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The Effect of Emotional Landmarks on Navigation

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By

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Abstract

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Navigation is an essential activity that dictates which environments individuals choose to travel through. Effective navigation occurs when individuals reach their destination point efficiently and without harm. Previous research dictates that landmarks are one of the most popular ways in which individuals maintain orientation and remember a route. The goal of the current study was to investigate how emotional landmarks (landmarks that hold either a positive or negative connotation) effect navigational decision-making. Based on individuals' tendencies to choose low risk options, it was hypothesized that participants would use the positive landmarks more effectively (i.e. participants would travel in the direction of the positive landmarks, allowing them to reach the destination point faster). Sixty participants completed a virtual reality maze. Throughout the maze were either positively or negatively rated pictures. Each participant completed four trials of the same maze, and had a minute and a half to find the destination point during each trial. Participants completed a demographic questionnaire and a Positive and Negative Affect Schedule (PANAS) afterwards. Contrary to my hypothesis, neither females nor males utilized positive landmarks more effectively and efficiently in the virtual reality environment. Instead, females preferred negative landmarks, and performed better in the virtual reality maze when exposed to these landmarks.

Introduction

Over time, human navigation has changed from the use of stars as landmarks to listening to computer-generated voices providing turn-by-turn directions. Humans seem to have an innate sense of spatial awareness that benefits in natural navigational abilities. However, with the invention of the Global Positioning System (GPS) navigation has lost its complexity. Therefore, individuals who may once have believed they had a poor sense of direction have developed a sense of security. Although the GPS is an excellent navigational resource, it does not focus on environmental factors. A GPS is programmed to find the shortest route to the destination but does not have the ability to choose routes based on the quality of the neighborhoods or surroundings. Consequently, many people are left driving through dangerous regions, cemeteries, or other areas associated with negative emotions. Little research has been conducted to test how emotional aspects of the environment influence navigational ability. The current study investigates how emotional qualities of landmarks could benefit or harm navigational ability.

Although navigation feels like a single, natural process, it consists of many different mechanisms. The goal of the following section is to explain the most common definitions and discuss some of the theories related to navigation. First I will define navigation and the components that assist in efficient navigation. After, I will summarize previous research that explores the different aspects of navigation, as well as, the factors that influence navigation. Then, the role of landmarks in navigation will be explained. Next, there will be a brief description on how emotion affects the decision making process. Finally, I will describe the purpose and hypothesis of the current study.

The Components of Navigation: Locomotion, Wayfinding, and Orientation

Navigation is defined as the process by which individuals move throughout the environment. It encompasses both the design and implementation of movements. These two aspects of navigation are better known as locomotion and wayfinding (Montello, 2005). Locomotion is the body's movement in proximal (movements occurring attached to or near the body) and distal (movements occurring away from the body) surroundings. Movement that requires direct energy is known as active locomotion. Active locomotion is driven by the individual--it is self-directed and self-powered. The process of active locomotion allows an individual to explore and learn his or her surrounding environment. Movement that requires little or no energy from an individual is passive locomotion. Passive locomotion occurs when individuals are moving in a vehicle, such as a car, train, or plane (Montello, 2005). The goal-oriented aspect of navigation is called wayfinding. Wayfinding involves knowledge of the destination and a plan of movement (Montello, 2005, & Gerber & Kwan, 1994 as cited in Saucier et. al., 2002). According to Dudchenko (2010), there are three types of wayfinding: oriented search, route following, and landmark-to-landmark. Oriented search occurs when an individual is at a known start location and searches for a destination relative to that location. Following a marked pathway is an example of route following. The last type of wayfinding, landmark-to-landmark, integrates the use of directions, an explanation of how to locate a destination, using specific features in the environment. Although locomotion and wayfinding typically work together to create the traditional form of navigation, it is possible to have wayfinding without locomotion, and vice versa (Montello, 2005). For instance, pacing back and forth while studying is still a form of locomotion, but is not goal oriented. The ability to plan a trip to another country is a form of wayfinding without locomotion. Locomotion and wayfinding are the basis by which individuals navigate through their environment.

In order to successfully navigate, a destination must be reached safely and efficiently. Effective navigation occurs when one maintains awareness of his or her geographical orientation (Montello, 2005). During navigation orientation is always fluid - movement causes orientation to continually change. Therefore, it is important that individuals continuously update their geographical orientation. Two proposed mechanisms that allow individuals to maintain their orientation are landmark-based and dead reckoning processes (Montello, 2005). Individuals who use landmark-based processes maintain their orientation through recognizing and remembering distinguishable features in their environment throughout navigation. Dead reckoning is a more scientific and mathematically based mechanism that requires individuals to keep track of their movements, speed, and start location. Montello (2005) suggests that individuals keep track of their orientation by means of reference points. According to Hart and Moore (as cited in Montello, 2005), there are three different types of methods used to describe a reference point: egocentric, fixed, and coordinated. An egocentric description is relative to the person, a fixed description is relative to a landmark, and a coordinated description is based on imaginary axes. For instance, if an individual uses the egocentric method they would describe their location using themselves as a reference point. Therefore, an individual may explain their location as a place they were present at previously. If an individual uses the fixed method, they would describe their location using features in his or her environment. This is the most commonly used method. Any individual who describes his or her location using colors in his or her environment, buildings, or signs is using the fixed method. Lastly, if an individual describes their location using the coordinate method, he or she may utilize the latitude and longitude values found on maps. Pilots and sailors use this to describe their locations as they are traveling.

As stated earlier, updating orientation is essential for understanding location. Maintaining orientation while navigating requires a significant amount of attentional resources. For instance, in order to remember a route, many individuals will intentionally memorize the path or landmarks that lead them to their destination (Montello, 2005), an effortful process. Three tactful processes or strategies that people often use to help maintain orientation are: edge following, route or directional following, and the look back strategy (Montello, 2005). Edge following requires that the destination falls along an edge (i.e. shore, etc.). Therefore, if one follows that edge, they will always reach the destination. Route or directional following is beneficial for short distances. Individuals travel short distances away from a base to gain information about their environment without losing site of their start location. Therefore, they can maintain their orientation while learning more about their surroundings. The look back strategy involves a significant amount of memory storage. In this strategy, individuals look behind them and memorize the view in order to remember their path and maintain their orientation. If individuals do not maintain their orientation they will lack the ability to familiarize themselves with their environment.

What is Efficient Navigation?

