INVESTIGATING THE EFFECTS OF ENGAGING IN INTERACTIVE FICTION ON PLAYERS' SPATIAL ABILITIES

A Thesis

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

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August 2017

Major Subject: Visualization

ABSTRACT

Text-based interactive fiction games require a player to navigate through an environment without visual input. Research has been done in the areas of spatial cognition to improve spatial ability test scores, however, interactive fiction has not previously been examined as a means to improve spatial ability. This thesis investigates the effects of engaging in interactive fiction on players' spatial abilities. Nine interactive fiction games were developed based on 3 fairy tale stories with 3 levels of difficulty each. A between-subjects study was conducted over 3 days with 20 participants in the experimental group and 8 in the control group. Both groups took spatial ability measures at the beginning and end of the study, but only the experimental group participated in the interactive fiction game intervention. Qualitative and quantitative data was collected. The results deepen our understanding about whether interactive fiction may function as an effective intervention to affect spatial abilities, as well as about spatial strategies that players use to engage in interactive fiction. The results have implications for the design and use of interactive fiction for purposes other than entertainment, such as education and training.

CONTRIBUTORS AND FUNDING SOURCES

Contributors

This work was supervised and supported by a thesis committee consisting of Professor Sharon Lynn Chu and Professor Jinsil Hwaryoung Seo of the Department of Visualization and Professor Frank Shipman of the Department of Computer Science.

All work for this thesis was completed independently by the student.

Funding Sources

There are no outside funding contributions to acknowledge related to the research and compilation of this document.

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1. INTRODUCTION

1.1 Introduction

This thesis investigates spatial understanding in text-based interactive fiction (IF) games and the potential role of these games as training interventions for improving spatial abilities of players. Although the taxonomy of spatial cognition has been applied to other visual virtual environments (VE) such as virtual reality, the cognitive requirements and design guidelines for spatial navigation in text-based environments such as interactive fiction have not yet been examined on an empirical basis. The need for navigational and spatial guidelines exists because "many VEs require the user to navigate, navigation in VEs is difficult, and disorientation is upsetting." (Vinson, 1999). This is especially true of IF, in which there is no visual input to aid users as they traverse through the game space. This thesis aims to investigate how users understand space within the context of IF and whether experience with IF games can function as training for spatial ability, as well as content understanding. We will examine the results in terms of their implications for whether training in IF and learning spatial strategies can lead to improved spatial cognition abilities.

This thesis consists of 6 sections: Introduction, Background, Methodology, Data Analysis and Result, Discussion, and Conclusion. The background section will contain a literature review related to interactive fiction and spatial cognition. Previous research dealing with using interventions to improve spatial cognition will also be discussed. The

Methodology section describes the study design, measures, and materials, including the creation of the interactive fiction games used in the study. The Data Analysis and Results section presents the analysis of qualitative and quantitative data obtained, while the Discussion section goes into more detail about the significance of the results. Finally, the Conclusion section presents a summary of the thesis, describes study limitations, and makes recommendations for potential future work.

1.2 Objectives and Research Questions

The objectives of this thesis are related to spatial cognition and interactive fiction and the following research questions:

1. Does engaging in interactive fiction games increase spatial ability?
2. Does engaging in progressively harder interactive fiction games increase spatial ability?
3. What types of spatial encoding strategies do people use to engage in interactive fiction?
4. What are the effects of engaging in interactive fiction on story understanding?

The goals of this thesis were to: 1) investigate the effects of interactive fiction on spatial ability test scores through an empirical study; 2) examine the types of spatial encoding strategies players utilize in IF; and 3) explore the effects of engaging in interactive fiction on content understanding and familiarity. For our study, interactive fiction games of 3 different difficulty levels were developed based on the stories of Cinderella, Little Red Riding Hood, and Beauty and the Beast. Participants played 6 of these games over the course of a 3-day intervention. Their spatial ability test scores were measured both pre- and post-intervention, and a post-study interview was also conducted. Qualitative and quantitative results are presented and discussed in this thesis.

2. BACKGROUND

2.1 Interactive Fiction

Sometimes referred to as "text adventures," this genre of game generally takes the form of text-based narrative stories in which the player assumes the role of a character and interacts with a virtual world. Parser-based interactive fiction games have been in existence since the release of the game *Adventure* in the mid-1970s, although the term "interactive fiction" was not commonly used until the 1980s (Maher, 2006). In parser-based IF, this is done through the typing of text commands. A flexible natural language-parser is an algorithm utilized to translate this entered textual input into commands that update the status of the game and provides the relevant updated output to the player in the form of a written description (Maher, 2006). Commands such as 'go north' can be used to navigate, while other commands like 'pick up key' allow players to interact with objects in the story by examining, taking, leaving, or using them.

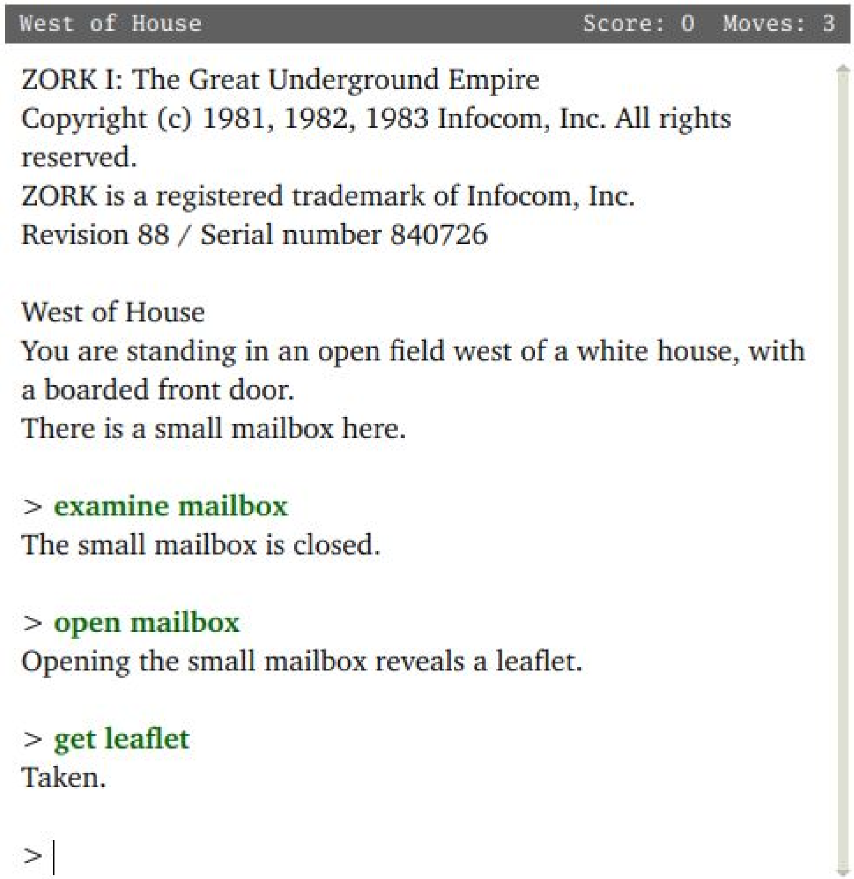

Figure 2.1. *Example screenshot from parser-based IF Zork I*

Interactive fiction can also contain elements of puzzle solving, exploring the virtual environment (made up of "rooms"), or conversing with other characters within the story. In most cases players also have an inventory, and are allowed to pick up game objects and carry them around with them. Events in the game can be triggered by various means. Completing objectives such as speaking to characters or solving puzzles can cause the story to progress. IF games are finished either when the player makes some fatal error and “loses” the game by being unable to continue any further, or when a player “wins” by completing all objectives and traversing through the central events in a strand of the story. In many instances, winning is defined as reaching a favorable outcome in the story, such as being triumphant in a final encounter (for example, a battle). Losing frequently means the player did not achieve a favorable outcome, and in many cases, the game ends with the death of the player’s character.

Although this thesis will mainly focus on parser-based IF, other forms of interactive fiction such as Choose Your Own Adventure (CYOA) and hypertext games also exist. Unlike parser-based IF, which have a more “open world” setup in which players are free to explore and interact with the game in any way they wish, regardless whether or not it will advance the story, CYOA games are much more close-ended. In a manner similar to the types of books of the same name, text-based Choose Your Own Adventure games provide the player with the text of a story before presenting them with a multiple choice option for how they will respond.

Figure 2.2. *Screenshot from Pendragon Rising CYOA by Ian Thomas*

Hypertext IFs are similar to CYOA in that they are choice-based, however, the options are presented differently. Instead of being offered at the end of each section of story text, words within the story text in hypertext IFs can be clicked on. Doing so can either provide the player with more information, such as a description, about the word they clicked on, or further the plot by making a story choice such as in CYOA IFs.

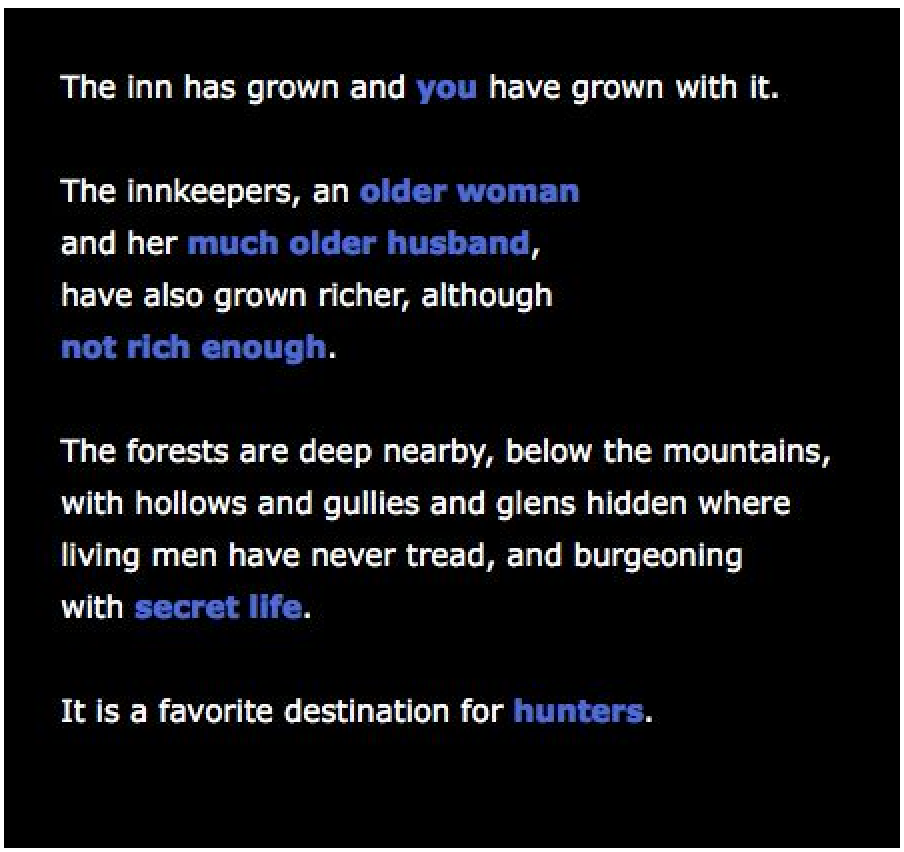

Figure 2.3. *Screenshot from Hunting Unicorn hypertext IF by Chandler Groover*

One of the distinctive features of interactive fiction is that it allows players to be active participants in creating the story. In these types of games, the player functions not just as a reader, but also as a co-author of the story, since their decisions determine the outcome as well as the path taken to reach it. Due to their interactive nature, IFs also usually have many possibilities for choices to make within the story that lead to a variety of different story endings. Because each playthrough can be completely different, the genre naturally invites replaying or rereading in order to find closure or examine other possible outcomes, or to get a more complete picture of the story (Mitchell & McGee, 2012).

The element of interactivity found in games such as IF also lends itself to applications other than rereading. Writing about the potential educational applications afforded by the feature of interactivity in games, Roussou (2004) states that "a strong connection binds interactivity, engagement, and learning," while the work of Malone and Lepper (1987) presents games as providers of intrinsic motivation by facilitating learning through fun. This has been shown to be applicable to IF in a study whose results showed that the students met several educational learning objectives after playing through interactive fiction games (Koenitz, 2015, p. 200). In this study, children played through IF games in order to learn about health issues such as cross-contamination and how viruses are spread by playing through the games as a detective solving a mystery. Players had to question other characters, look for clues, and come to a conclusion based on evidence they gathered about what happened. The learning objectives were embedded into the story and game experience, and players showed an overall improvement in understanding of these learning objectives from pre-study to post-study.

Modern IFs are expected to follow what has become known as the "Player's Bill of Rights." This is a set of guidelines laid out by Nelson (1994) to inform fair, well-designed IF and ensure a high standard of game for players. In it, he states that "a fine line between a challenge and a nuisance: the designer has to think, first and foremost, like a player (not an author, and certainly not a programmer.)" He also notes that IFs "intentionally annoy the player most of the time" (Nelson, 1994). Before these guidelines were developed, early parser-based IFs could prove to be frustrating for users. Aspects of the game would be too difficult or events, such as player death, would appear to happen inexplicably. Some games are intentionally designed to defy one or more of these rules for a specific reason, for example, *9:05* by Adam Cadre (2000). In this game, the player has received a call that they are late for an important meeting and they need to shower, get dressed, and eat breakfast before rushing out of the house. It requires more commands and more specific commands than most other standard IFs, for example, requiring a player to get out of bed before allowing them to move around. This creates a deliberate sense of being disoriented or hurried while being forced to deal with obstacles posed by everyday minutiae such as when one is running late in real life (Douglass, 2007). Nelson's 17 tenets are outlined below:

1. Not to be killed without warning
2. Not to be given horribly unclear hints
3. To be able to win without experience of past lives
4. To be able to win without knowledge of future events

5. Not to have the game closed off without warning
6. Not to need to do unlikely things
7. Not to need to do boring things for the sake of it
8. Not to have to type exactly the right verb
9. To be allowed reasonable synonyms
10. To have a decent parser
11. To have reasonable freedom of action
12. Not to depend much on luck
13. To be able to understand a problem once it is solved
14. Not to be given too many red herrings
15. To have a good reason why something is impossible
16. Not to need to be American
17. To know how the game is getting on

While the Player's Bill of Rights provides guidelines for fair, well-designed games, the Interactive Fiction Cruelty Scale (Plotkin, 1996) provides a measure of how easy or difficult it is for a player to progress past obstacles. Its main criteria are: whether it is possible for the game to reach an unwinnable state, and when (if ever) the player finds out that the game has reached an unwinnable state. These ratings can often serve as guides to the player for how often they should be saving their game, in case they need to restore an earlier version in the event of the game becoming unwinnable. The five possible ratings on the Cruelty Scale are: merciful, polite, tough, nasty, and cruel. More information about the ratings are detailed in Table 2.1 below.

Rating	Description
Merciful	Game cannot become unwinnable.
Polite	Game can become unwinnable, but player is aware of it and can use undo to go back to a winnable state.
Tough	Game can become unwinnable, but player usually has some kind of warning before it does. Undo cannot be used to go back to a winnable state, but previous save files can.
Nasty	Game can become unwinnable abruptly, but player is aware of it if it does. Undo cannot be used to go back to a winnable state, but previous save files can.
Cruel	Game can become abruptly unwinnable without the player being aware of it, and undo cannot be used to go back to a winnable state. Previous save files may or may not be able to return the game to a winnable state, and player may have to restart the game.

