give route directions. Following the presentation of directions, the participant will be asked to play a game before the next portion of the experiment begins. In the second portion of the experiment, the participant will be asked to recall previous directions and accuracy measurements will be taken.

All responses are treated as confidential, and in no case will responses from individual participants be identified. Rather, all data will be pooled and published in aggregate form only. Participation is voluntary, refusal to take part in the study involves no penalty or loss of benefits to which participants are otherwise entitled, and participants may withdraw from the study at any time without penalty or loss of benefits to which they are otherwise entitled.

Signature of participant   Date

Questionnaire

1. Age: ____________________________

2. How many years of legal driving experience do you have (including learner's permit)

☐ 8 years ☐ 7 years ☐ 6 years ☐ 5 years

☐ 4 years ☐ 3 years ☐ 2 years ☐ 1 year

3. Gender: ☐ Male ☐ Female

4. Average miles driven per week:

☐ 0-25 miles ☐ 26-75 miles ☐ 76-150 miles ☐ 151 or more miles

5. How often do you use any type of navigational aids (i.e., paper maps, navigational websites, GPS, etc.) (check one):

☐ Very Frequently (daily) ☐ Often (weekly) ☐ Sometimes (monthly)

☐ Seldom (yearly) ☐ Never

6. How would you rate your confidence in your mapping/navigational abilities?

☐ Superior ☐ Good ☐ Average ☐ Poor

7. Are you familiar with or have you driven in the Burbank, CA area?

☐ Yes ☐ No

8. Major: ____

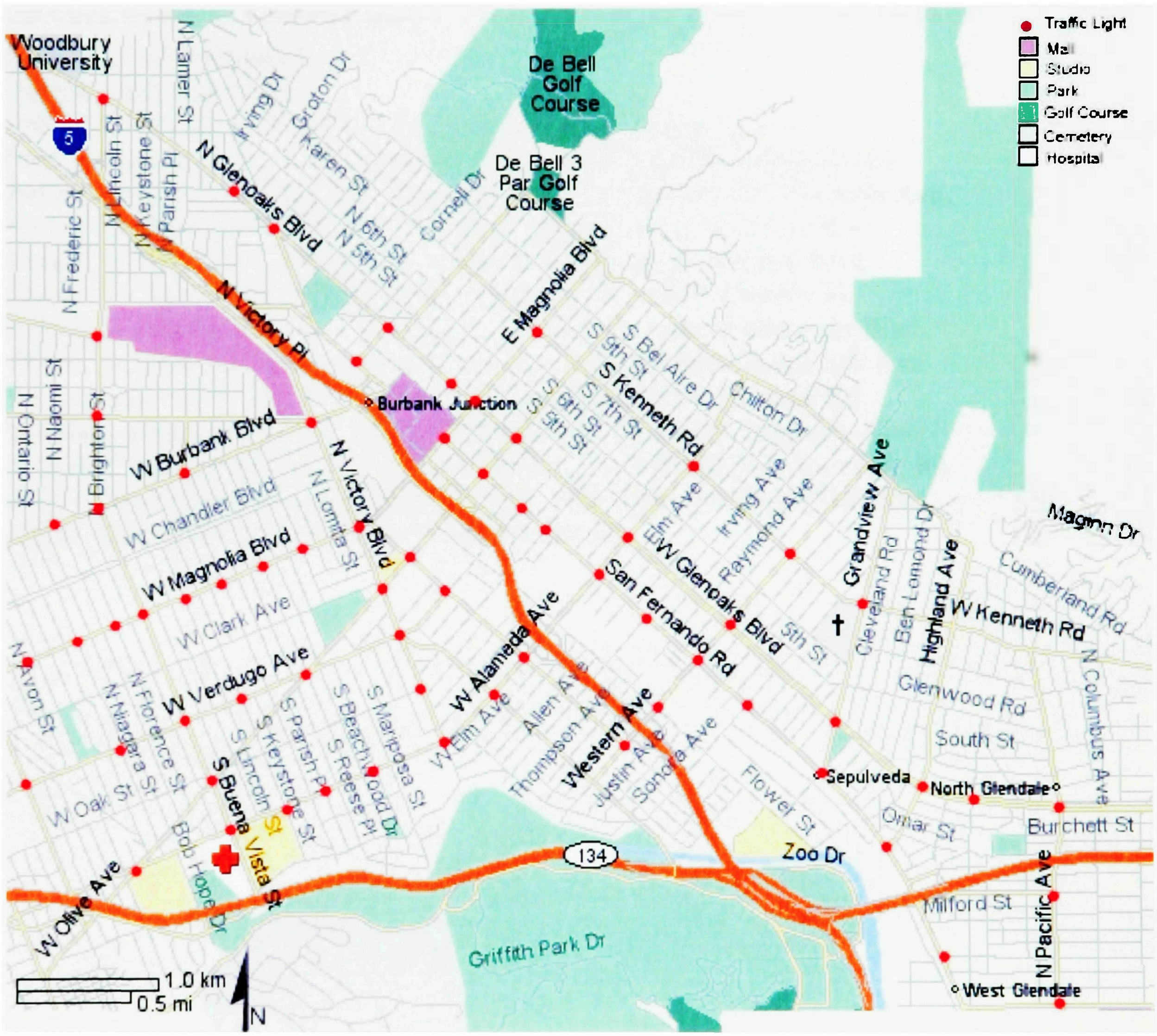
Optional contact information
If you would like to be contacted about the outcome of this study, please complete the section below.