Previous research has suggested that people may create a “cognitive map” to aid navigation. A cognitive map is a mental representation of past routes traveled. Research conducted by O’Keefe and Nadel (as cited in Berthoz, Viaud-Delmon, & Lambrey, 2002), suggested that cognitive maps are located in the hippocampus, the area of the brain believed to be responsible for navigation, as well as both long-term and short-term memory storage.

Cognitive maps are proposed to contain directions and distances traveled between landmarks (Dudchenko, 2010). Although, a cognitive map would simplify the understanding of navigation, research focusing on the use of landmarks has provided evidence against this idea. Instead of relying on an overall representation of an environment through the cognitive map, the research suggests that individuals continuously update their location through utilizing certain landmarks (Dudchenko, 2010). Therefore, rather then depending on remembering specific movements, individuals use the features in their environment to continually update orientation and location. In a study conducted by Wang and Spelke (as cited in Dudchenko, 2010), participants were familiarized with an environment and its landmarks. Afterwards, participants closed their eyes and became disoriented with their surroundings by rotating for one minute. As expected, participants could no longer describe their location. Therefore, landmarks are necessary for individuals to remember their locations. This type of navigation depends on the individual, "an egocentric updating system" (Dudchenko, 2010, p. 89). Using an egocentric system allows individuals to always understand and recognize their position.

Prior experience with certain paths affects the way individuals navigate. According to Berthoz, et.al. (2002), individuals use two types of mental navigation strategies both relying on memory: route strategy and survey strategy. The route strategy depends on the memorization of movements and landmarks, while survey strategy requires individuals to hold a mental representation of the environment. Both of these strategies require the successful utilization of landmarks. In route strategy, one must remember the landmarks accessible to them along the route. For survey strategy, landmarks must have previously been stored in memory.

Although many paths are stored in memory, individuals are capable of immediately changing their course if it is disrupted. Iaria, Fox, Chen, Petrides, and Barton (2008) tested the bottom-up attentional system that aids in spatial navigation. The bottom-up attentional system is "stimulus driven" (Iaria, et. al, p. 1017). For instance, the bottom- up attentional system is utilized when attention is disturbed by a salient feature or activity in the environment. In Iaria et al.'s (2008) study participants learned a virtual reality environment and became familiar with the shortest route to a target location. After participants were familiar with the shortest route, the path was blocked, and they were required to find a new route that would lead them to their target destination. During the procedure, brain activity was measured using functional magnetic resonance imaging (fMRI). Their results showed activation of the right fronto-temporo-parietal network when participants were exposed to the unexpected navigational disruption, areas in the brain associated with bottom- up attentional processing. These results indicated that bottom-up attentional processing is imperative when quick changes are made to a navigational route. Therefore, this research is crucial when determining what landmarks to utilize in the environment--landmarks should be consistent.

The Beneficial Use of Landmarks

As stated earlier, wayfinding and orientation are important components of navigation. One of the most effective ways to successfully wayfind and orient is through the use of landmarks. Any stationary object that helps an individual remember a location can be considered a landmark. Landmarks can range from ordinary, everyday objects to intricate, detailed structures. For instance, some individuals may use a specific shrub as a landmark, while others may use paintings or street signs. In general, remembering distinct features that are present in the environment is an efficient way to navigate. According to Stankiewicz and Kalia (2007) the most effective landmarks are persistent, perceptually salient, and informative. For a landmark to be persistent it must be present at all times of navigation. For example, the house an individual grows up in is a persistent landmark. A perceptually salient landmark is a landmark that is eye catching to the navigator, such as a brightly colored painting or large building (i.e. the Empire State Building). Lastly, for a landmark to be informative, it must provide information about a navigator's location. For instance, signs that help individuals find their destination are informative landmarks. If a landmark is missing or low in any of these three qualities, the landmark loses effectiveness.

Although any element in an environment can act as a landmark, recent research has indicated that structural landmarks are more effective then object landmarks (Stankiewicz & Kalia, 2007). Structural landmarks were defined as "hallway structures" (i.e. hallways that were built into the environment, such as turns and walls). Object landmarks were pictures on the walls. Stankiewicz and Kalia (2007) used a virtual reality environment and measured the usefulness of structural versus object landmarks. They measured the retention rate associated with each type of landmark (the length of time participants remembered the landmarks), how individuals used structural landmarks after increasing the salience of object landmarks, and how individuals used certain landmarks if no other landmarks were present. Memory for the landmarks was measured one year after the initial observation. The results showed that participants encode structural landmarks first, but tend to use those landmarks that are associated with the most information. These results also indicated that landmarks are encoded into long-term memory, because participants were able to recall landmarks after one year. Landmarks were more likely to be stored in memory when associated with the most information.

Although landmarks are effective navigational cues for everyone, recent research has shown that females are more likely to use landmark navigation then males (Barkley & Gabriel, 2007). In general males favor Euclidean or directional cues, and therefore are more likely to use maps to aid in navigation. According to a study conducted by Saucier et. al. (2002), this difference in navigational preference is based on ability, not strategy. On both a real world and paper task males performed better with Euclidean directions and females performed better with landmark-based information. Neither males nor females tended to effectively utilize a different strategy when presented with their disfavored instructions.

Previous research has also indicated that females outperform men on spatial tasks that require landmark information (Astur, et.al, 2006, Levy, Astur, & Frick, 2005, O'Laughlin & Brubaker, 1998, & Sacier, et.al, 2002, as cited in Barkley & Gabriel, 2007). In a study conducted by Barkley & Gabriel (2007), the response time for detecting a missing cue in a picture was measured. The goal of this study was to determine whether or not males and females would react differently if a preferred cue was removed. This hypothesis was based on a theory by Jacobs and Schenk (2003, as cited in Barkley & Gabriel, 2007), which stated that both males and females utilize landmark and Euclidean cues, and these cues work together while navigating. In the study the removed cue varied in position and quality. The distal gradient cues were place in the background and had faded features. These were cues more likely used for directional information. Proximal pinpoint cues were single defined cues placed in direct view and were features that would be used as landmarks. Males were found to have a longer response time to missing cues, compared to women, but there was less difference between males and females for the distal cues. These results suggest that women pay more attention to objects and have a better memory for landmark information, while males rely on distal cues if they need landmark information (Barkley & Gabriel, 2007). Therefore, although both males and females may utilize Euclidean and landmark information during navigation, females are superior at landmark-based navigation.