Table 2.1. *Cruelty Scale for Interactive Fiction*

2.2 Spatial Cognition

Before discussing them within the context of IF, we will first cover some background information about spatial cognition, spatial ability measures, and spatial cognition interventions.

2.2.1 Spatial Knowledge and Navigation

Spatial knowledge used for navigation can be classified into three categories: landmark knowledge, route knowledge, and survey knowledge (Siegel & White, 1975). Landmark knowledge deals with memorable objects that serve as static points of reference, such as a tree or a building. Route knowledge is egocentric and relates to information about the sequential order of locations and corresponding actions when traveling from one point in an environment to another. It relies heavily upon landmarks since landmarks serve as the cues for navigational actions. An example would be turning right at the tree or going left at the house. The final category is survey knowledge. It is similar to a cohesive map put together from a variety of sources (which can include route knowledge) and includes more information about spatial properties (such as distance.) In this model, the navigator can alter his or her perspective based on what is most useful for the task at hand. Spatial navigation within the context of virtual environments can also be classified into landmark knowledge, route knowledge, and survey knowledge because evidence suggests that “the way in which we navigate is the same whether the environment is virtual or real” (Vinson, 1999).

Although sometimes described as “cognitive maps”, constructivist views of spatial knowledge prefer to categorize the mental representations of this knowledge into cognitive collages and spatial mental maps (Tversky, 1993). Both of these spatial mental representations include knowledge a person has about spatial relations. Such knowledge can be gained through a variety of means, including visiting a place in person or learning about it from language, such as in the form of a written or spoken description. Some of the distinctions between the two representations are that spatial mental maps preserve spatial information more accurately and allow for perspective shifts while cognitive collages are less map-like, and are made up of varied pieces of disparate (and not necessarily visual) knowledge that may not form easily into a cohesive whole (Tversky, 1993). This can sometimes cause spatial distortions if the collage contains inaccurate information.

Despite the fact that frames of reference for environments can also cause distortions, they can also help organize spatial elements such as by helping locate or orient elements within an environment, or by combining different spaces into one (Tversky, 2000). Hierarchical organization is one example of this. In this frame of reference, different spatial entities are contained within others, the way a room is located inside of a house, which is located inside of a city that is located inside of a state. Both distance and direction distortions have been found to occur because of this, for example, the relative locations of cities may be distorted based on the state in which they are located. This is supported by a study in which the responses of a large number of students in San Diego replied that they thought San Diego was west of Reno, possibly due to the fact that the state of California is on the west coast, while Nevada is located inland (Albert & Coupe, 1978).

2.2.2 Spatial Ability Measures

There is a wide variety of tests designed to measure different aspects of spatial ability. The first spatial ability measure that will be discussed in this thesis is a self-reported sense of direction scale known as the Santa Barbara Sense of Direction Scale (SBSOD) developed by Hegarty et al. (2002). This test consists of 15 one to seven point Likert scale items that ask the participant to rank their spatial abilities based on statements such as “I am very good at giving directions.” Similar self-reported measures have been shown to accurately predict a subject’s geographical orientation and environmental spatial ability (Bryant, 1982). The SBSOD has been shown to be accurate in measuring sense of direction “related to tasks that require one to update location in space as a result of self-motion” (Hegarty et al., 2002). Although somewhat more highly correlated with spatial knowledge gained through experience in the physical world, it has also been applied to virtual environments (Hegarty et al., 2002). In our study, we make use of the original SBSOD as well as a version adapted for IF.

The Manual for Kit of Factor-Referenced Cognitive Tests presents other types of spatial ability measures. The manual presents tests that are intended for research purposes in identifying certain aptitude factors. The spatial ability measures are described in the Spatial Orientation section. Spatial orientation within the test is defined as “The ability to perceive spatial patterns or to maintain orientation with respect to objects in space” (Ekstrom et al., 1976). The tests apply spatial ability mainly to mental rotations of images configurations.

The first of the spatial ability tests is the Card Rotations test. This test was inspired by Thurstone’s Cards (Thurstone, 1950) and can be classified as cognition of figural transformations in the structure-of-intellect ability (Guilford, 1972). In it, participants are given a limited amount of time to identify whether variations of irregular shapes are rotated or reflected. The second test is the Cube Comparisons test. This test was inspired by Thurstone’s Cubes (Thurstone, 1950) and can be classified as cognition of figural systems in the structure-of-intellect ability (Guilford, 1972). In it, participants are given a limited amount of time to decide whether images of cube pairs can be of the same cube, assuming that cubes can have no two faces alike.

2.2.3 Spatial Cognition Interventions

Previous research has been done in the area of of trying to improve scores on spatial ability tests using various intervention methods. Gittler and Glück (1998) examined the effect of taking courses in Descriptive Geometry on students' Three-Dimensional Cube Test scores. Participants took the initial Three-Dimensional Cube test and were retested 2 years later, after being enrolled in Descriptive Geometry classes. The study results suggested that experience with Descriptive Geometry had a significant effect on spatial ability test scores (Gittler & Glück, 1998). Additionally, the results showed that changes in spatial ability test scores from pre- to post-intervention were equal for both male and female participants.

Osberg (1997) investigated the effect of experiencing virtual environments on the spatial processing skills and cognitive development of children. The focus of this study was to determine how thinking deeply about spatial concepts affects spatial cognition. Participants were tested pre-intervention on their spatial skills using "An Inventory of Piaget's Developmental Tasks," which includes sections on perspective and image transformation. Subjects then participated in interacting with a 3D virtual reality puzzle game over the course of 5 days. During this time, they were each instructed to create their own virtual world that would fit like a puzzle piece with those of the other students. After the intervention, participants then repeated the pre-intervention test and scored higher overall in the majority of sections. The results of the study support the hypothesis that training in 3D environments can help improve spatial cognition, although it was unable to pinpoint exactly which aspect of the intervention may have led to the improvements in spatial ability scores (Osberg, 1997).

2.3 Space and Spatial Cognition in Interactive Fiction

Space is an essential element in interactive fiction. Although IF takes place in an unseen virtual environment, it nevertheless requires players to navigate. Because of this, it is useful to have an understanding of spatial cognition as it applies to virtual environments.

2.3.1 Space and Navigation in IF

Space in IF is made up of "rooms." A "room" is a way to denote that an area is separate from others and can be either indoors or outdoors. A kitchen, a beach, or a village square could all be classified as rooms. A player may move from one room to another, but cannot "walk around" within one room. Objects and characters with whom the player may interact may be present inside a room. It is possible for rooms to be locked, in which case the player would need to find a key, solve a puzzle, or complete some other objective in order to gain access to it.

As was previously mentioned, players move throughout the environment in parser-based IF games by typing text commands such as "go north" or "go south." In most cases, IFs take place in a survey perspective, and descriptions include either 4 or 8 cardinal directions, and sometimes the ability to move up and down as well. Some IFs make use of nonconventional directions, such as "port," "starboard," "fore," and "aft," such as on a ship, or "widdershins" to mean counterclockwise. Despite the differences in terminology, the method and function of input and resulting output remains essentially the same. The text output of IF usually displays the name of the room where the player is currently located, a description of that room including objects contained within, and information about the direction of exits to other rooms.

The layout of rooms and their connections are not always simple, and the environment of many early IFs were laid out like a maze with asymmetrical exits, such as in Zork I. A player may go north from Room 1 to get to Room 2, but may need to go east to get back to Room 1 from room 2, for example, implying that the pathway between rooms is not straight. Distances between rooms are not always consistent either. This led many players of such games to explore the game environment and create their own hand drawn maps to help learn the layout (Maher, 2006). An example of such a map is provided in Figure 2.3 below, which has been reprinted with permission from its creator, John T. Mayer.

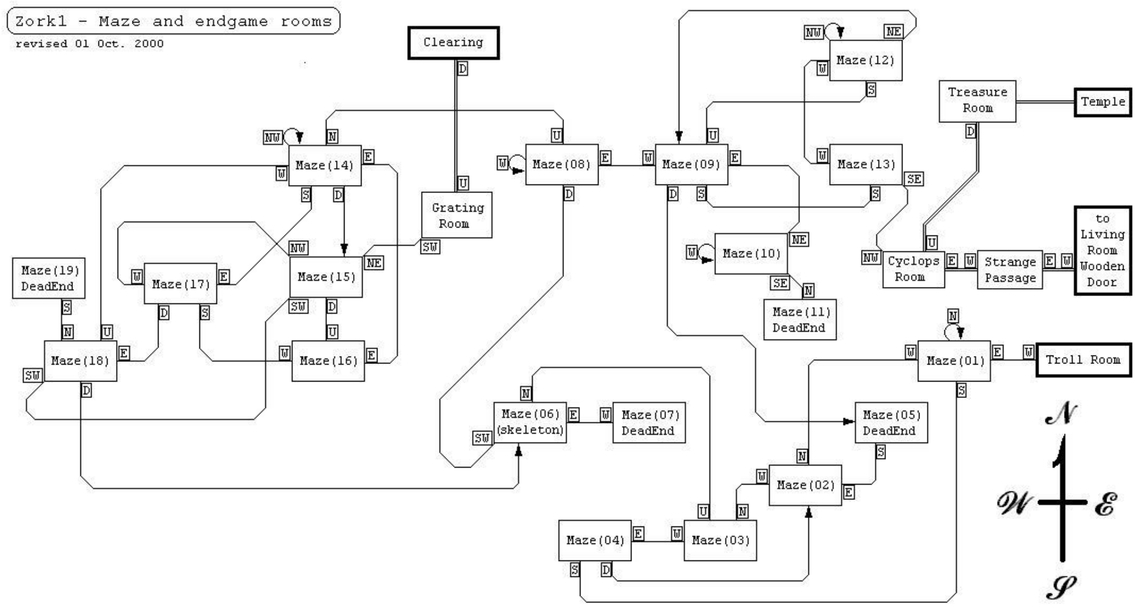

Figure 2.4. *Example map from parser-based IF Zork I**

2.3.2 Environment Design for IF Creators

There are several factors that interactive fiction creators should take into account when designing the spatial layout of games. Short, a prominent IF author, states in her guide to IF geography that having an environment than can be easily understood gives the player a greater sense of presence and immersion in the game (2007). She has developed a guide for designing navigable IF environments based on principles of playability, essentially assuming that the player's job is to explore the game world fully and deeply in a manner that flows naturally with the story and does not require spending too much mental energy on trivial tasks. (Short, 2007) A number of the guide's components pertain to designing comprehensible layouts which align with aiding the player in gaining landmark, route, and survey knowledge and developing a spatial mental model in a manner similar to that of the real world, despite the lack of any visual cues in IF. In terms of landmark knowledge, Short warns against having too many identical rooms since it would be easy to confuse them. Since landmarks in IF are provided either in the textual description of the room or the objects contained within, this could be avoided by ensuring that all rooms have unique descriptions or objects. In this way, a player can remember rooms by thinking of them as “the dusty room” or “the room with the mirror,” for example. Short also describes including a landmark that can be seen from multiple locations to help orient a player. This allows the player to think of rooms in terms of their spatial relation to the landmark rather than just in terms of other rooms. Other recommendations include utilizing hierarchical macroscopic geography by breaking up the map into areas larger than rooms but smaller than maps. Since space is often thought of in a hierarchical context (Tversky, 2000), a hierarchical structure in IF could help facilitate the generation of spatial mental models. Making use of multi-location rooms is similar to hierarchical organization in that it allows for the player to “effectively cluster several places under a single mental heading: four or five locations can all be mentally tagged ‘the plaza’, with the internal relationships of ‘North Plaza’, ‘West Plaza’, etc., being obvious enough not to need special memorization” (Short, 2007). For route knowledge, Short provides several examples for methods of creating memorable map topologies including using hubs, formal symmetry, and street map or hallway-style layouts.

2.3.3 Navigational Demand for IF Players

Due to the nature of the text-based format of interactive fiction, there is generally no visual input to aid a player with navigation as there is in the 3D virtual environments of other types of video games (the most recent Quest software does provide an option to have a map that updates as a player moves, however this is a relatively new setting.) Players gain knowledge about the geography and appearance of the game space through interaction with the IF and its textual output. Combining this element of spatial processing with the verbal processing necessary for using text commands to interact with the story creates a unique off-screen narrative experience for the player (Wolf, 1997). Barrett states that in works such as interactive fiction, space is "a governing principle for possibilities" (2015) and that players "rely on the spatial for both interactions and the meanings that result" (2015).

Previous research suggests that the element of interactivity in IF creates a navigational demand that is not present when one is simply reading a non-interactive story (Gander, 2004). Gander's study (2004) compared the differences in spatial understanding between participants who played through an interactive IF (players) compared to those who read a non-interactive version of the same story (readers). The research found that players "supplied longer, more elaborate verbal descriptions of spatiality of the game world" (Gander, 2004) and remembered spatial facts better. This provides evidence that players likely construct a mental map in order to navigate the game world in IF. This is further supported by the players mixing up the directions east and west. This could possibly be due to fact that east and west are often thought of in relative terms of left and right while north and south are absolute (Tversky et. al, 1999). Evidence for players forming mental models is also supported by the hierarchical organization of their descriptions of the space (Tversky, 2000). For example, despite the fact that rooms in IF are technically discrete, players described a town and the places in it, as well as a house and the rooms within it in the game *Anchorhead* (Gander, 2004). Although the established taxonomy of spatial cognition has previously been applied to other virtual environments, such as virtual reality (Gillner & Mallot, 1998), there remains a need for further investigation of the cognitive requirements for spatial navigation in interactive fiction.

This section has given some background context for what interactive fiction is, as well as a brief overview of spatial cognition, spatial ability tests, and interventions related to IF for improving spatial ability test scores. Additionally, space and navigation in interactive fiction have been addressed from both the view of a game creator and a game player. This section has also addressed spatial cognition in interactive fiction as well as the need for further research in this area. Gittler & Glück (1998) and Osberg (1997) showed that spatial ability can be improved with different methods of intervention. The work of Moffat et al. (1998) showed a correlation between performance on spatial ability measures and the ability to navigate a virtual maze, although this work did not address virtual navigational tasks as a means to improve spatial ability. Gander (2004) showed that players were most likely forming mental models of the game space to navigate as supported by the work of Tversky (2000), although he did not address the specific types of spatial encoding strategies used by IF players. Koenitz (2015) showed that engaging in interactive fiction can aid players in gaining knowledge and meeting learning objectives, however this was applied to health issues rather than story familiarity. To that end, the research questions being posed in this study are as follows:

1. Does engaging in interactive fiction games increase spatial ability?
2. Does engaging in progressively harder interactive fiction games increase spatial ability?
3. What types of spatial encoding strategies do people use to engage in interactive fiction?
4. What are the effects of engaging in interactive fiction on story understanding?

The next section will detail the methodology used in this study to investigate these research questions.