Name ____
Address____
City, State & Zip ____
Email ____
Phone number ____

Appendix C

Map A – Low Landmark (LL)

Map B – High Landmark (HL)



Map A Transcript

This is a map of a town. I want to point out to you that this direction is north. I am going to take you on an imaginary Sunday afternoon drive that someone took and I want you to remember the drive.

Starting at 1000 Flower St.
Turn left onto Flower St.
Follow Flower St. to Western Ave., turn right onto Western Ave.
Follow Western Ave. to San Fernando Rd., turn left onto San Fernando Rd.
Follow San Fernando Rd. to W. Alameda Ave., turn left onto W. Alameda Ave.
Follow W. Alameda Ave to W. Olive Ave., turn right onto W. Olive Ave.
Follow W. Olive Ave to N. Victory Blvd., turn left onto N. Victory Blvd.
Follow N. Victory Blvd to N. Lincoln St., turn right onto N. Lincoln St.
Follow N. Lincoln St. to N. Glenoaks Blvd, turn right onto N. Glenoaks Blvd.
Follow N. Glenoaks Blvd., to Grandview Ave., turn left onto Grandview Ave.
Follow Grandview Ave. to S. Kenneth Rd., turn left onto S. Kenneth Rd.
Follow S. Kenneth Rd. to E. Magnolia Blvd., turn left onto E. Magnolia Blvd.
Follow E. Magnolia Blvd. to San Fernando Rd., turn left onto San Fernando Rd.
Follow San Fernando Rd. to Grandview Ave., turn right onto Grandview Ave.
Follow Grandview Ave. till ends at 1000 Flower St.

Map B Transcript

This is a map of a town. I want to point out to you that this direction is north and the legend is located in the top right corner. Symbols of the legend are as follows, red circle – traffic light, purple – mall, yellow – studio, light green – park, dark green – golf course, gray – cemetery, and white – hospital. I am going to take you on an imaginary Sunday afternoon drive that someone took and I want you to remember the drive.

Starting at Dreamworks Studio at 1000 Flower St.
Turn left out of the studio onto Flower St.
Follow Flower St. to 1st light, turn right onto Western Ave.
Follow Western Ave. to 1st light, turn left onto San Fernando Rd.
Follow San Fernando Rd. to 2nd light, turn left onto W. Alameda Ave.
Follow W. Alameda Ave to 8th light, passing Disney Studio, St. Joseph Medical Center, and NBC studio on your left, turn right onto W. Olive Ave.
Follow W. Olive Ave to 3rd light, passing a park on your left, turn left onto N. Victory Blvd., Nickelodeon Studio will be on the corner of W. Olive and N. Victory Blvd.
Follow N. Victory Blvd, going through 2 lights, passing the New Burbank Empire Center Mall on your left, to N. Lincoln St., turn right onto N. Lincoln St.
Follow N. Lincoln St. to 1st light, turn right onto N. Glenoaks Blvd.
Follow N. Glenoaks Blvd., to 9th light, past a park on your right, turn left onto Grandview Ave.
Follow Grandview Ave. to 1st light, just past the cemetery; turn left onto S. Kenneth Rd.
Follow S. Kenneth Rd. to 3rd light, turn left onto E. Magnolia Blvd.
Follow E. Magnolia Blvd. to 2nd light, New Burbank Empire Center mall will be on your right, turn left onto San Fernando Rd.
Follow San Fernando Rd. to 8th light, turn right onto Grandview Ave.
Follow Grandview Ave. until it ends at Dreamworks Studio on Flower St.