Affect and Navigational Decision Making

Individual mood, as well as the surrounding environment impacts all decisions. Overall, people categorize stress as a negative emotion. According to a study conducted by Thomas, Laurance, Nadel, and Jacobs (2010), after induced stress females revealed a decrease in navigational ability. This loss in navigational ability only existed during cognitive-map guided navigation, but did not effect landmark- guided navigation. Participants in the cognitive- map guided group navigated through an environment that consisted of distal cues that directed movement in a certain region. The landmark- guided navigation environment involved clear proximal cues that guided navigation in a certain area. In order to induce stress participants completed the Trier Social Stress Test (TSST), which consisted of various surveys and tasks. Participants completed a number of virtual reality tasks where they had to search for a target feature. The results of this study showed that cognitive- map guided navigation was only disrupted for females after they were exposed to the TSST. Neither males nor females were affected by the induced stress when completing landmark-guided navigation.

Although stress does not have a substantial effect on navigational decision-making, evidence has shown that emotions play a big role in everyday choices. According to Mikels, Maglio, Reed, and Kaplowitz (2011) individuals use two different decision making strategies interchangeably: deliberative and affective, or intuitive. When individuals analyze their options they are using the deliberative strategy, but if they depend on their emotions or “gut feeling” they are employing the affective, or intuitive, strategy. Research has shown that integrating emotions into the decision-making process through the affective or intuitive model leads to poor judgment (Mikels, et al., 2011). While this may be true to some extent, Mikels, et al. (2011) found that higher quality conclusions were made when their participants encoded information into their working memory through an affective process. Though these results supported the use of emotion in decision-making, they did not focus on what type of emotion, positive or negative, was superior in the process. According to Cassotti, et. al. (2012) and Chuang and Lin (2007), individuals who are exposed to positive stimuli are less likely to make riskier choices. Therefore, there is a possibility that individuals associate positive stimuli with safer decisions.

The Current Study

The goal of the current study is to investigate how landmarks with positive and negative connotations effect how individuals navigate throughout their environment. Although many studies have concentrated on how environmental influences can effect navigation (Iaria, et. al., 2008, Stankiewicz & Kalia, 2007, Saucier, et. al. 2002, & Barkley & Gabriel, 2007), no study has looked at the emotional aspect. In the current investigation, I use a virtual reality environment, which consists of picture landmarks associated with positive and negative emotions, to test the stated hypothesis. The purpose of these pictures is to induce the desired emotion (positive or negative). Based on previous research on emotional decision-making and the positive influence of landmarks on navigation, I hypothesize that individuals exposed to positive landmarks will navigate through the virtual reality environment more effectively. I believe that positive landmarks will be utilized more efficiently compared to the negative landmarks. Therefore, individuals exposed to the positive landmarks will navigate towards the landmarks more willingly and without hesitation, leading them to the destination point faster.

Method

Participants

Sixty Union College students (33 females and 27 males, average age = 19.4) were recruited through the Union College Psychology Department recruitment website. Participants were compensated with either $4 or a half participation credit for their involvement. Four additional students were recruited as pilot subjects in the same way. Participation in the current study was voluntary and participants were allowed to withdraw from the study at any time. Participants were randomly assigned to two groups. Half the participants were given pictures with a positive connotation as landmarks, and half were given pictures with negative connotation.

Materials

Maze Suite 1.0

A 3-dimensional virtual reality maze was designed using Maze Suite 1.0, a program created by Ayaz, Allen, Platek, and Onaral (2008). The purpose of Maze Suite 1.0 is to provide researchers with a user-friendly and simple program to create a 3-dimensional environment, and therefore, conduct controlled and interactive spatial and navigational experiments. Maze Suite 1.0 consists of three applications: Maze Maker, Maze Walker, and Maze Analyzer. Maze Maker is used to generate the maze environment. Through Maze Maker one can choose a color scheme, arrange walls, insert pictures or objects, create desired lighting, set time limitations, choose a start and end position, and assemble Maze Lists (a group of mazes). Maze Walker runs the maze program when the participant is completing the task. It tracks the participants' movements and saves the collected data. Maze Analyzer is used to analyze data collected from Maze Walker. It calculates the length of the route, velocity of the participants' movement, and participants' overall completion time of the maze. Maze Analyzer also allows one to retrace the participants' route (Ayaz, et al., 2008).

Six mazes were designed for the current study. The mazes were identical, except for the pictures, which represented positive and negative landmarks. Three mazes included positive landmarks, and three included negative landmarks. Additionally, each maze consisted of eight neutral pictures. All mazes contained the same neutral landmarks. The mazes consisted of a black floor, grey ceiling, and brick walls (except for one green wall which marked the destination point). Participants viewed the maze as the first person. The maze mimicked a scene individuals could observe during their daily life.

International Affective Picture System (IAPS)

The landmarks for the current study were pictures selected from the International Affective Picture System (IAPS). The IAPS was originated in order to have a standard set of pictures for researchers investigating emotion and attention (Lang, Bradley, & Cuthbert, 2008). The IAPS consists of 716 photographs. These pictures were previously rated on pleasantness, arousal, and dominance on a scale of 1-10 (1 being the lowest, and 10 being the highest). In the current study 32 IAPS photographs were used: twelve positive pictures (pleasantness: $M = 7.67$, $SD = 0.31$; arousal: $M = 5.74$, $SD = 0.44$; dominance: $M = 5.81$, $SD= 0.67$), twelve negative pictures (pleasantness: $M = 1.98$, $SD = 0.54$; arousal: $M = 5.68$, $SD = 1.01$; dominance: $M = 3.53$, $SD = 0.67$), and eight neutral photos (pleasantness: $M = 5.56$, $SD = 1.66$; arousal: $M = 4.96$, $SD = 2.09$; dominance: $M = 5.34$, $SD = 2.195$). Each maze included twelve landmarks. Eight of the photographs were from the neutral group, and were placed at random decision points throughout the maze. Four of the photographs were chosen from either the positive or negative group, and were placed at specific decision points, which would lead the participant to the destination.

The goal of the current study was to investigate the effect of positively and negatively associated landmarks on navigation. Therefore, three sets of positive and negative pictures were used to make certain that the valence of the landmark (picture) was being assessed, and this was causing the performance differences between the mazes, rather than some other unknown difference between the pictures. The average pleasantness score for the positive and negative pictures in the mazes was kept constant. Therefore, every participant was exposed to pictures that had similar pleasantness scores in the positive mazes. This was also true for the negative mazes.