3. METHODOLOGY

3.1 Study Design

A between-subjects study was conducted to investigate our research questions.The independent variables were whether or not participants played the IF games and the spatial complexity of the IF game environments, defined by the number of rooms. This varied based on the level of difficulty of the game, with easy, medium, and hard versions having 6, 8, and 10 rooms, respectively. The dependent variables were spatial ability scores, perceived spatial ability scores, usability and enjoyment scores (for the IF games themselves), story familiarity, perceived story familiarity, and spatial encoding strategies.

3.2 Study Protocol

In this study, each participant came in person for two study sessions. During the first, they each completed a pre-study survey that included exercises meant to measure their spatial ability. Based on their performance on these spatial tests, participants were assigned to one of two categories: easy or medium. Participants in the "easy" category then played an interactive fiction game of easy difficulty, while participants in the "medium" category played an interactive fiction game of medium difficulty. Regardless of their category, participants completed a short interactive fiction tutorial before playing the game, and a post-IF questionnaire after playing the game. This questionnaire included spatial questions about the environment of the game they had just completed.

At the end of the first session, participants were given links to 5 additional interactive fiction games and asked to play them in order sometime before coming to the second session of the study three days later. The first 2 games were the same level of difficulty as the one they had played in the session, while the last 3 games were one level of difficulty higher (medium for the "easy" group and hard for the "medium" group.) After playing each of the 5 games, participants were asked to complete a post-IF questionnaire. The second session was scheduled for three days after the first. In the second session, participants took the post-study questionnaire and a post-study interview was conducted.

Activity	**Time**
Briefing/Introduction	5 minutes
Pre-Study Questionnaire	15 minutes
IF Tutorial	10 minutes
Interactive Fiction Game	15 mins
Post IF Questionnaire	10 minutes
Buffer time	10 minutes
Estimated total session time	~65 minutes

Table 3.1. *Estimated activity time for Session 1*

During the 3 days between Session 1 & Session 2, participants were given access to the study's other interactive fiction games and asked to play at their convenience. Participants completed the Post IF Questionnaire after each one. The number of IFs played and the amount of time spent participating in this portion of the study were dependent upon the individual participants.

Activity	Time
Debriefing & Interview	15 minutes
Buffer time	5 minutes
Estimated total session time	20 minutes

Table 3.2. *Estimated activity time for Session 2*

3.3 Study Participants

All participants were required to be at least 18 years of age and proficient in written English. Participants were recruited through the Texas A&M University bulk email system, as well as by word of mouth. Participants were registered on a first-come, first-served basis. The experimental group consisted of 20 participants. Ten were male and 10 were female. Twelve of the participants were undergraduate students, 5 were graduate students, and 3 were faculty or staff. Eleven were in the 18-22 age range, six were in the 23-27 range, and there was one participant each in the 28-32 range, the 33-37 range, and 43+ range. There were no participants in the 38-42 range.

The control group consisted of 8 participants. Three of the control group were male, and 5 were female. One of the control group participants was an undergraduate student, 4 were graduate students, and 3 were faculty or staff. One was in the 18-22 age range, five were in the 23-27 range, and two were in the 43+ range. There were no participants in the 28-32 range, 33-37 range, or the 38-42 range.

3.4 Study Materials

3.4.1 Creation of IFs

This study utilized three parser-based interactive fiction games, with three levels of difficulty each. All games were developed using the desktop version of the Quest 5.6.3. software. In order to minimize the variable of genre and story, all three IFs were fairy tales with which the average player will most likely be familiar in order to eliminate story complexity as a confound. The stories chosen were Little Red Riding Hood, Cinderella, and Beauty and the Beast. All three games were developed specifically for this study and were designed to be comparable in terms of their relatively short length, relative difficulty levels, linear story, spatial complexity, and navigation method in the game world. Game screenshots are included below, and transcripts can be found in Appendix A.

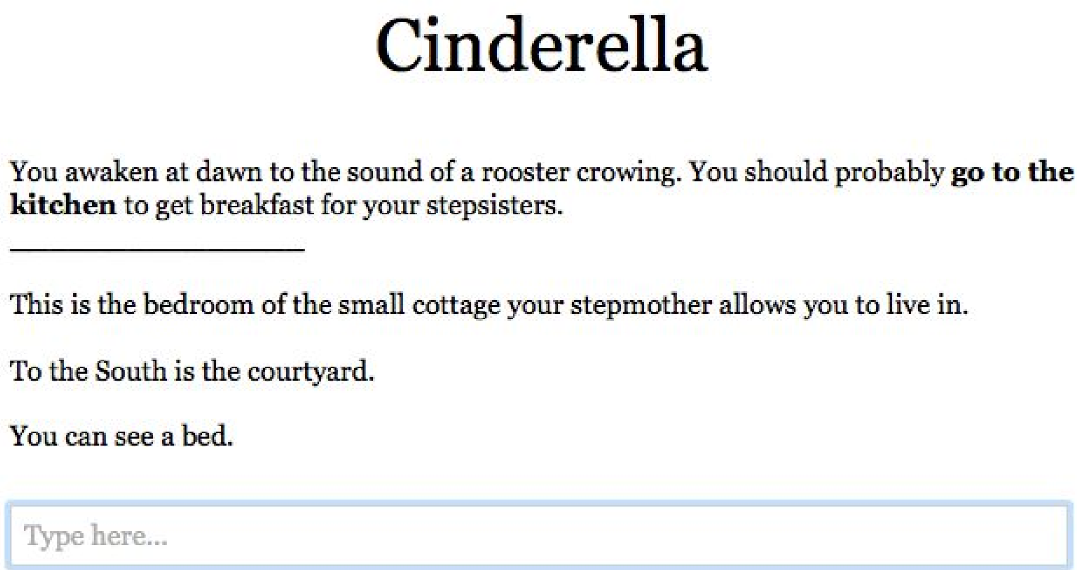

Figure 3.1. *Screenshot of the Cinderella game used in this study*

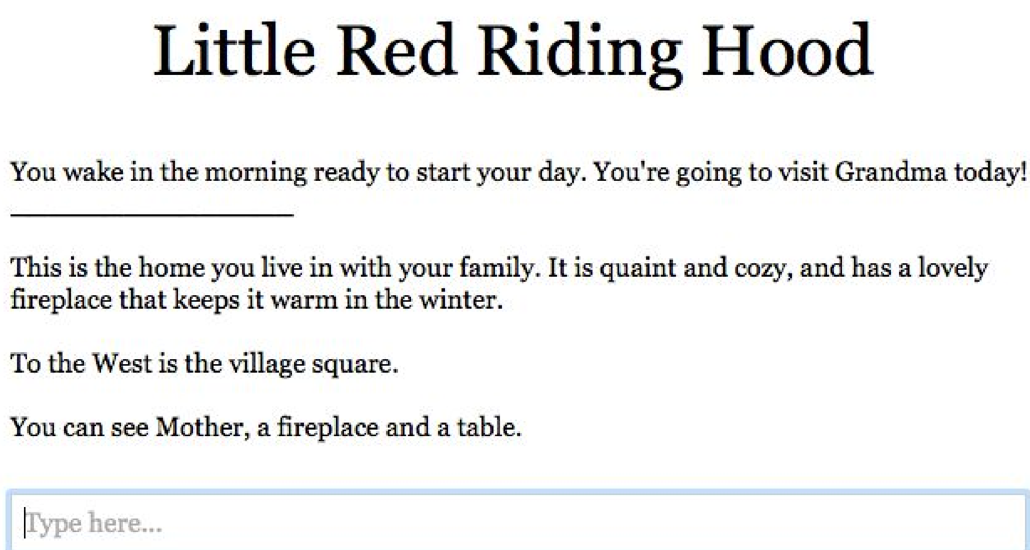

Figure 3.2. *Screenshot of the Little Red Riding Hood game used in this study*

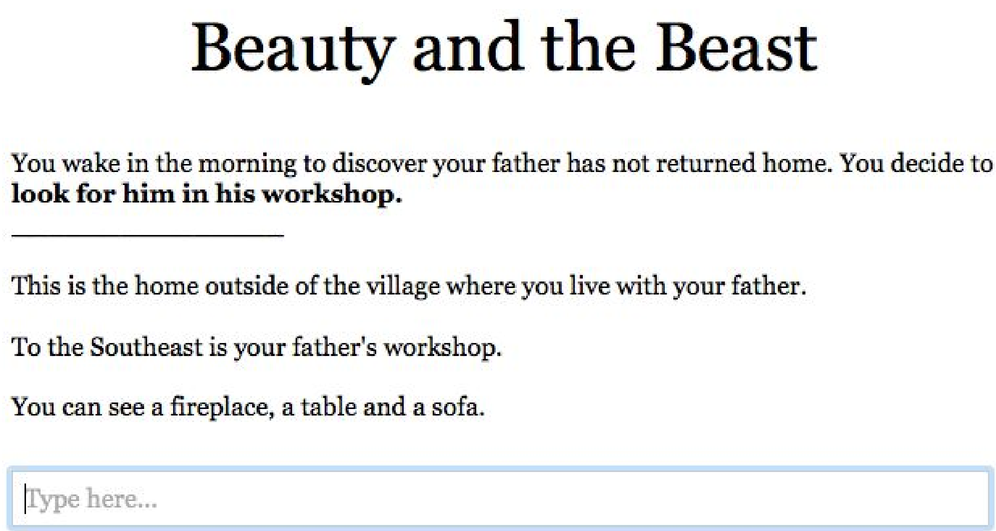

Figure 3.3. *Screenshot of the Beauty and the Beast game used in this study*

All of the IFs ranked in the ‘Merciful’ category on the cruelty scale (Plotkin, 1996), meaning that the games cannot ever reach an unwinnable state. If the player continues exploring and interacting with the narrative, they should always be able to progress through the story. Additionally, the IFs prompt the user with hints at certain points in the story as to what their next goal should be. These games have the typical characteristics of IF games, although they are shorter than most and clues are more explicit. The format of these games are fairly typical of what you would find both in classic and modern IFs.

All three IFs have a low difficulty level, which here refers to the number and type of commands necessary to finish the game. Other than one story choice per game, navigational commands are the only necessary input for a player to complete the game.

There are no puzzles to be solved and story events trigger automatically when a player enters a room, so that they function essentially as "spatial stories" in which space comprises an essential element of the narrative. Although the player does have the option to roam the world of the story freely and interact with objects and characters, this functions as an element of exploration and has no impact on the main story. The main story for all IFs have this linearity. The player's decisions and actions do affect the outcome of the main story, but do not change the length or course of the overall plot. For example, in Little Red Riding Hood, the player chooses whether or not to share some baked goods with the wolf in the woods, but either option allows the story to continue and does not affect later events. Different endings to the stories are available based on player actions (whether the player "wins" or "loses" during the final confrontation), but it does not alter the number of moves in which the game can be completed. All IFs can be completed in a minimum of nineteen turns, although this is only possible if players use exclusively navigational commands to go to the next event location and do not explore or interact with the virtual environment outside of the confines of the main story line.

All of the IFs are developed to be consistent in terms of length, story linearity, spatial complexity and navigation method. All games are designed to be around 1100 words long. This length is for completing the game in the minimum number of turns, and will be higher depending on if a player makes a mistake or decides to do more exploring. All games feature a similar linear story. In the games, players must meet initial objectives, complete a story choice (which has 2 possible outcomes), and then navigate back to the starting place to complete the final encounter (which has 2 possible outcomes based on if the player wins or loses). Each IF's environment contains a different number of rooms based on its level of difficulty (6, 8, or 10). Regardless of the number of rooms, all of them must be visited by the player at least once in order to complete the game. All three are parser-based, in which the player navigates a multi-room environment through the use of extrinsic directions (go north, go south, etc.) The IFs allow for movement in eight cardinal directions (north, northeast, northwest, south, southeast, southwest, east, and west.) The game environment is only one level in each IF and does not allow for up and down movement. Room descriptions are provided after each turn and contain information about where the player is, what objects are in the current room, and the locations of any connected rooms.

Each of the three IFs has three levels of difficulty. The story itself as well as story length in each level of difficulty remained the same, however, the number of rooms varied. The versions of each game had different numbers of rooms depending on if it was the Hard, Medium, or Easy version of the story. These levels had 10, 8, and 6 rooms respectively, and the maps for each can be seen in the figures below.