Demographic Questionnaire

The demographic questionnaire consisted of three questions: age, gender, and whether or not the participant was able to guess the purpose of the study (see Appendix). If participants believed they determined the objective of the study, they were asked to explain their reasoning.

Positive and Negative Affect Schedule (PANAS)

The Positive and Negative Affect Schedule is a questionnaire used to determine an individuals' mood at the moment (see Appendix). Participants are shown a list of twenty words that are associated with positive or negative emotions. Ten words are associated with positive emotions and ten with negative emotions. They are asked to rate each word on a scale of 1 to 5 (1 being slightly or not at all, and 5 being extremely) based on how they are feeling in a present moment. The positive words were: interested, excited, strong, enthusiastic, proud, alert, inspired, determined, attentive, and active. The negative words were: distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, and afraid.

Procedure

The current study required participants to perform two tasks: navigate a 3D virtual reality maze and complete a short demographic questionnaire, which included the PANAS. Both tasks took place on the same day, and combined took approximately thirty minutes. Upon entering the study, participants were placed into either the positive or negative landmark group and were randomly assigned to a maze type within their group. Participants were not aware of the different types of mazes, or the group to which they were assigned.

All participants were given an informed consent form, which outlined the tasks in the study and their right to withdraw from the study at any time. Afterwards, participants were instructed on how to navigate through the maze. They were told that their goal was the find a bright green wall as quickly as possible and that the pictures throughout the maze may or may not help them find the bright green wall. Each participant completed four trials of the same maze. Participants were given a minute and half to explore the maze, and thirty seconds between each trial to rest their eyes. Immediately after the completion of the fourth trial they were instructed to complete the demographic questionnaire and PANAS that was placed next to their computer. Participants were then debriefed about the purpose of the study and were compensated with either a half participation credit or four dollars for their involvement.

Results

The following analyses are based on three dependent measurements: emotional affect caused by the landmarks, the overall completion times of the maze, and the velocity, or speed, at which the participant moved about the maze. Emotional affect was measured to rule out the possibility that worse performance with the negative landmarks might be due to a general decrease in mood, rather than the negativity of the landmarks themselves. The latter two measurements were chosen because together they give a comprehensive representation of how efficiently each participant completed the maze.

The PANAS scores were used to gauge the emotional affect caused by the positive or negative landmarks. As seen in Table 1 little difference in emotional affect was observed for either type of landmark. Based on the descriptive statistics positive affect was higher than negative affect regardless of type of landmark. Males also seem to have displayed a higher positive affect when exposed to negative landmarks compared to positive landmarks. To test these observations a 2 (Sex: male or female) x 2 (Landmark type: positive or negative) analysis of variance (ANOVA) was conducted for both the positive and negative affect scores. The positive affect ANOVA displayed no main effect for sex (F (3,56) = .61, p = .44) or landmark type (F (3,56) = .79, p = .38), and no interaction between sex and landmark type in the direction of significance (F (3,56) = 1.67, p = .20). Similarly, no main effect for sex (F (3,56) = 3.76, p = .06) or landmark type (F (3,56) = .43, p = .52) and no interaction between sex and type (F (3,56) = .03, p = .86) were observed in the negative affect ANOVA, although, the main effect for sex approached significance. From these results, it can be inferred that landmark valence did not affect participant mood.

Table 1. Average emotional affect score for either type of landmark. These scores were determined by the PANAS data. PANAS scores ranged from 1 to 5.

	Positive Landmark		Negative Landmark	
	Positive Affect	Negative Affect	Positive Affect	Negative Affect
Male	2.46	1.39	2.95	1.28
Female	2.58	1.64	2.49	1.57

It appears that overall completion time decreased across the four trials for both male and females when exposed to either type of landmark (see Figures 1 and 2). Males seem to have displayed no difference in completion time for either type of landmark (Figure 1), while, contrary to my hypothesis, females seem to have completed the maze task faster when exposed to negative landmarks (Figure 2). A 2 (Sex) x 2 (Landmark Type) x 4 (Trial) ANOVA was conducted to determine the significance of these observations. This ANOVA revealed a main effect for trial, $F\ (3, 168) = 37.37$, $p < .05$, such that overall completion time declined across trials. A main effect was observed for sex, $F\ (3, 168) = 18.84$, $p < .05$, such that completion times for males were significantly faster than for females. There was no significant main effect for landmark type, $F\ (1,56) = 1.65$, $p = .21$. This ANOVA displayed a significant interaction between trial and sex, $F\ (1,56) = 3.15$, $p < .05$, such that the overall time for males tended to decrease faster across trials compared to females. There were no significant interactions between trial and landmark type, landmark and sex, and trial, landmark type, and sex ($F\ (3,168) = .99$, $p = .39$, $F\ (1,56) = 1.45$, $p = .23$, and $F\ (3,168) = .39$, $p = .76$). These results indicate that males completed the virtual reality task faster than females, and improved more quickly across trials than females.

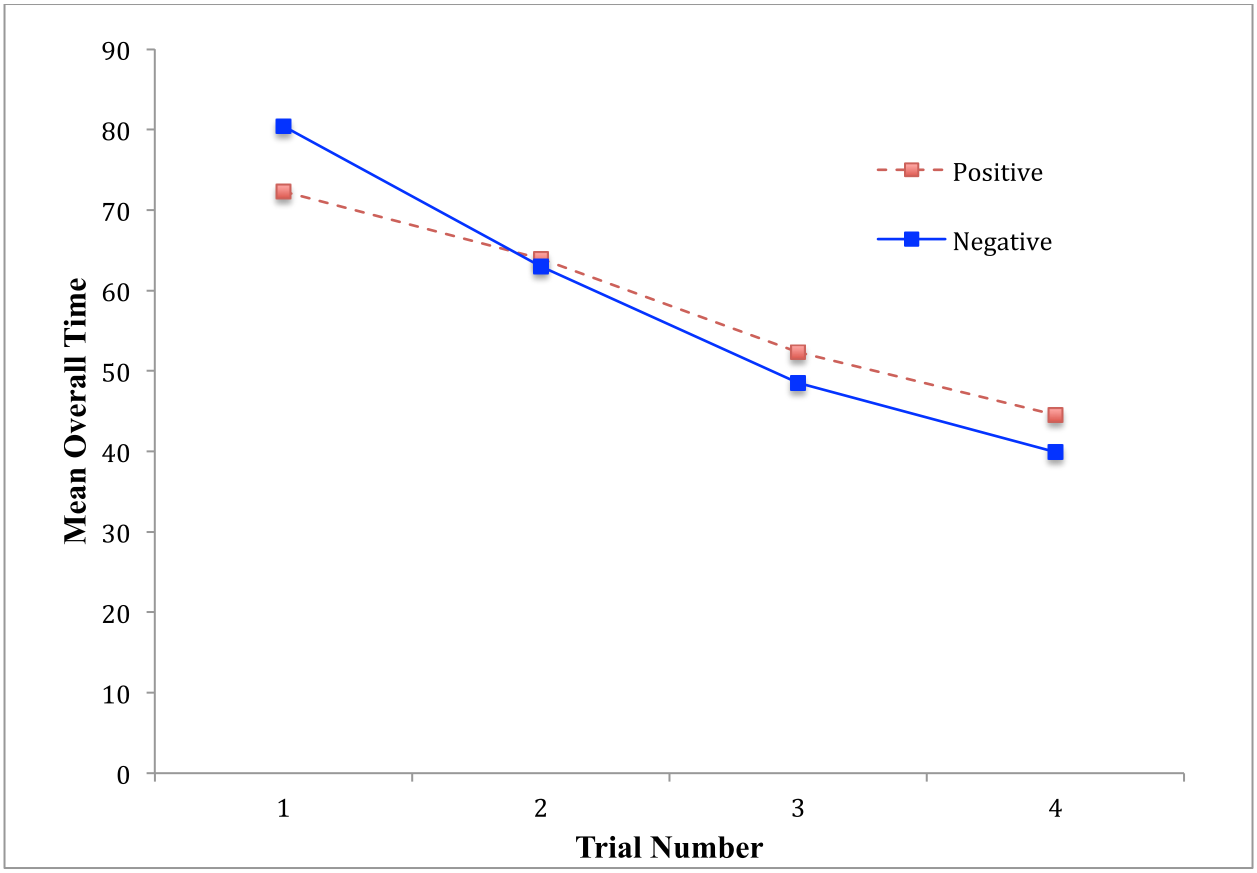

Figure 1. Average overall completion time for each trial as a function of type of landmark for the male participants.

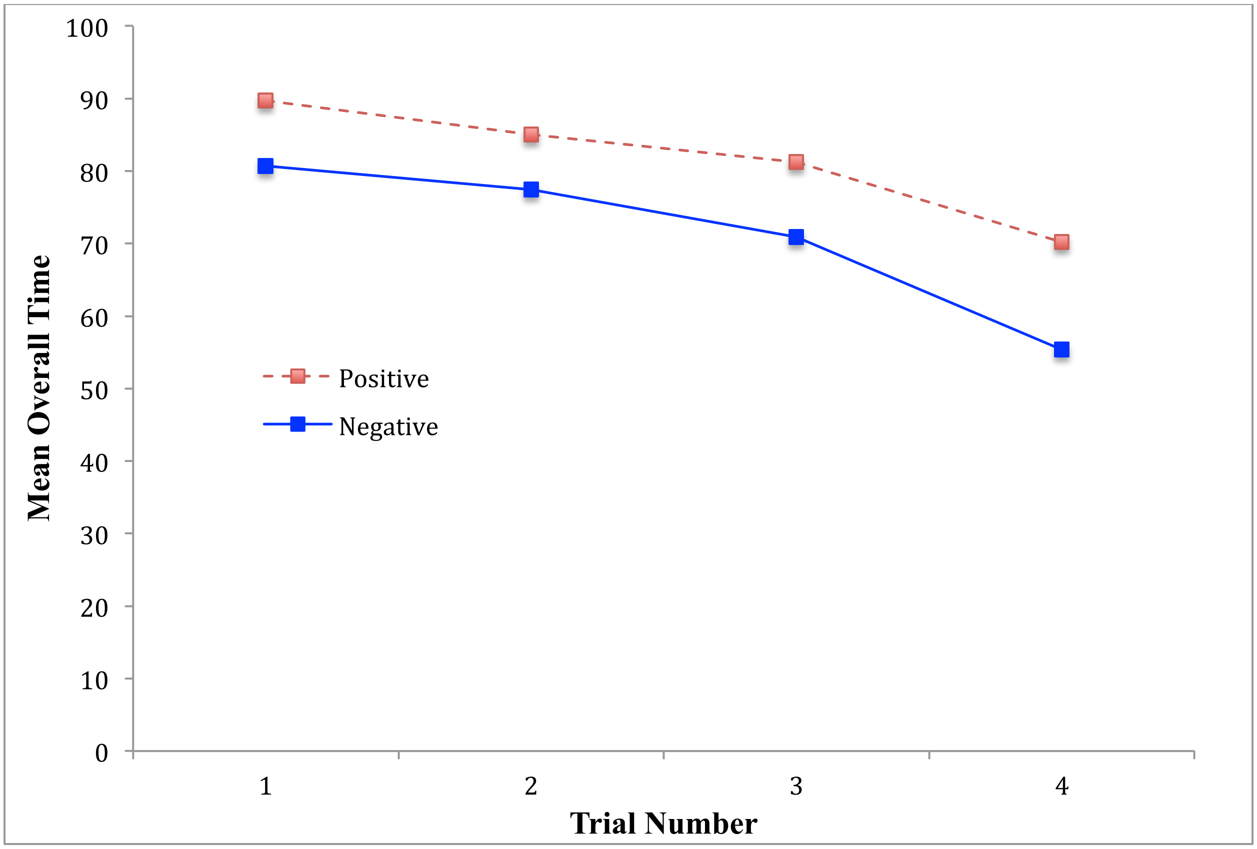

Figure 2. Average overall completion time for each trial as a function of type of landmark for the female participants.