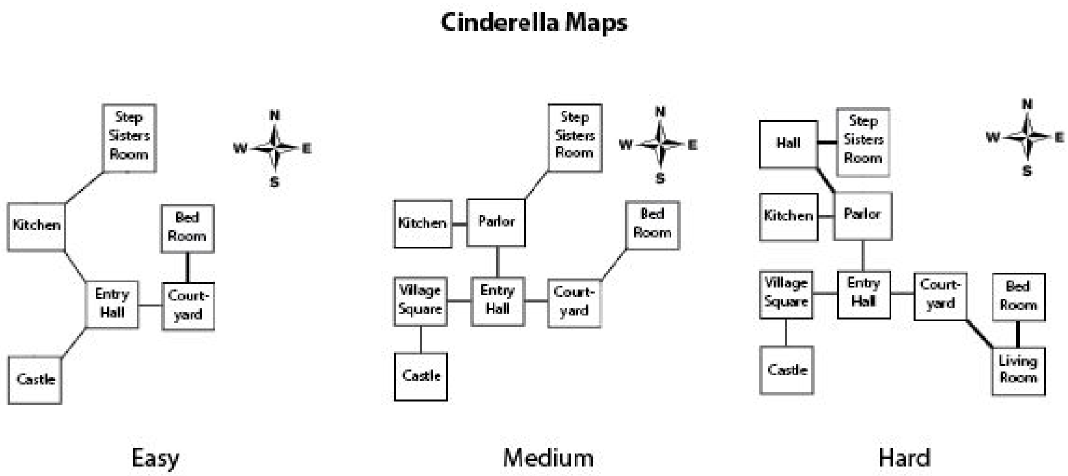

Figure 3.4. *Maps of the Cinderella games used in this study*

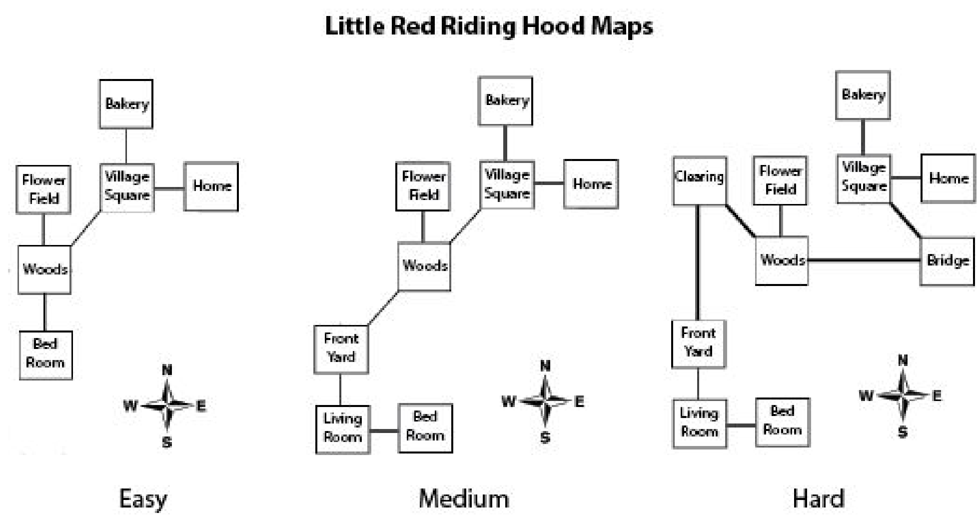

Figure 3.5. *Maps of the Little Red Riding Hood games used in this study*

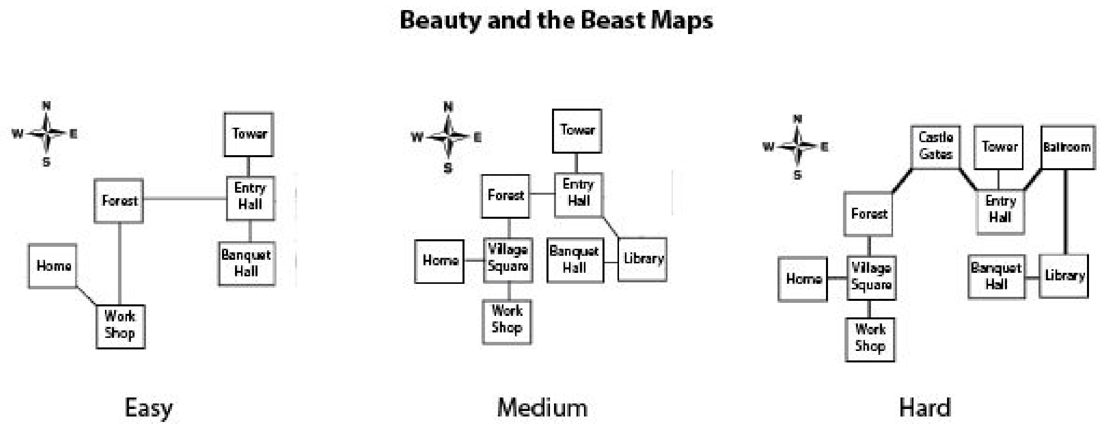

Figure 3.6. *Maps of the Beauty and the Beast games used in this study*

3.5 Study Measures

Data were taken at different points during the study through two different means: questionnaires and an interview. The questionnaires were the pre-study questionnaire, taken before engaging in any IF, the post-IF questionnaires, taken after playing each IF, and the post-study questionnaire, taken after playing all IFs. The interview was conducted post-study. Within each of these, multiple measures were collected as detailed in the section below.

3.5.1 Pre-Study Questionnaire

The pre-study questionnaire was given to participants first, before playing any interactive fiction. The first section of the pre-study questionnaire consisted of a demographic questionnaire to obtain information about the participants, including age, gender, student status, experience with IF and ASL, and familiarity with the story of the chosen IFs. The information gathered in this section was mainly used to test for within-subject significance of other measures.

Participants were also asked to rank their familiarity with each of the three stories (Cinderella, Little Red Riding Hood, and Beauty and the Beast) on a scale from 1 to 7. If they indicated that they were familiar with a story, they were asked to provide a short summary of that story. This was used to assess self-reported story familiarity.

The card rotations spatial ability test consisted of two 3 minute sections with ten questions each. In each question, a shape was presented, along with 8 variations of the shape below it. Participants were instructed to identify whether each of the 8 variations was the same as the presented shape (a rotation) or different from the presented shape (a reflection.) This test was used to assess spatial ability.

The cube comparisons spatial ability test consisted of two 3 minute sections with twenty one questions each. In each question, an image of a cube with shapes and letters on it was presented. Another cube with shapes and letters was shown next to it, and participants were asked to decide if the second cube was the same as or different from the first cube. This test was used to assess spatial ability.

The Santa Barbara Sense of Direction Scale (SBSOD) scale was utilized as a measurement for the pre-study questionnaire to assess environmental spatial ability. The questions rely on self-reported abilities of sense of direction (SOD) and spatial knowledge that relates to orienting oneself within an environment. The questions pertain not just to SOD in the real world, but can also be applied to virtual space (Hegarty et al., 2002). For each question, participants ranked their level of agreement or disagreement with a statement of their spatial abilities on a numerical scale ranging from 1 to 7. This test was used to measure perceived spatial ability.

3.5.2 Post-IF Questionnaires

Post-IF questionnaires were presented to participants after playing each IF. There were 9 IF questionnaires, one for each interactive fiction game. They are identical except for the map question, whose multiple choice answers are unique to each IF.

For the post-IF questionnaires, questions from the NASA Task Load Index (NASA-TLX) scale were used to assess the mental demand of the exercise, as well as the participant's impressions of their overall performance and the effort required to achieve that level of performance. It also collects data about the participant's frustration level during the task. Participants are asked to rank questions about how demanding the task was on a scale from 1 to 21, or "Very Low" to "Very High." This was used to assess perceived performance.

The post-IF questionnaire also asked participants to answer a question about the spatial layout of the game they just played. This was presented in the form of multiple choice question with 6 possible answers, only one of which was correct. In addition, in the first session, participants were also asked to draw a map of the environment from memory after playing their first interactive fiction game. This helped assess spatial ability.

The post-IF questionnaire also included a version of the SBSODS adapted for the IF. Nine of the fifteen original questions were modified to be about interactive fiction, while six were omitted since they could not be adapted. For each question, participants ranked their level of agreement or disagreement with a statement about their spatial abilities on a numerical scale ranging from 1 to 7. Any IF-specific questions, such as how much players enjoyed a particular game, were also present in the post-IF questionnaires. This was used to assess perceived spatial ability.

3.5.3 Post-Study Questionnaire

The post-study questionnaire was completed by participants in the second session, after they had completed the interactive fiction intervention. The post-study questionnaire is almost identical to the pre-study questionnaire. Its only omission is the demographic section. The card rotations and cube comparisons sections are the same, although answer choices are presented in a random order. The only addition is a final section that asks participants to rank the games they played in terms such as how much they enjoyed them and how difficult they were to navigate.

3.5.4 Post-Study Interview

The post-study interview was conducted in the second session after a participant had completed the post-study questionnaire. The interview went into more detail of participants' answers from earlier questionnaires. It dealt with topics such as previous experience with IF, how easy or difficult it was for them to navigate the virtual space, and some of the spatial challenges the tasks provided. A portion of the interview also focuses on the participant's spatial and navigation strategies while playing the interactive fiction games. This was used to gain data about spatial encoding strategies.

4. DATA ANALYSIS AND RESULTS

4.1 Data Analysis

4.1.1 Quantitative Data Analysis

Quantitative data analysis was done using *IBM SPSS Statistics* software. Tests performed included two-tailed Pearson bivariate correlations, one-way ANOVAs, and one-way repeated measures ANOVAs were all run with the collected data. For both the Card Rotations and Cube Comparisons tests, each correct answer was worth 1 point while each incorrect answer was worth -1 point. For the map question in each post-IF questionnaire, if a participant managed to correctly identify the map of the environment in the game they just played, they received a score of 1. Otherwise, the score was 0. Maps that the players drew in the first session were scored based on their accuracy of the number of rooms provided (one point each) and the correct directional connections between rooms (one point each.) All other questions on self-reported scales, such as the SBSOD and NASA-TLX were assigned the numerical values indicated by the participant.

Two-tailed Pearson bivariate correlations were used to determine if there was any correlation between spatial ability measures. One-way ANOVAs were used to determine if there was a statistically significant difference between elements such as usability or enjoyment among the three interactive fiction games. One-way repeated measures ANOVAs were used to determine if there was a statistically significant difference among measures that were repeated more than once over the course of the study, for example, pre-study spatial tests and post-study spatial tests, as well as answers that were collectected on surveys after each interactive fiction game was played.

4.1.2 Qualitative Data Analysis

Qualitative Analysis was done using MAXQDA: Qualitative Data Analysis software. Participants' responses to open-ended questions were analyzed using open coding and grounded theory methods. Coding describes "extracting concepts from raw data and developing them in terms of their properties and dimensions" (Strauss & Corbin, 2008). This study utilized a coding method in which categories were created based on the content of participant responses to interview questions. These codes were treated as subconcepts and were then grouped into sets based on their broader category. The number of responses provided in each set and category was recorded.

4.2 Results

4.2.1 Usability

A one-way ANOVA was conducted to determine whether there was a statistically significant difference in usability among all interactive fiction games used in the intervention. Usability was not significantly significant, $F(5, 60) = .541$, $p = 0.744$; Wilks' $\Lambda = 0.612$; partial $\eta^2 = 0.043$. Although this suggests that all games were a similar level of usability, there were several trends. The Beauty and the Beast (hard) game was the least usable, while the Beauty and the Beast (medium) game was the most usable.

4.2.2 Enjoyment

A one-way ANOVA was conducted to determine whether there was a statistically significant difference in enjoyment among all interactive fiction stories used in the intervention. Enjoyment between stories was not significantly significant, $F(2, 65.836) = 0.269$, $p = 0.765$. Although this suggests that all games had a similar level of enjoyment, trends show that Little Red Riding Hood games were enjoyed the least overall, and Beauty and the Beast games were enjoyed the most.

4.2.3 Correlations among spatial ability measures

Card Rotation test scores and Cube Comparisons test scores had a statistically significant positive linear relationship, Pearson correlation = .605, $p = .005$ (2-sided).

Map drawing performance after IF 1 and Cube Comparisons test scores did not have a statistically significant linear relationship, Pearson correlation = -0.090, $p = .732$ (2-sided).

Map drawing performance after IF 1 and Card Rotations test scores did not have a statistically significant linear relationship, Pearson correlation = 0.080, $p = .761$ (2-sided).

Map drawing performance after IF 1 and initial self-reported sense of direction did not have a statistically significant linear relationship, Pearson correlation = 0.287, $p = 0.265$ (2-sided).

4.2.4 Interactive fiction and spatial ability

Difference between pre and post spatial ability by scales

Card Rotation

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in the Card Rotations Test scores over the course of a 3-day interactive fiction intervention. There was a statistically significant difference between the pre-intervention Card Rotations Test scores and the post-intervention Card Rotations Test scores, $F(1, 19) = 24.709$, $p < .0005$; partial $\eta^2 = .565$. Participants' scores improved overall from pre-intervention to post-intervention.

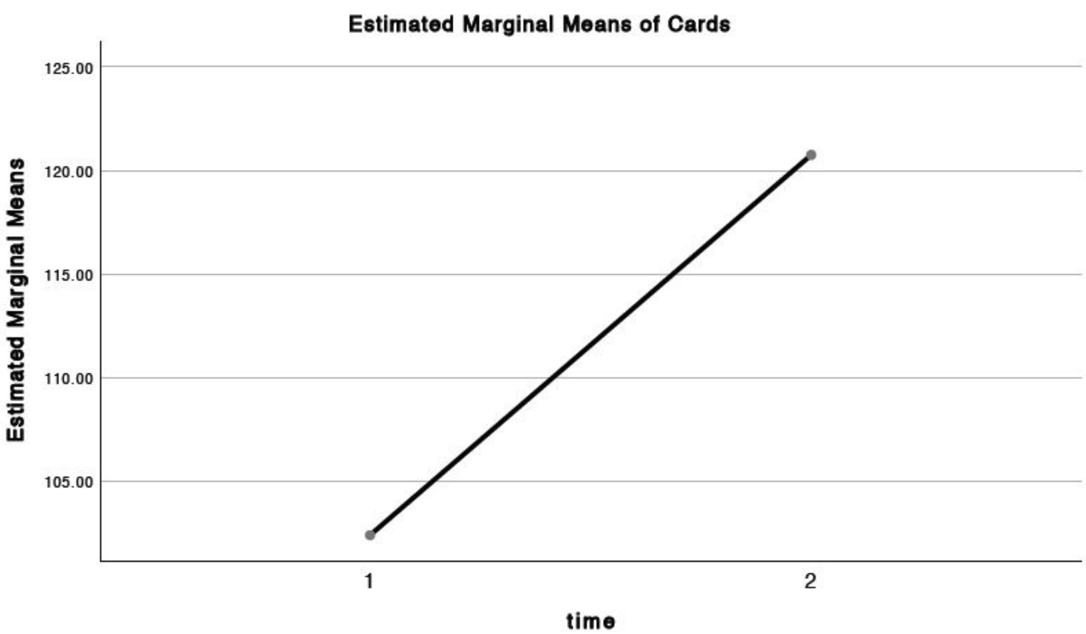

Figure 4.1. *Card Rotation Scores Over Time - IF Players*

However, the same one-way repeated measures ANOVA was conducted with the control group members to determine whether there were statistically significant differences in their Card Rotations Test scores over the course of a 3-days without the interactive fiction intervention. There was a statistically significant improvement in their Card Rotations Test scores as well, $F(1, 7) = 45.457$, $p < .0005$; partial $\eta^2 = .867$.

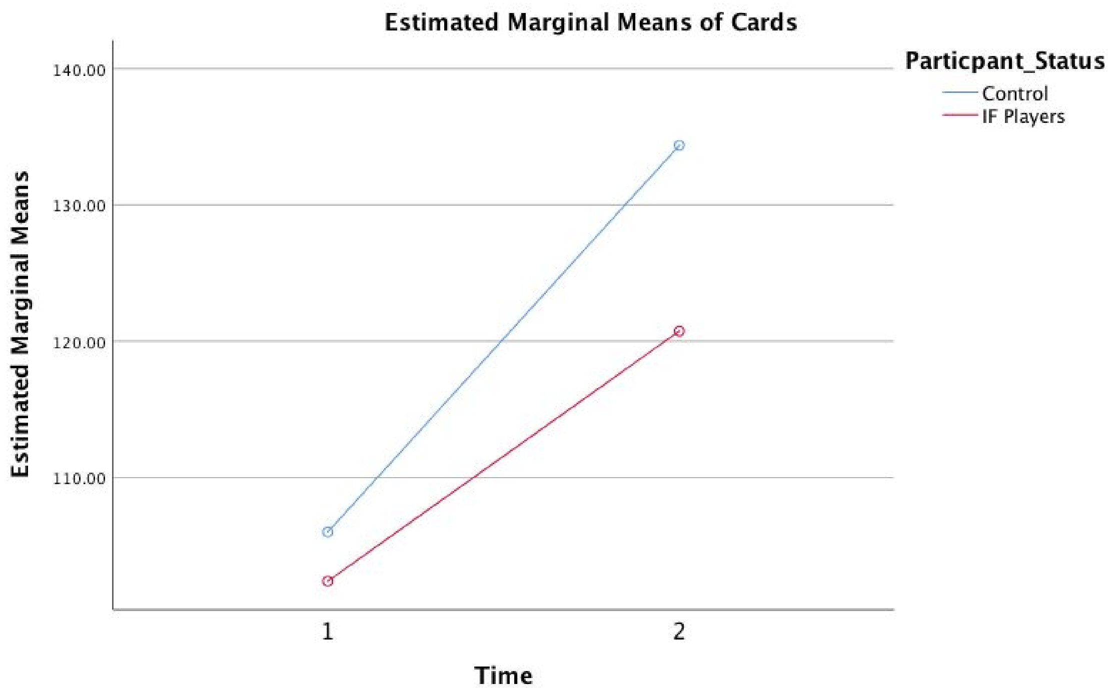

Figure 4.2. *Card Rotation Scores Over Time - IF Players and Control Group*

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in their Card Rotations Test scores between the participants who completed the interactive fiction intervention versus the control group. There was no statistically significant difference between the two groups in their Card Rotations Test scores over time, $F(1, 26) = 2.420$, $p = .132$; Wilks' $\Lambda = .915$; partial $\eta^2 = .085$. Time, not participant status, was the only factor that was statistically significant. Although the difference was not statistically significant, the control group did score higher overall on both the first and second tests.