Both males and females also increased their velocity of movement (or speed) across trials for both landmark types (see Figures 3 and 4). Males displayed no difference in velocity when exposed to either positive or negative landmarks (Figure 3), while females seemed faster when exposed to negative landmarks (Figure 4). These observations were analyzed with a 2 x 2 x 4 ANOVA (similar to the one for overall completion time). This ANOVA revealed a main effect for trial, F (3,168) = 14.79, $p < .05$, such that participant speed increased for each trial. This ANOVA also revealed a main effect for sex, F (1, 56) = 16.45, $p < .05$, such that males were significantly faster at completing the maze task. No main effect for landmark type was observed, F (1,56) = .82, $p = .37$, although the ANOVA revealed a significant interaction between landmark type and sex, F (1, 56) = 4.35, $p < .05$, such that one gender performed better with a specific landmark type compared to the other. No interactions were observed between trial and landmark type, trial and sex, and trial, landmark type and sex (F (3,168) = .45, p = .72, F (3,168) = .37, p = .77, and F (3,168) = .16, p = .93).

In order to determine the reason for the gender by landmark type interaction, two 2 (Landmark type) x 4 (Trial) ANOVAs, one for males and one for females, were completed for velocity. A main effect for trial was observed for both males (F (3, 75) = 7.16, $p < .05$) and females (F (3, 93) = 8.15, $p < .05$), such that velocity increased across the four trials. The female ANOVA also revealed a main effect for landmark type, F (1, 31) = 4.36, $p < .05$, such that females completed the mazes with negative landmarks faster. No main effect for landmark type was observed for males. Neither females nor males revealed a significant trial and type interaction.

To determine whether or not a similar pattern was also observed for the overall completion times, two 2 x 4 ANOVAs were also completed using completion times as the dependent variable. These ANOVAs revealed a main effect for trial for both males (F (3, 75) = 21,34, $p < .05$) and females (F (3, 93) = 16.17, $p < .05$), such that overall time decreased across trials. A main effect for landmark type was observed for females, F (1, 31) = 5.49, p < .05, such that females exposed to negative landmarks completed the maze task faster. No main effect of landmark type was observed for males. There was also no significant interaction between trial and type for either males or females. Therefore, negative landmarks positively effected female navigation; females completed the maze task faster, and moved about the maze more efficiently when exposed to negative landmarks.

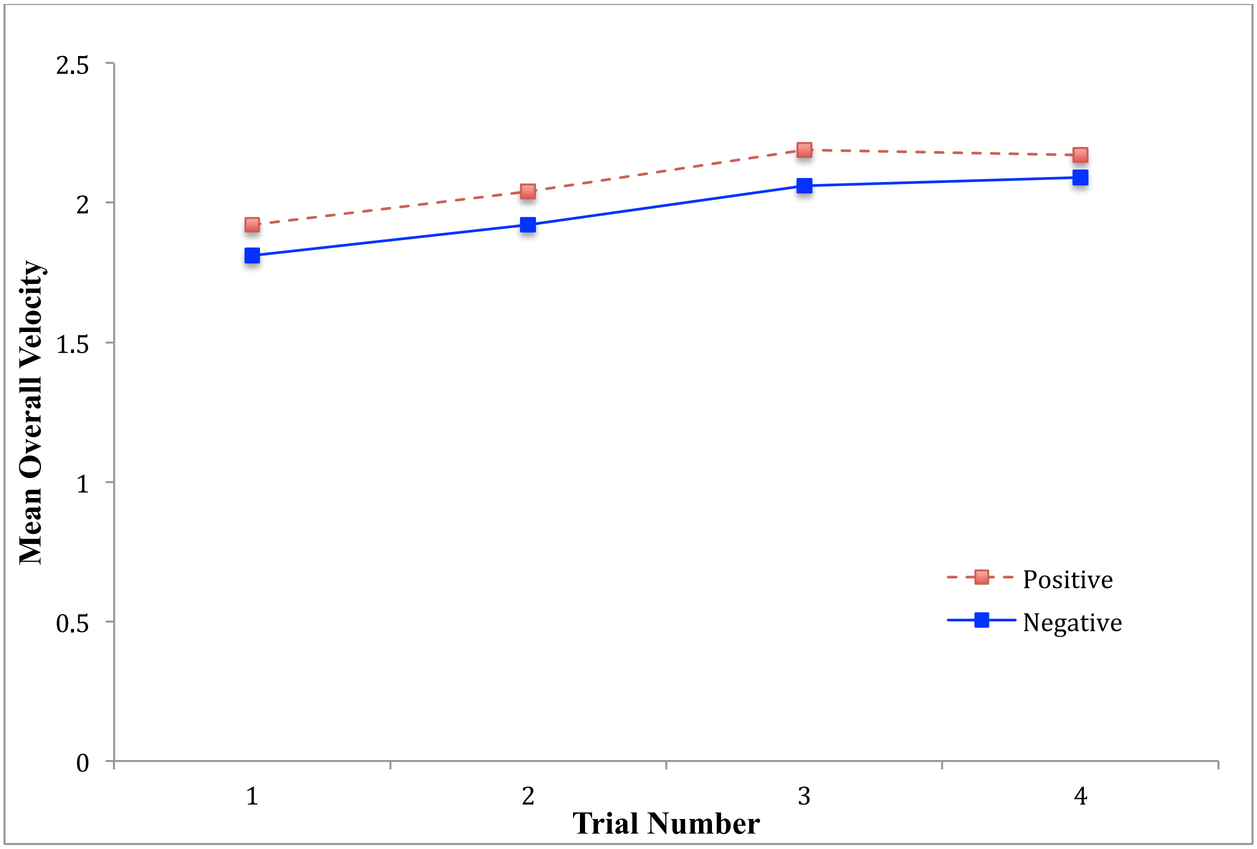

Figure 3. Average velocity for each trial as a function of type of landmark for the male participants.

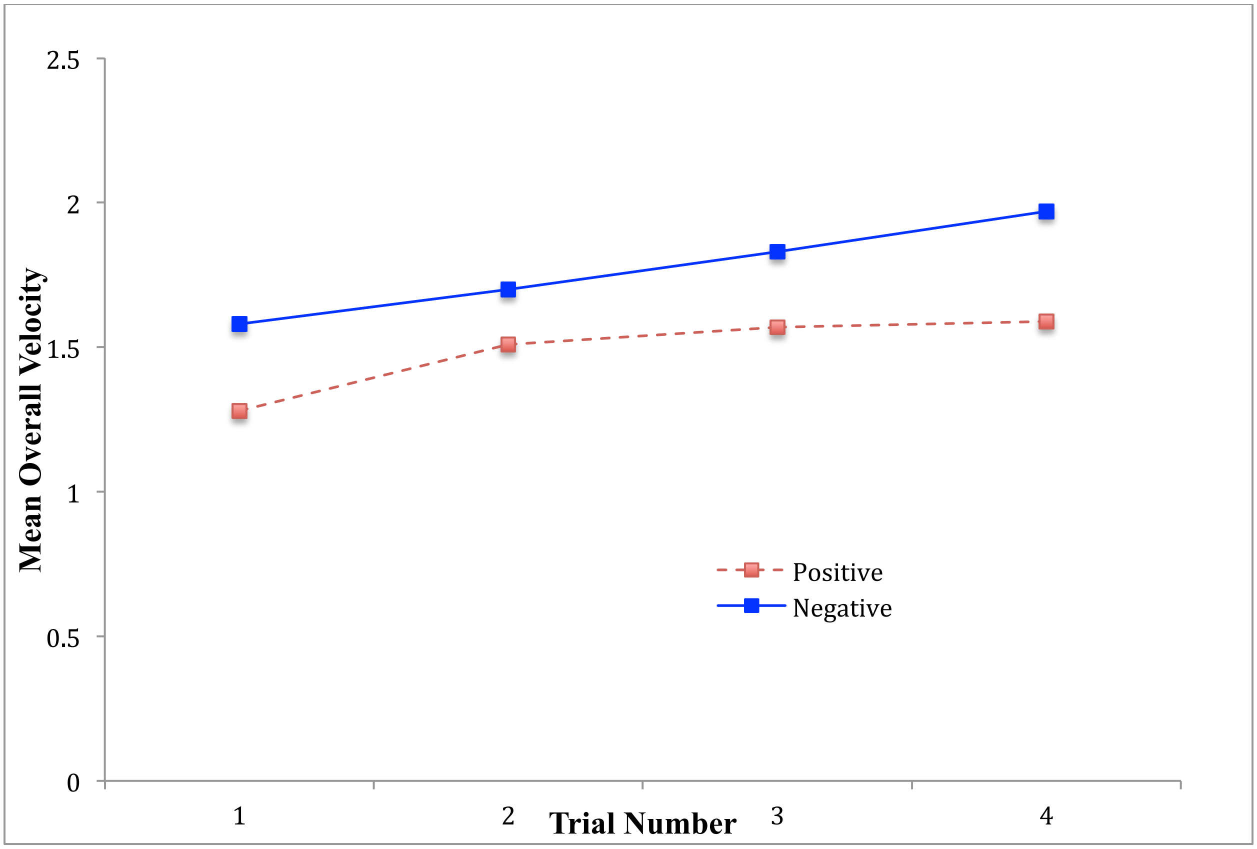

Figure 4. Average velocity for each trial as a function of type of landmark for the female participants.

Discussion

The goal the current study was to investigate how emotional landmarks effect navigation. Contrary to the hypothesis, neither males nor females utilized positive landmarks more effectively or efficiently than negative landmarks. Instead, females were better able to utilize negative landmarks while navigating. Therefore, females traveled faster and more efficiently in the virtual reality maze environments that consisted of negative pictures. Males showed impartiality towards positive or negative landmarks in the maze environments-- no difference in navigational ability was observed for males when exposed to either type of landmark. These results illustrate that navigational ability in females increases when they are exposed to undesirable or adverse landmarks.

Although prior research indicated that females navigate better than males in landmark-based environments (Barkley & Gabriel, 2007 & Saucier, et. al., 2002), this was not replicated in the current study. Overall males performed better on the landmark-based virtual reality mazes for both conditions compared to females. The virtual environment in the present study was designed to be real-world applicable. Despite the efforts to design a realistic setting, the maze resembled a video game or computer game environment. In general, males spend more time playing video games than females (Terlecki, et al., 2011). Therefore males that participated in the current study may have had past experience with video and computer games, which could have given them an advantage in the maze environment. For instance, the male participants could have been more experienced in how to navigate through virtual environments, allowing them to navigate through the maze with very little difficulty. For this reason, the use of landmarks to successfully navigate in the maze environment may not have been as necessary, leading them to do equally well in both the positive and negative environments.

An alternative reason why males were not affected by the object landmarks in the virtual maze is the presence of structural landmarks. According to Stankiewicz and Kalia (2007), structural features are more effective landmarks than object landmarks. In their study, participants navigated through an environment that contained both structural and object landmarks. Their results displayed that individuals are more likely to encode, remember, and utilize structural landmarks than object landmarks (Stankiewicz & Kalia, 2007). In the current study, males showed no difference in navigational ability when exposed to either type of emotional landmark. Therefore, instead of employing the picture landmarks, the male participants could have used the structural features of the virtual reality environment to aid in their navigation. Furthermore, extensive experience with video games may have allowed more of the males to notice and use small structural differences throughout the maze that females failed to notice.

Though males performed better in the landmark-based virtual reality maze, prior research states that males and females may prefer different types of visual cues during navigation (Barkley & Gabriel, 2007). Generally, males favor distal indistinct cues that are useful in Euclidean directions, while females prefer defined pinpoint cues that are typically described as landmarks (Barkley & Gabriel, 2007). The picture landmarks in the current study were chosen based on pleasantness, arousal, and dominance ratings (Lang, Bradley, & Cuthbert, 2008). Since the emotional connotation of the picture landmarks took precedence in the current study, the physical quality of the pictures was not a critical aspect while designing the virtual reality maze. Therefore, many different pictures, containing both distal indistinct and defined pinpoint cues, were chosen to act as landmarks along the maze. These physical features of the pictures may have affected how male or female participants utilized the landmarks and whether or not they noticed their location.

While the different features of the picture landmarks are important in determining the meaning of the current results, the purpose of the present study was to determine the role of emotional landmarks in navigational decisions. These results indicate that females showed an advantage for landmarks with negative emotional connotations. Previous research has indicated that females are superior at recognizing and understanding emotional differences than males (Hall, 1978 & Hampson, van Anders, & Mullin, 2006). Prior to 1976, research speculated that female ability in recognizing emotion, particularly negative or threatening emotions, was an evolutionary phenomenon (Hall, 1978). According to Hall, females were more sensitive to emotional cues, whether they were auditory or visual (i.e. facial) (1978). More recently, Hampson, van Anders, and Mullin (2006), tested to see if they could support this evolutionary theory. The notion that female ability in identifying facial emotional cues has evolved is based on sex differences in child rearing (Hampson, van Anders, & Mullin, 2006). Because females are more attentive to their infants in order to promote “attachment promotion” (Ainsworth, 1979; Hall, Lam, & Perlmutter, 1986, as cited in Hampson, van Anders, & Mullin, 2006), meaning mothers are more likely to respond to infant signals so their child can receive a secure and healthy upbringing, they have become more advanced in recognizing emotional facial expressions. Additionally, this finding has been observed more prominently for negative emotions than positive emotions, because adverse emotions are more likely to illicit feelings of protectiveness (Hampson, van Anders & Mullin, 2006).