Cube Comparisons

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in the Cube Comparisons Test scores over the course of a 3-day interactive fiction intervention. The intervention elicited statistically significant changes in Cube Comparisons Test scores over time, $F(1, 19) = 18.097$, $p < .0005$; partial $\eta^2 = .487$. Participants' scores improved from pre-intervention to post-intervention.

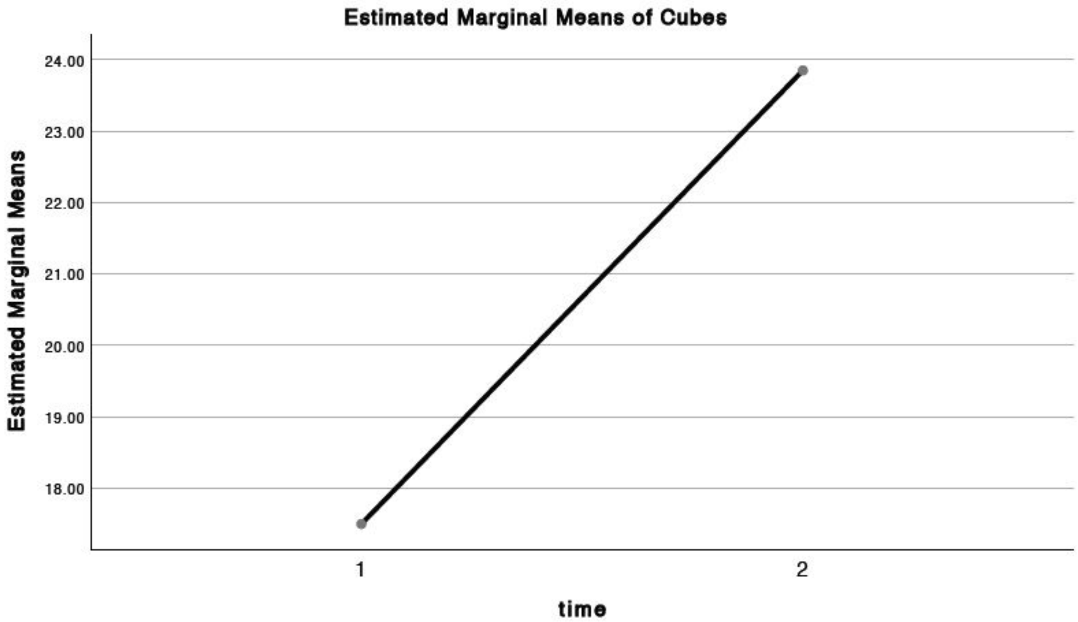

Figure 4.3. *Cube Comparison Scores Over Time - IF Players*

However, the same one-way repeated measures ANOVA was conducted with the control group members to determine whether there were statistically significant differences in their Cube Comparisons Test scores over the course of 3-days without the interactive fiction intervention. There was a statistically significant improvement in their Cube Comparisons Test scores as well, $F(1, 7) = 24.216$, $p < .005$; partial $\eta^2 = .776$.

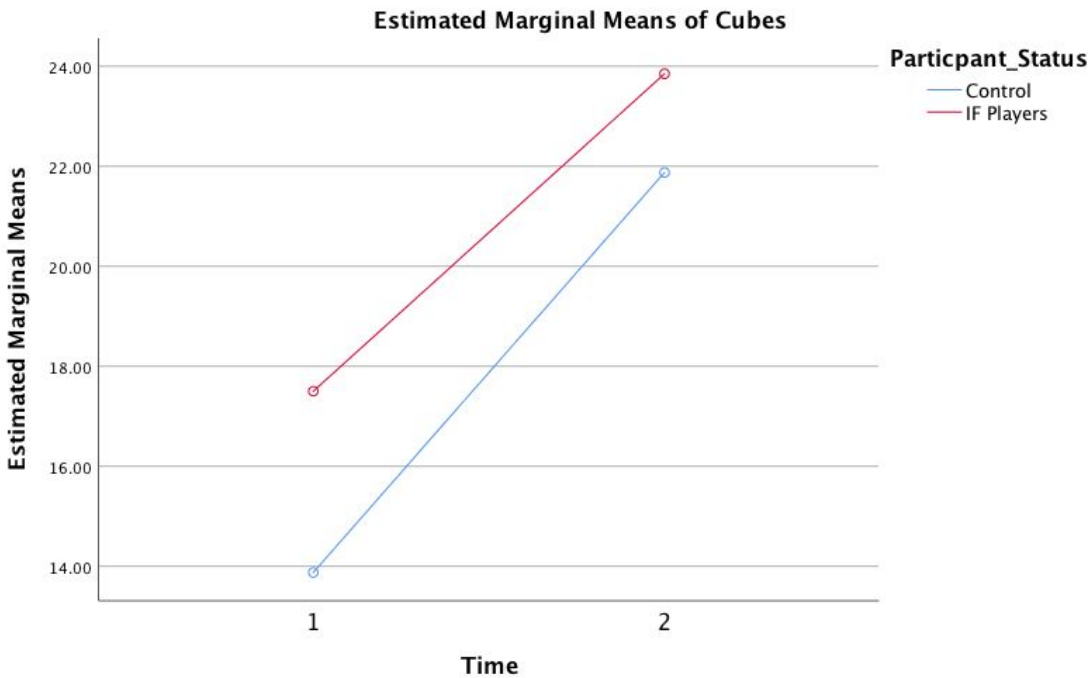

Figure 4.4. *Cube Comparison Scores Over Time - IF Players and Control Group*

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in the Card Rotations Test scores between the participants who completed the interactive fiction intervention versus the control group. There was no statistically significant difference between the two groups in their Card Rotations Test scores over time, $F(1, 26) = .406$, $p = .530$; Wilks' $\Lambda = .459$; partial $\eta^2 = .015$. Time, not participant status, was the only factor that was statistically significant. Although the difference was not statistically significant, the IF players did score higher overall on both the first and second tests.

Self-Reported Sense of Direction

A one-way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference between the pre-intervention Santa Barbara Sense of Direction Scale (SBSOD) scores over the course of a 3-day interactive fiction intervention. The intervention did not elicit statistically significant changes in self-reported sense of direction over time, $F(1, 19) = 0.072$, $p = .792$; Wilks' $\Lambda = .996$; partial $\eta^2 = .004$.

The same one-way repeated measures ANOVA was conducted with the control group members to determine whether there were statistically significant differences in their self-reported sense of direction over the course of 3-days without the interactive fiction intervention. There was no statistically significant difference in the self reported sense of direction of the control group either, $F(1, 7) = 2.100$, $p = .191$; Wilks' $\Lambda = .769$; partial $\eta^2 = .231$.

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in self-reported sense of direction over time between the participants who completed the interactive fiction intervention versus the control group. There was no statistically significant difference between the two groups, $F(1, 26) = 1.577$, $p = .220$; Wilks' $\Lambda = .966$; partial $\eta^2 = .057$. Time, not participant status, was the only factor that was statistically significant. Although the difference was not statistically significant, IF players reported higher senses of direction both the first and second times compared to the IF players.

4.2.5 Progressively harder interactive fiction and spatial ability

Enjoyment over time

A one-way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference in enjoyment among all interactive fiction games by chronological order in which they were played. Enjoyment was not significantly significant over time, $F(5, 60) =$, $p = 0.581$; Wilks' $\Lambda = 0.812$; partial $\eta^2 =$ 0.046 Although this suggests that users enjoyed all games approximately the same amount, there were several trends. Users enjoyed the first game they played the most and the fourth game they played (the one in which the difficulty increased) the least.

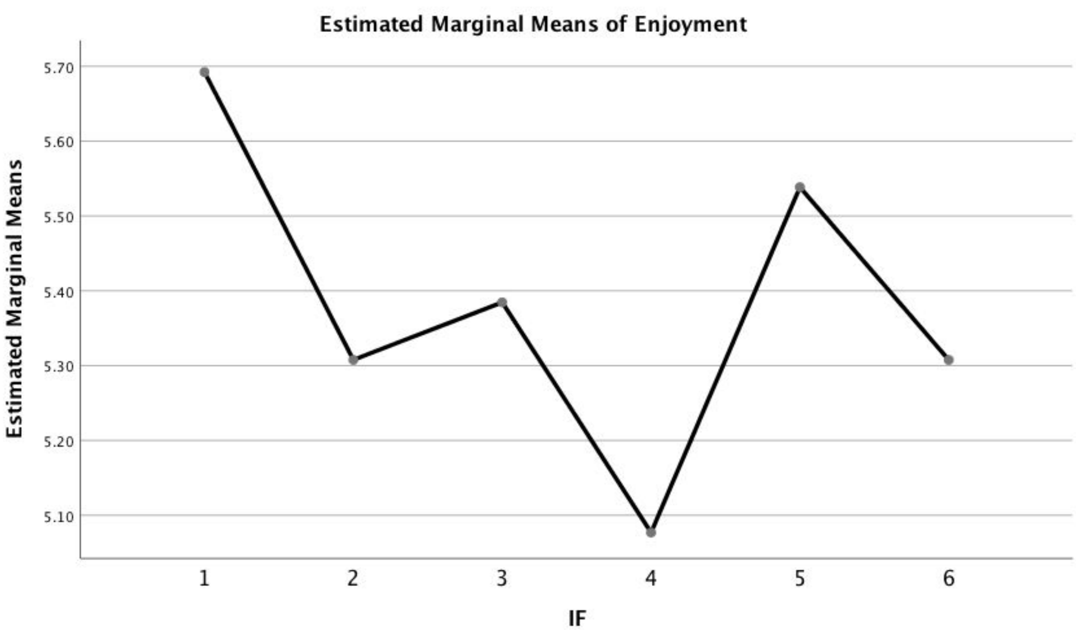

Figure 4.5. *Enjoyment of IFs Over Time*

Sense of Direction in IFs over Time

A one-way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference in sense of direction in IF among all interactive fiction games by chronological order in which they were played. Enjoyment was not significantly significant over time, $F(5, 65) = 0.920$, $p = 0.474$; Wilks' $\Lambda = 0.556$; partial $\eta^2 = 0.066$. Although not statistically significant, there were several trends. Self-reported sense of direction was highest in the second IF and lowest in the fourth (the game in which the difficulty increased)

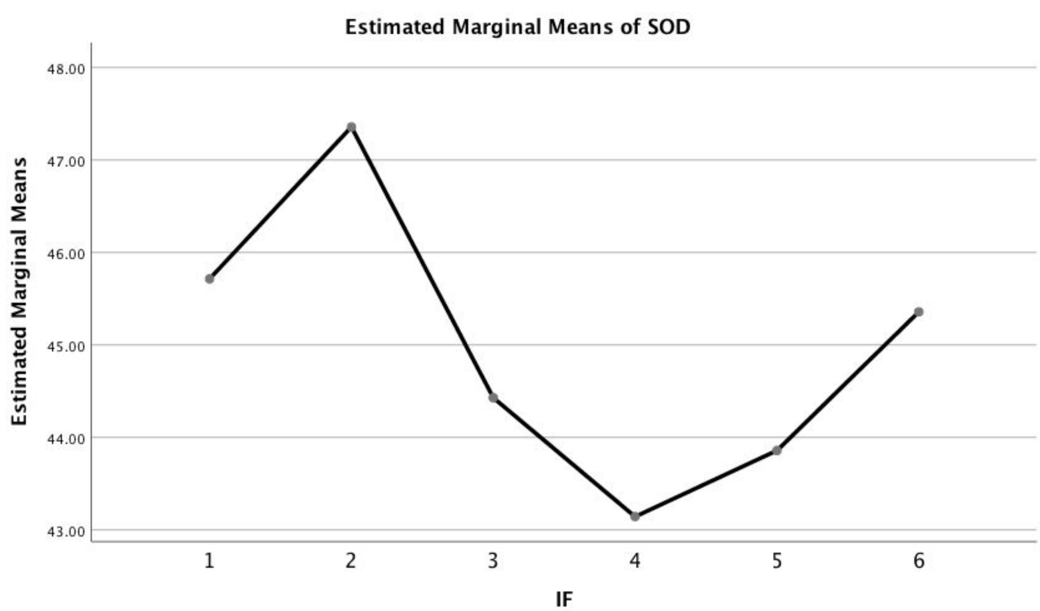

Figure 4.6. *Sense of Direction in IF Over Time*

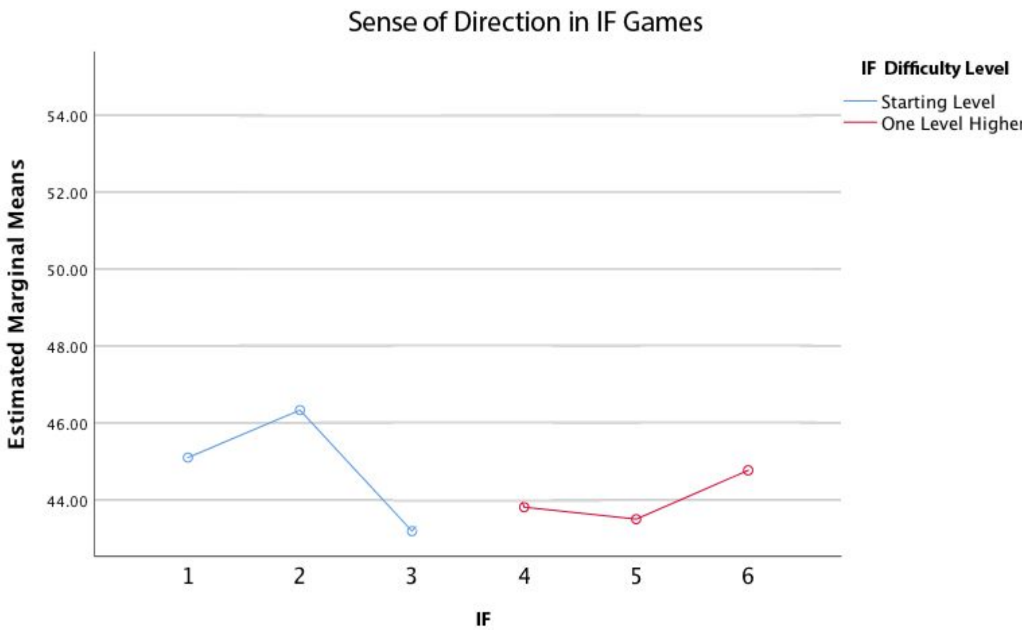

Figure 4.7. *Sense of Direction in IF Over Time by IF Difficulty Level*

Differences in Post-IF Multiple Choice Map Performance Over Time

A one-way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference in performance on post-IF map multiple choice questions in the chronological order in which they were played. Map performance was not statistically significant over time, $F(5, 65) = 0.788$, $p = 0.562$; Wilks' $\Lambda = 0.829$; partial $\eta^2 = 0.057$. Although not statistically significant, there were several trends. Users did the best on the first IF they played and the worst on the second. There was an overall decrease in performance on the fourth IF (where the level of difficulty increased), before performance increased in IF 5 and levelled off in 6.