Although facial cues are not utilized as landmarks in the environment, it is possible that the emotion recognition advantage for females may transfer to objects and structures used as landmarks. Since females are more responsive towards negative emotions, the adverse characteristics of the negative landmarks in the current study may have invoked a meaningful reaction. Therefore, these landmarks may have influenced females to move faster, as well as, more effectively and efficiently around the negative mazes. While the PANAS scores indicated that the positive and negative landmarks had little effect on the emotions of the participants, a possible explanation for this result is that these landmarks evoked a feeling of protectiveness (an emotion that may not have been evaluated by the PANAS). However, instead of causing females to avoid these landmarks, it may have triggered them to use the negative landmarks in the most efficient manner in order to reach their destination point quicker. According to Stankiewicz and Kalia (2007), an effective landmark is one that is persistent, perceptually salient, and informative. The current study indicates that the emotional quality of landmarks may also influence an individual's navigational ability.

One other aspect of the current study that should be mentioned is that the participants explored a virtual reality environment that was quite different from real environments. Therefore, the findings of the current study may not be transferrable to a real-world environment. All environments contain different sounds, smells, and other sensory characteristics that were not present in the virtual reality environment. Consequently, it is difficult to determine how the findings of the current study would apply to natural environments. So, no statements can be made about how negative landmarks will affect females in natural environments.

The current study provides new information about decision making in human navigation. This research gives insight on how emotional aspects of the environment shape human locomotion and wayfinding. In the current study, females performed better on a virtual reality navigational task when exposed to negative landmarks. Future research should attempt to isolate the factors that make negative landmarks beneficial for female navigation and why these factors are not beneficial to males.

References

Ayaz, H., Allen, S. L., Platek, S. M., & Onaral, B. (2008). Maze suite 1.0: A complete set of tools to prepare, present, and analyze navigational and spatial cognitive neuroscience experiments. *Behavior Research Methods, 40*(1). 353- 359. doi: 10.3758/BRM.40.1.353

Barkley, C. L., & Gabriel, K. I. (2007). Sex differences in cue perception in a visual scene: Investigation of cue type. *Behavioral Neuroscience, 121*(2), 291-300. doi: 10.1037/0735-7044.121.2.291.

Berthoz, A., Viaud- Delmon, I., & Lambrey, S. (2002). Spatial memory during navigation: what is being stored, maps or movements? In Galaburda, A. M., Kosslyn, S. M., & Christen, Y. (Eds.), *The Languages of the brain* (pp. 288-303). Cambridge: Harvard University Press.

Cassotti, M., Habib, M., Poirel, N., Aïte, A., Houdé, & Moutier, S. (2010). Positive emotional context eliminates the framing effect in decision- making. *Emotion,* 1-6. doi: 10.1037/a0026788.

Chuang, S. C., & Lin, H. M. (2007). The effect of induced positive and negative emotion and openness-to-feeling in student's consumer decision making. *Journal of Business and Psychology, 22*, 65-78. doi: 10.1007/s10869-007-9049-6.

Dudchenko, P. A. (2010). *Why people get lost: The psychology and neuroscience of spatial cognition.* New York: Oxford University Press.

Hall, J. A. (1978). Gender effects in decoding nonverbal cues. *Psychological Bulletin, 85*(4), 845-857.

Hampson, E., van Anders, S. M., & Mullin, L. I. (2006). A female advantage in the recognition of emotional facial expressions: test of an evolutionary hypothesis. *Evolution and Human Behavior, 27*, 401-416. doi: 10.1016/j.evolhumbehav.2006.05.002.

Iaria, G., Fox, C. J., Chen, J. K., Petrides, M., & Barton, J. J. S. (2008). Detection of unexpected events during spatial navigation in humans: bottom-up attentional system and neural mechanisms. *European Journal of Neuroscience, 27*, 1017-1025. doi: 10.1111/j.1460-9568.2008.06060.x.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (2008). International affective picture system (IAPS): Affective ratings of pictures and instruction manual. Technical Report A-8. University of Florida, Gainesville, FL.

Mikels, J. A., Maglio, S. J., Reed, A. E., & Kaplowitz, L. J. (2011). Should I go with my gut? Investigating the benefits of emotion focused decision making. *Emotion, 11*(4), 743-753. doi: 10.1037/a0023986.

Montello, D. R. (2005). Navigation. In P. Shah & A. Miyake (Eds.), *The Cambridge handbook of visuospatial thinking* (pp. 257- 289). New York: Cambridge University Press.

Saucier, D. M., Green, S. M., Leason, J., MacFadden, A., Bell, S., & Elias, L. J. (2002). Are sex differences in navigation caused by sexually dimorphic strategies of by differences in the ability to use the strategies? *Behavioral Neuroscience, 116*(3), 403- 410. doi: 10.1037/0735-7044.116.3.403.

Stankiewicz, B. J., & Kalia, A. A. (2007). Acquisition of structural versus object landmark knowledge. *Journal of Experimental Psychology, 33*(2), 378- 390. doi: 10.1037/0096-1523.33.2.378.

Terlecki, M., Brown, J., Harner-Steciw, H., Irvin-Hannum, J., Marchett-Ryan, N., Ruhl, L., & Wiggins, J. (2011). Sex differences and similarities in video game experiences, preferences, and self-efficacy: Implications for the gaming industry. *Current Psychology, 30*, 22-33. doi: 10.1007/s12144-010-9095-5.

Thomas, K. G. F., Laurance, H. E., Nadel, L., & Jacobs, W. J. (2010). Stress- induced impairment of spatial navigation in females. *Psychological Society of South Africa, 40*(1), 32-43.

Appendix

Are you male/ female?

How old are you?

Can you guess the purpose of this study?

This scale consists of a number that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

__ interested

__ distressed

__ excited

__ upset

__ strong

__ guilty

__ scared

__ hostile

__ enthusiastic

__ proud

__ irritable

__ alert

__ ashamed

__ inspired

__ nervous

__ determined

__ attentive

__ jittery

__ active

__ afraid