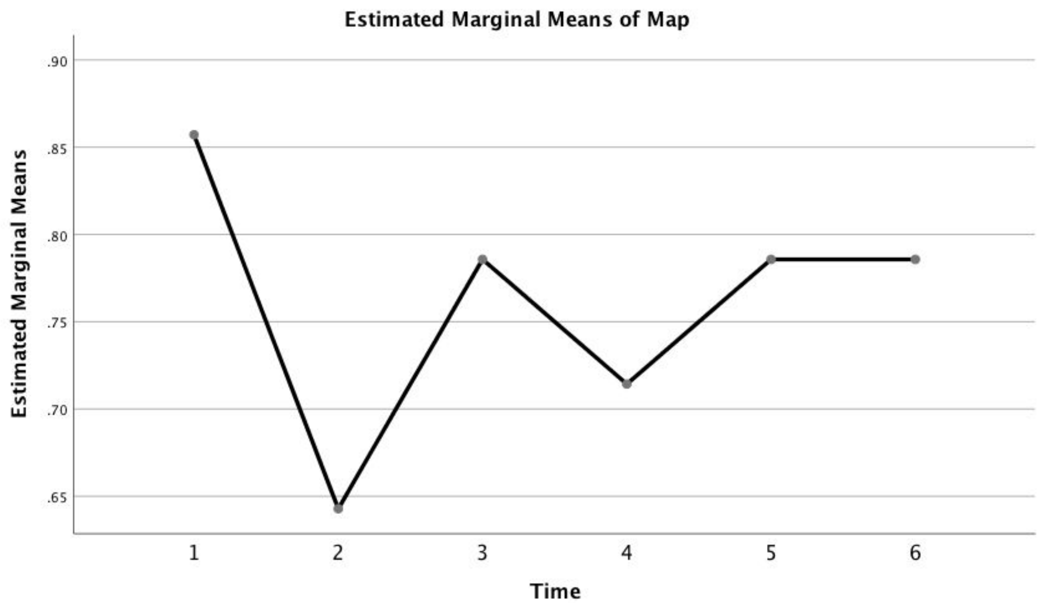

Figure 4.8. *Map Multiple Choice Over Time*

Figure 4.9. *Map Multiple Choice Over Time by IF Difficulty Level*

4.2.6 Spatial encoding strategies in interactive fiction

Post-study interviews were conducted with participants in which they were asked about their sense of direction in the games and any navigational strategies they utilized. Their responses were transcribed and analyzed. The 54 total responses were coded into 13 categories. These codes were then grouped by content into 9 unique sets.

Set	Number of Responses
Using Information Provided by Game	14
Mental Models / Visualization	9
Common Sense / Real World Layout	7
Relying on Sense of Direction	6
Hubs / Room Connections	6
Knowledge from Previous Playthroughs	5
Using Paper to Write / Draw	3
Trial & Error	2
Command Sequence/ Programming	2

Table 4.1. *Spatial Encoding Strategy Sets*

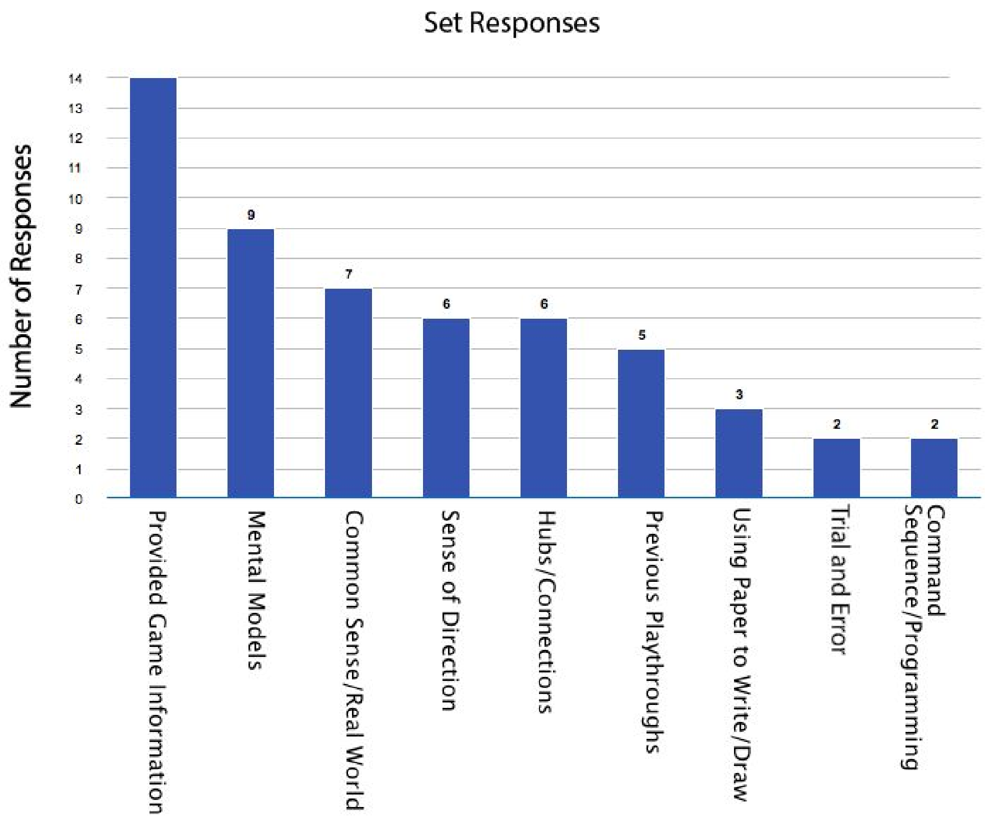

Figure 4.10. *Spatial Encoding Strategy Set Responses*

Spatial Encoding Strategies

Gender

A two-way ANOVA was conducted to examine the effects of gender and set category on the number of provided responses for each set. The interaction effect between gender and set category on the number of provided responses for each set was statistically significant, $F(8, 99) = 2.078$, $p = 0.045$, partial $\eta^2 = 0.144$.

There were several trends in the data. Females and males each provided the same number of responses in the "Relying on Information Provided by the Game" set, while males provided more responses than females in the “Mental Models” and “Common Sense/Real World Layout” sets. Males provided more responses than females in the “Relying on Sense of Direction” set and in the “Hubs/Room Connections” set. Only male participants provided responses in the “Using Knowledge from Previous Playthroughs” set. Females provided more responses than males in the “Using Paper to Write/Draw” set. Only male participants provided responses in the “Trial and Error” and “Command Sequence/Programming” sets.

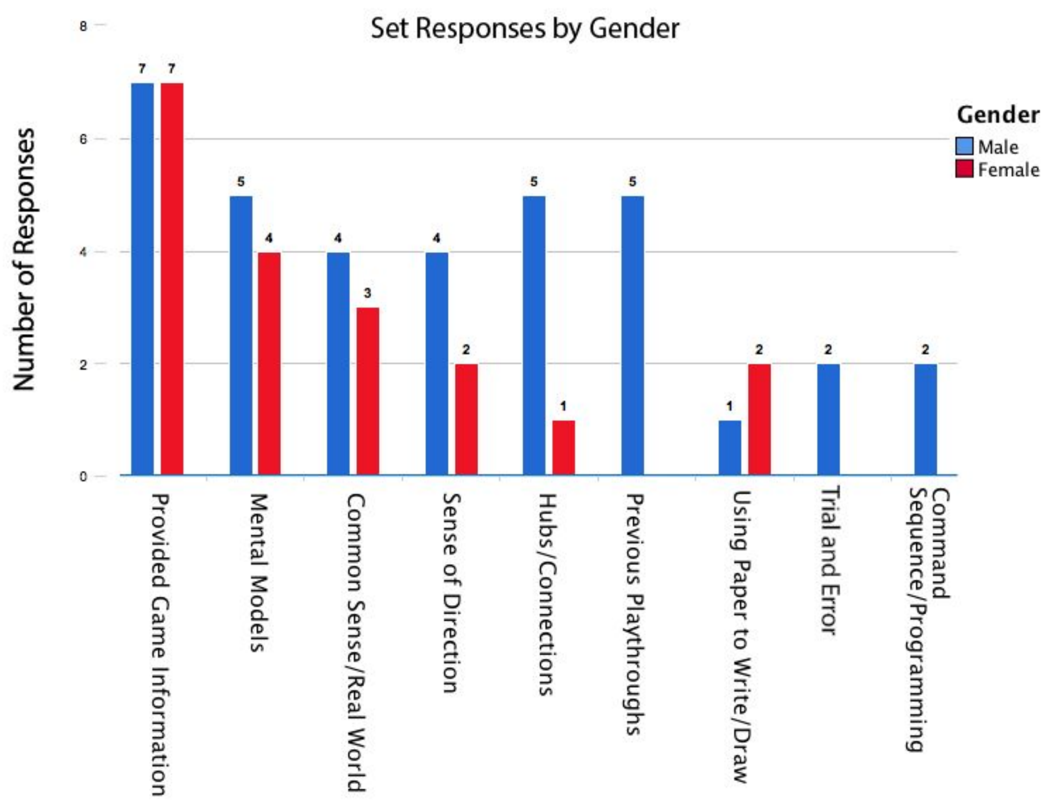

Figure 4.11. *Spatial Encoding Strategy Set Responses by Gender*

Classification

A two-way ANOVA was conducted to examine the effects of participant classification and set category on the number of provided responses for each set. The interaction effect between participant classification and set category on the number of provided responses for each set was not statistically significant, $F(16, 90) = 1.236$, $p = 0.257$, partial $\eta^2 = 0.180$.

Although not statistically significant, there were several trends. Undergraduates provided the most responses in the “Relying on Information Provided by the Game” set while graduate students provided the fewest in that set. Undergraduate students provided the most responses in the “Mental Models” set while graduate students did not provide any in that set. Undergraduate students provided the most responses in the “Common Sense/Real World Layout” set while staff did not provide any responses in that set. Undergraduates provided the most responses in the “Relying on Sense of Direction” set while graduate students provided the fewest in that set. Graduate students and staff provided the same number of responses in the “Hubs/Connections” set while undergraduate students provided the fewest in that set. Graduate students provided the most responses in the “Using Knowledge from Previous Playthroughs” set while staff did not provide any responses in that set. Graduate students, undergraduate students, and staff provided the same number of responses in the “Using Paper to Write/Draw” set.

Only graduate students contributed responses to the “Trial and Error” set, and only staff contributed responses to the “Command Sequence/ Programming” set.

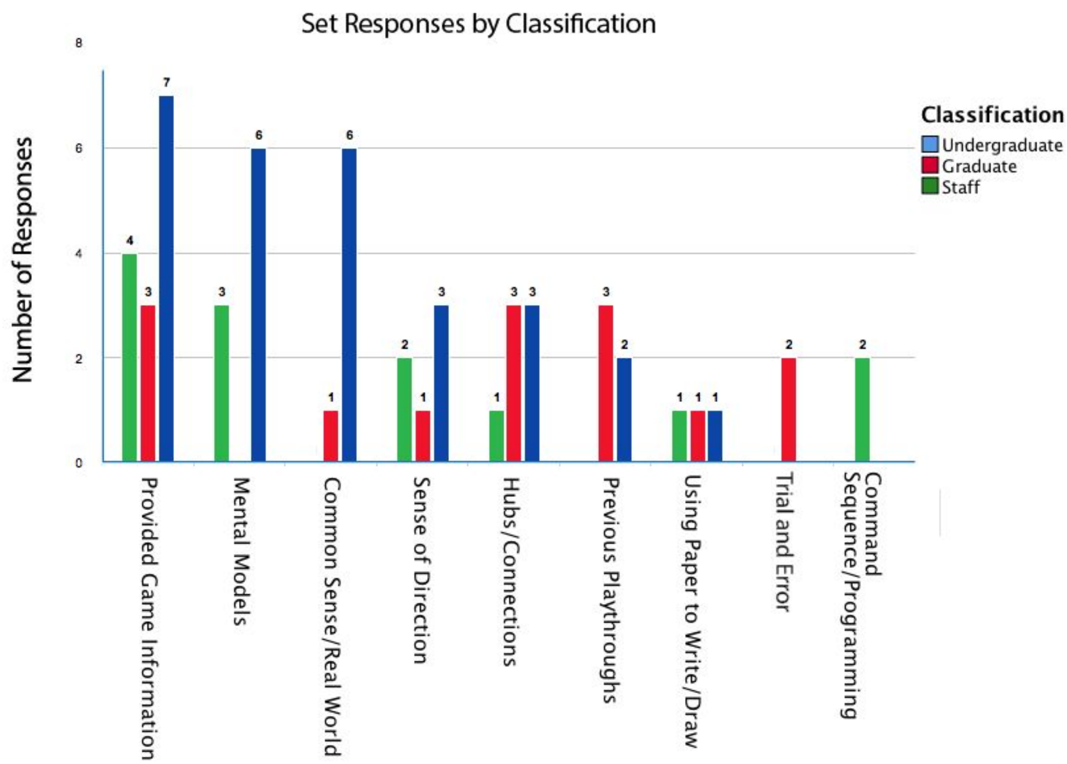

Figure 4.12. *Spatial Encoding Strategy Set Responses by Classification*

Spatial Encoding Strategy Sets

Using Information Provided by Game

This set includes 14 responses and is comprised of 2 codes: Paying attention to game objects (7) and Reading directions at the top of the screen each turn (7) Responses in this set indicated that participants were relying on the room descriptions provided by the game each turn in order to navigate and gain more information about their location rather than trying to memorize it. One example of a response coded in this set is “Overall

I just read where I needed to go at the top of the page. I didn't think the pressure to complete something in time- it was just like- it was just by the turn so I could take my time and see where I needed to go."

Mental Models / Visualization

This set includes 9 responses. One example of a response coded in this set is "I remember I was always trying to read the directions of like where to go but then I kind of just memorized the map so I would like kind of remember where to go… By going to each room I just like added to my mental map so that like when I had to go all the way back to beginning I basically had like everything planned out."

Common Sense / Real World Layout

This set includes 7 responses. Responses in this set indicated that participants were thinking about the game environment in terms of where rooms would logically be located in relation to one another in the real world. One example of a response coded in this set is "It was mainly a okay, well the kitchen wouldn't be next to the Village so… It's just like the same thing like common sense. Just knowing that I wouldn't go to, like, my stepsisters' room to get to the village from the parlor or something like that."

Relying on Sense of Direction

This set includes 6 responses. Responses in this set indicated that participants had a general directional sense of where rooms were in relation to one another. One example of a response coded in this set is "I had kind of a vague mental model of where things were relationally to each other but like I said I didn't make notes like okay I'm now west of the castle so if I go west again I'll be two spaces west of this and that."

Hubs / Room Connections

This set includes 6 responses and is comprised of 2 codes: Room Connections (4) and Grouping rooms/clusters/hubs (2) Responses in this set indicated that participants were thinking of rooms in terms of clusters or groups and in terms of their connections. One example of a response coded in this set is "I tried to remember- a couple, like, group a couple of rooms together. So like I think in Cinderella, once I got to the kitchen there were no other options except back into the parlor and so I would kind of group that in my head and then the same thing– so the parlor was kind of the central group for that map in my head, and we went to the stepsisters' room, or the kitchen, or back to the entry."

Knowledge from Previous Playthroughs

This set includes 5 responses. Responses in this set indicated that in their second playthrough of the story participants utilized information about the environment they remembered from their first playthrough of the game. One example of a response coded in this set is "Well actually I was paying less attention [the second time] because I knew. And I knew that some information on that was redundant so you have like five lines [of text] over there and I just needed to read one line to go to the bedroom. So for a guy who needs to just finish the game… I just need to win or finish so just pick up what was important for me."

Using Paper to Write / Draw

This set includes 3 responses and is comprised of 2 codes: Drawing a map (2) and Using abbreviations (1) Responses in this set indicated that participants used a physical representation of the game environment, either in the form of a drawn map or written directions. One example of a response coded in this set is "The first time or two I wrote down as I was navigating, I wrote which direction things were so I can remember how to get back. I'm a visual person so that that helped me."

Trial & Error

This set includes 2 responses from one participant. Responses in this set indicated that the participant completed the game through trial and error, essentially wandering through the game environment until events were triggered. One example of a response coded in this set is "That's it. Just trial and error."

Command Sequence/ Programming

This set includes 2 responses from one participant. Responses in this set indicated that the participant's strategy was to learn the order of commands needed to complete the game in a programming-style approach. One example of a response coded in this set is "I tried to essentially commit to memory what I would be doing as far as entering it in as a code. So again like I was talking about in some of the older games like super Nintendo Games you have a particular – some of the games would rely upon- as far as a skill game would be what's the button presses and what button presses you have to do and so you'd have to so-to-speak, code that. That's essentially a way of coding. As supposedly from… into getting a successful outcome. In that case it's far – and applying it to what I would normally do in terms of a coding situation– Or similarly to a coding situation if I were to be coding– In a programming situation. So I was trying to program."

4.2.7 Interactive fiction and story understanding

Self-reported story familiarity

Cinderella

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in IF players' self-reported story familiarity over the course of a 3-day interactive fiction intervention. There was a statistically significant difference between the pre-intervention story familiarity and the post-intervention story familiarity, $F(1, 19) = 4.540$, $p < .05$; partial $\eta^2 = .193$. The statistically significant difference was an overall increase in self-reported story familiarity.

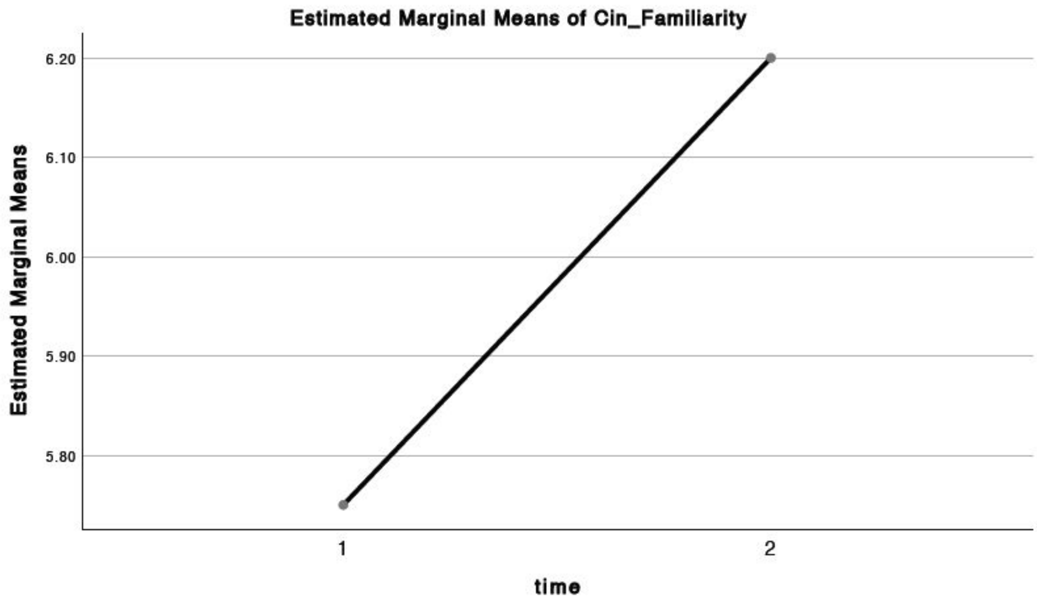

Figure 4.13. *Cinderella Story Familiarity Over Time - IF Players*

The same one-way repeated measures ANOVA was conducted with the members of the control group to determine whether there were statistically significant differences in their self-reported story familiarity. The changes in their story familiarity were not statistically significant, $F(1, 7) = .304$, $p = .598$; Wilks' $\Lambda = .958$; partial $\eta^2 = .042$. The IF players' story familiarity increased significantly whereas the control group's did not.

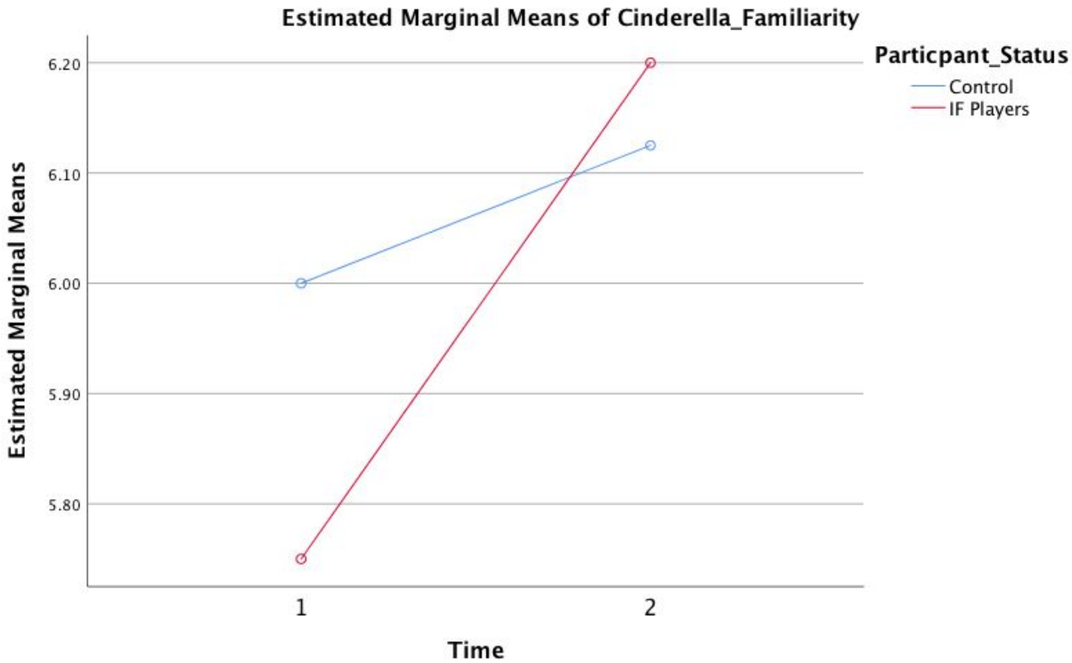

Figure 4.14. *Cinderella Story Familiarity Over Time - IF Players and Control Group*

Little Red Riding Hood

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in participants' self-reported story familiarity over the course of a 3-day interactive fiction intervention. There was a statistically significant difference between the pre-intervention story familiarity and the post-intervention story familiarity, $F(1, 19) = 20.470$, $p < .05$; partial $\eta^2 = .519$. The statistically significant difference was an overall increase in self-reported story familiarity.

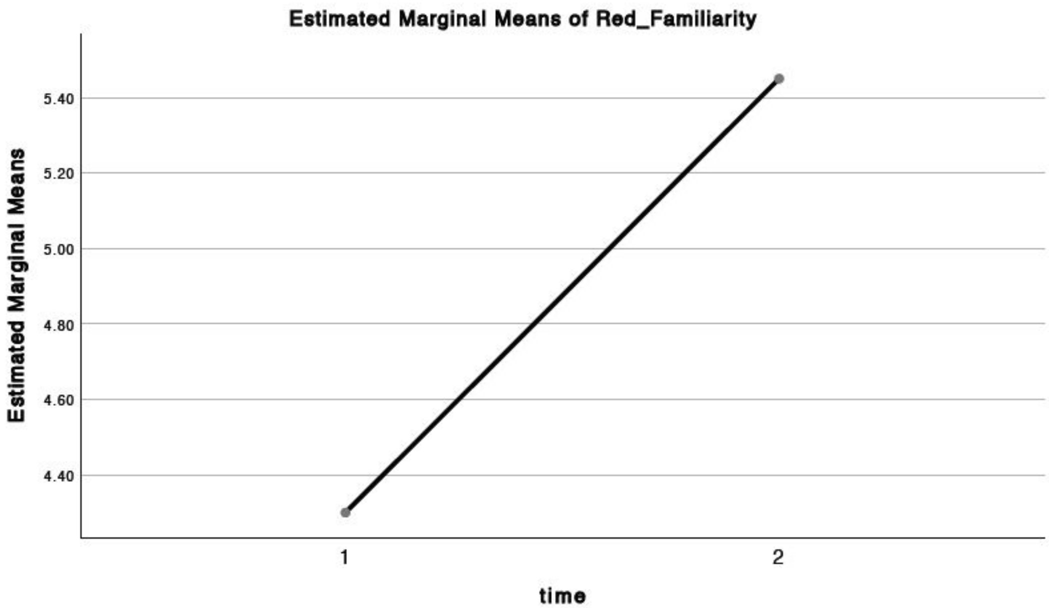

Figure 4.15. *Little Red Riding Hood Story Familiarity Over Time - IF Players*

The same one-way repeated measures ANOVA was conducted with the members of the control group to determine whether there were statistically significant differences in their self-reported story familiarity. The changes in their story familiarity were not statistically significant, $F(1, 7) = .127$, $p = .732$; Wilks' $\Lambda = .982$; partial $\eta^2 = .018$. The IF players' story familiarity increased significantly whereas the control group's did not.

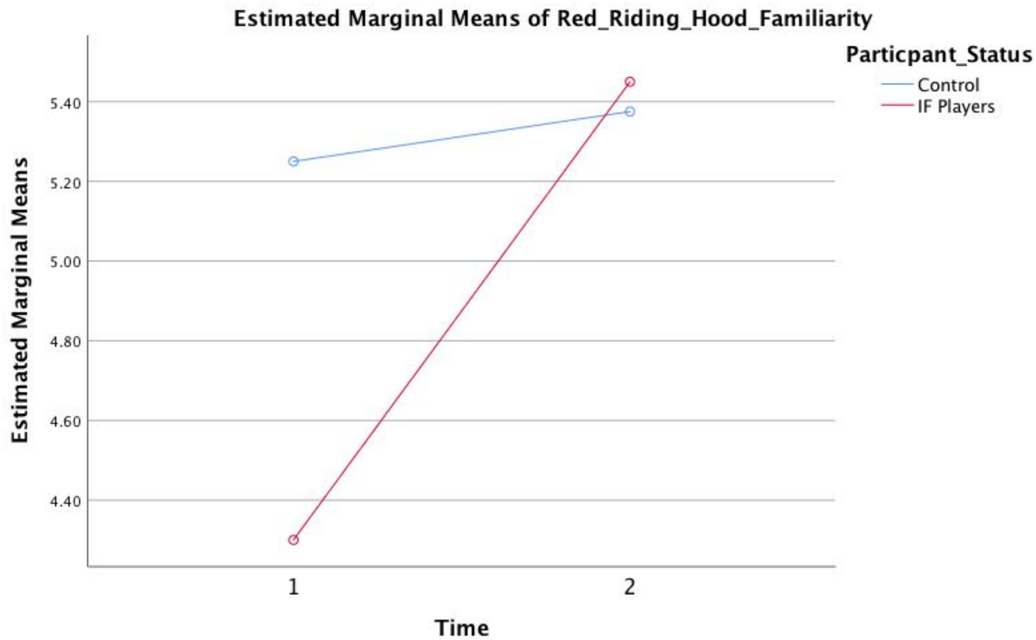

Figure 4.16. *Little Red Riding Hood Story Familiarity Over Time - IF Players and Control Group*

Beauty and the Beast

A one-way repeated measures ANOVA was conducted to determine whether there were statistically significant differences in participants' self-reported story familiarity over the course of a 3-day interactive fiction intervention. There was a statistically significant difference between the pre-intervention story familiarity and the post-intervention story familiarity, $F(1, 19) = 15.545$, $p < .05$; partial $\eta^2 = .450$. The statistically significant difference was an overall increase in self-reported story familiarity.

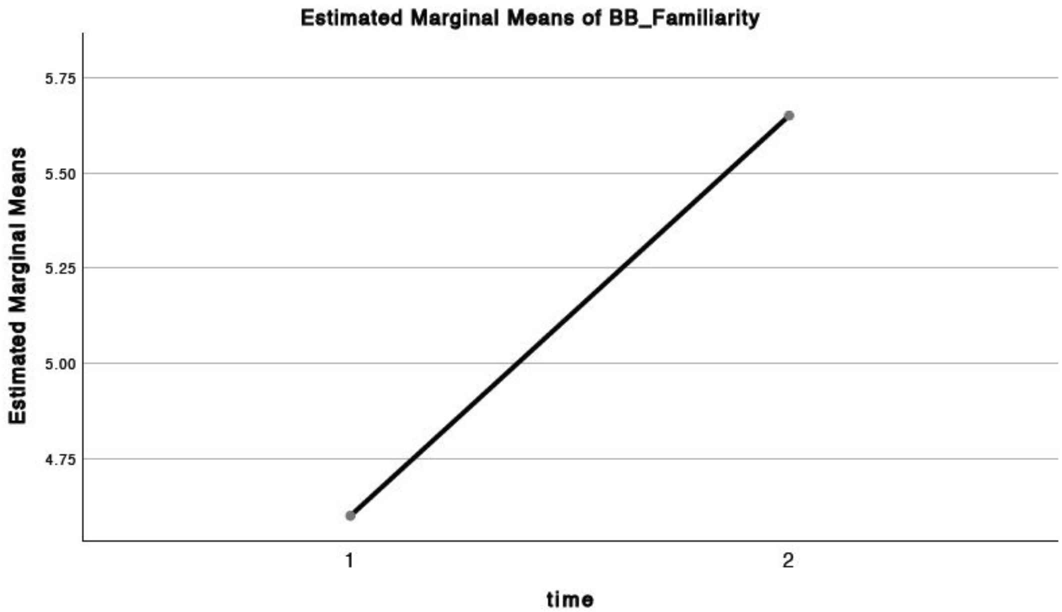

Figure 4.17. *Beauty and the Beast Story Familiarity Over Time - IF Players*

The same one-way repeated measures ANOVA was conducted with the members of the control group to determine whether there were statistically significant differences in their self-reported story familiarity. The changes in their story familiarity were not statistically significant, $F(1, 7) = .000$, $p = 1.000$; Wilks' $\Lambda = 1.000$; partial $\eta^2 = .000$. The IF players' story familiarity increased significantly whereas the control group's did not.

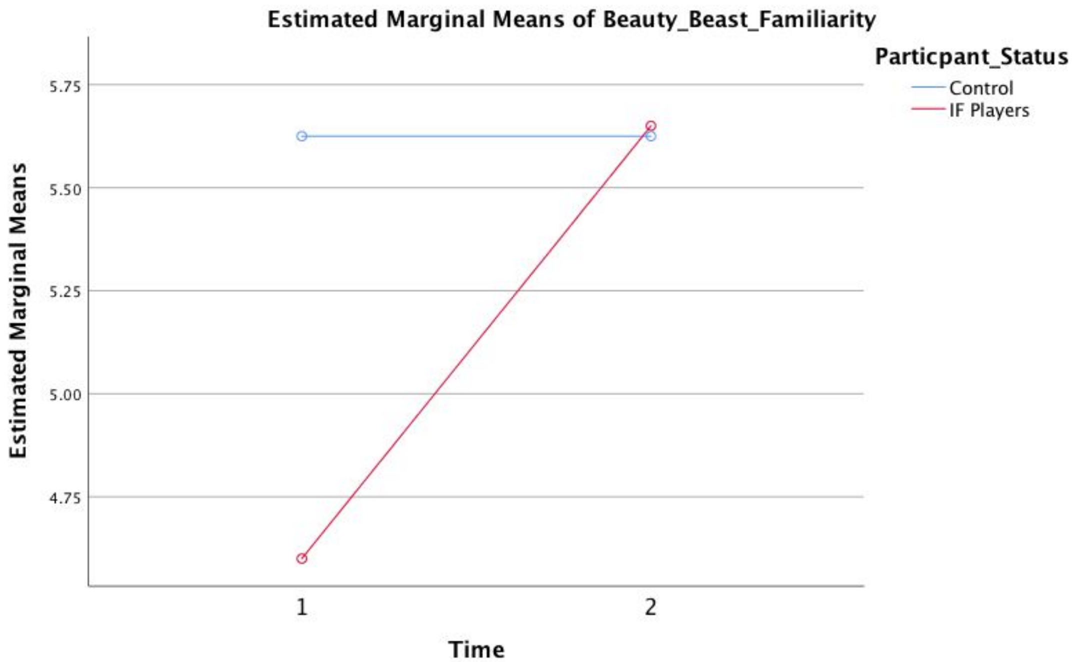

Figure 4.18. *Beauty and the Beast Story Familiarity Over Time - IF Players and Control Group*

Narrative Digest

Participants were asked to write summaries of each of the three stories on which the games were based both pre-intervention and post-intervention. All responses were analyzed using the narrative digest method, and the changes between story units added and removed from pre- to post-intervention were compared and analyzed. 104 of the total 164 story additions, or 63.03%, were elements found in the interactive fiction games. 23 of the total 82 removed story elements, or 28.05%, were elements not found in the interactive fiction games.

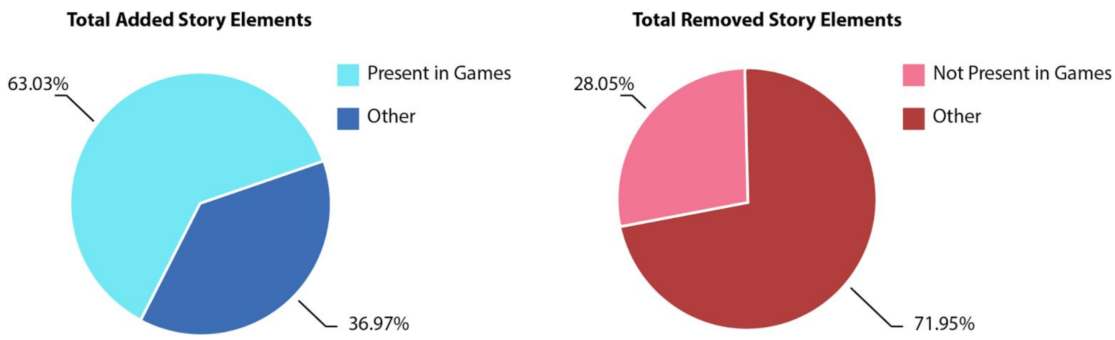

Figure 4.19. *Narrative Digest Elements*

The total number of participants whose stories did not change, did not know the story, or had summaries that changed 100% were totaled. If a story did not change, participants were familiar with the story and there were no story elements either added or removed in their summaries between pre to post. Some participants indicated that they did not know some of the stories during the pre-study questionnaire and therefore provided no story summary to analyze in the pre-study questionnaire. If a story changed 100%, it indicated that a participant did not know the story at the beginning of the study, but was familiar with it at the end of the study. Since they did not provide a summary in the pre-study questionnaire, all elements in their post study summary were added. Some participants responded that they did not know some of the stories at both the beginning and the end of the study, and therefore provided no story summary to analyze in either the pre- or post-study questionnaire.

	No Change Pre to Post	Didn't Know Story (Pre)	100% Change from Pre to Post	Didn't Know Story (Pre & Post)
Cinderella	0	0	0	0
Red Riding Hood	3	6	5	1
Beauty and the Beast	2	3	1	2

Table 4.2. *Narrative Digest Sets*

Cinderella

All 20 experimental group participants indicated being familiar with the story of Cinderella at the beginning and end of the study. Twenty of the total 44 story additions, or 45.45%, were elements found in the interactive fiction games. 7 of the total 30 removed story elements, or 23.33%, were elements not found in the interactive fiction games.

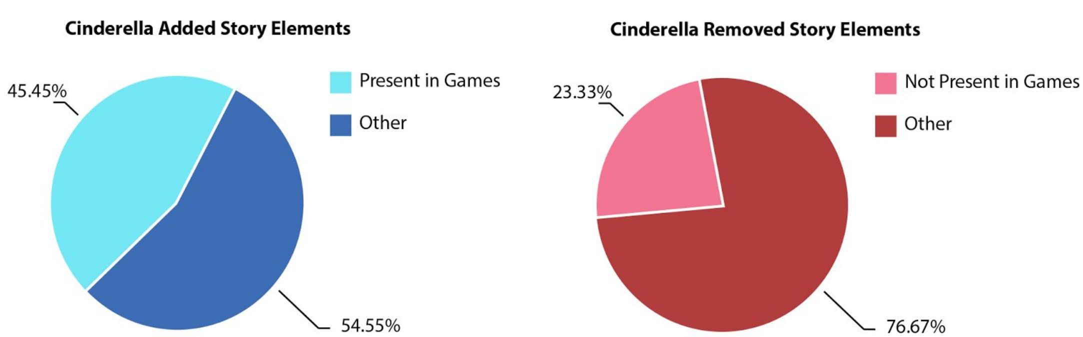

Figure 4.20. *Cinderella Narrative Digest Elements*

A one-way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference in the number of story elements present in participants' pre- and post-study summaries. The intervention did not elicit statistically significant changes in the number of story elements, $F(1, 18) = 0.465$, $p = 0.504$; Wilks' $\Lambda = 0.975$; partial $\eta^2 = 0.025$.

Repeating the same repeated measures ANOVA and adding baseline story familiarity as a covariate still did not show statistically significant changes in the number of story elements from pre- to post- intervention, $F(1, 17) = 0.450$, $p = 0.523$; Wilks' $\Lambda = 0.974$; partial $\eta^2 = 0.024$.

Little Red Riding Hood

Six of the 20 participants were unfamiliar with the story of Little Red Riding Hood at the beginning of the study. One participant still indicated being unfamiliar with the story at the end of the study. Forty of the total 54 story additions, or 74.07%, were elements found in the interactive fiction games. 12 of the total 19 removed story elements, or 63.16%, were elements not found in the interactive fiction games.

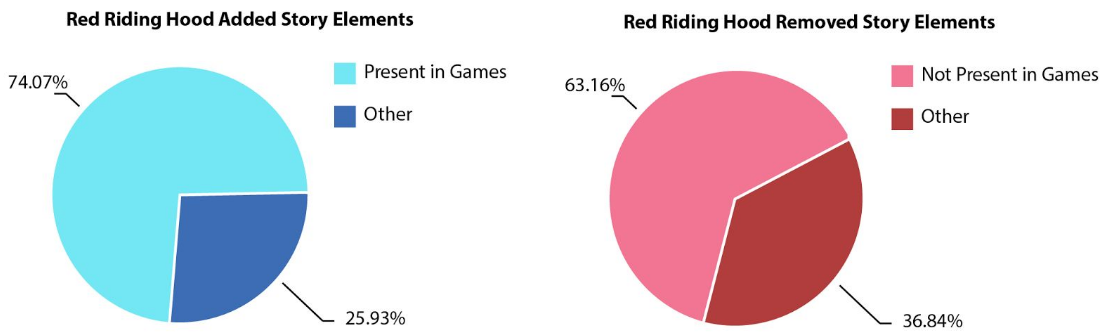

Figure 4.21. *Red Riding Hood Narrative Digest Elements*

A one-way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference in the number of story elements present in participants' pre- and post-study summaries. The intervention did not elicit statistically significant changes in the number of story elements, $F(1, 19) = 3.018$, $p = 0.099$; Wilks' $\Lambda = 0.863$; partial $\eta^2 = 0.137$.

However, repeating the same repeated measures ANOVA and adding baseline story familiarity as a covariate did show statistically significant changes in the number of story elements from pre- to post- intervention, $F(1, 18) = 12.946$, $p < .05$; partial $\eta^2 = 0.342$. The number of story elements increased overall.

Beauty and the Beast

Three of the 20 participants were unfamiliar with the story of Beauty and the Beast at the beginning of the study. Two participants still indicated being unfamiliar with the story at the end of the study. Forty four of the total 67 story additions, or

65.67%, were elements found in the interactive fiction games. 4 of the total 33 removed story elements, or 12.12%, were elements not found in the interactive fiction games.

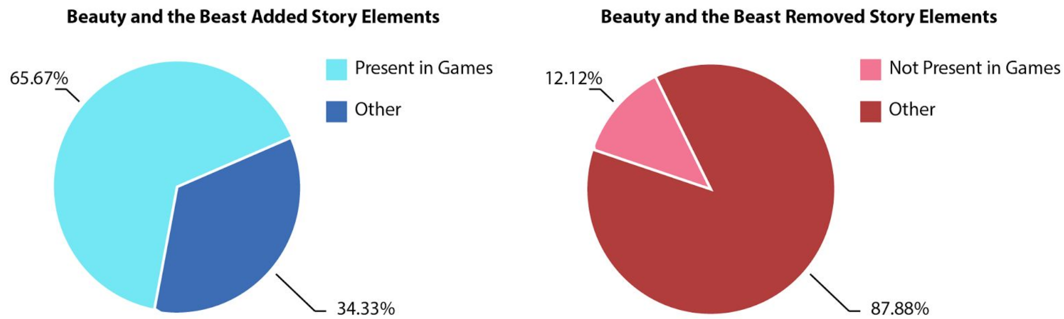

Figure 4.22. *Beauty and the Beast Narrative Digest Elements*

A one-way repeated measures ANOVA was conducted to determine whether there was a statistically significant difference in the number of story elements present in participants' pre- and post-study summaries. The intervention did not elicit statistically significant changes in the number of story elements, $F(1, 17) = 2.465$, $p = 0.135$; Wilks' $\Lambda = 0.873$; partial $\eta^2 = 0.125$.

Repeating the same repeated measures ANOVA and adding baseline story familiarity as a covariate still did not show statistically significant changes in the number of story elements from pre- to post- intervention, $F(1, 16) = 0.937$, $p = 0.347$; Wilks' $\Lambda = 0.867$; partial $\eta^2 = 0.055$.

4.2.8 Influence of other factors on spatial ability

Gender

Card Rotation

A one-way repeated measures ANOVA was conducted to determine whether gender was a statistically significant factor on the pre-study and post-study spatial ability test scores. Gender was not a statistically significant factor in performance on the card rotation test, $F(1, 26) = .185$, $p = .671$; Wilks' $\Lambda = .346$; partial $\eta^2 = 0.007$. Although they were not statistically significant, there were several trends. Male participants had the highest scores both pre-study and post-study, although males and females had comparable rates of improvement.

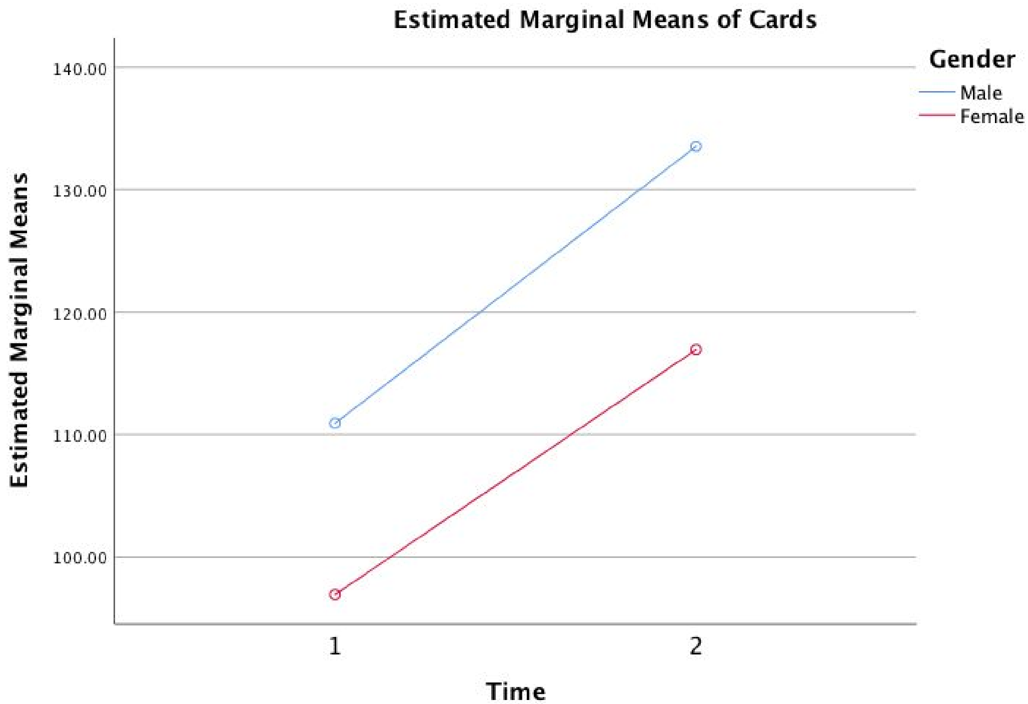

Figure 4.23. *Gender - Card Rotation*

Cube Comparisons

A one-way repeated measures ANOVA was conducted to determine whether gender was a statistically significant factor on pre-study and post-study spatial ability test scores. Gender was not a statistically significant factor in performance on the cube test, $F(1, 26) = .148$, $p = .703$; Wilks' $\Lambda = .435$; partial $\eta^2 = .006$. However, although they were not statistically significant, there were several trends. Male participants had the highest scores both times. Both male and female participants' scores improved at a similar rate rate from the first test to the second.

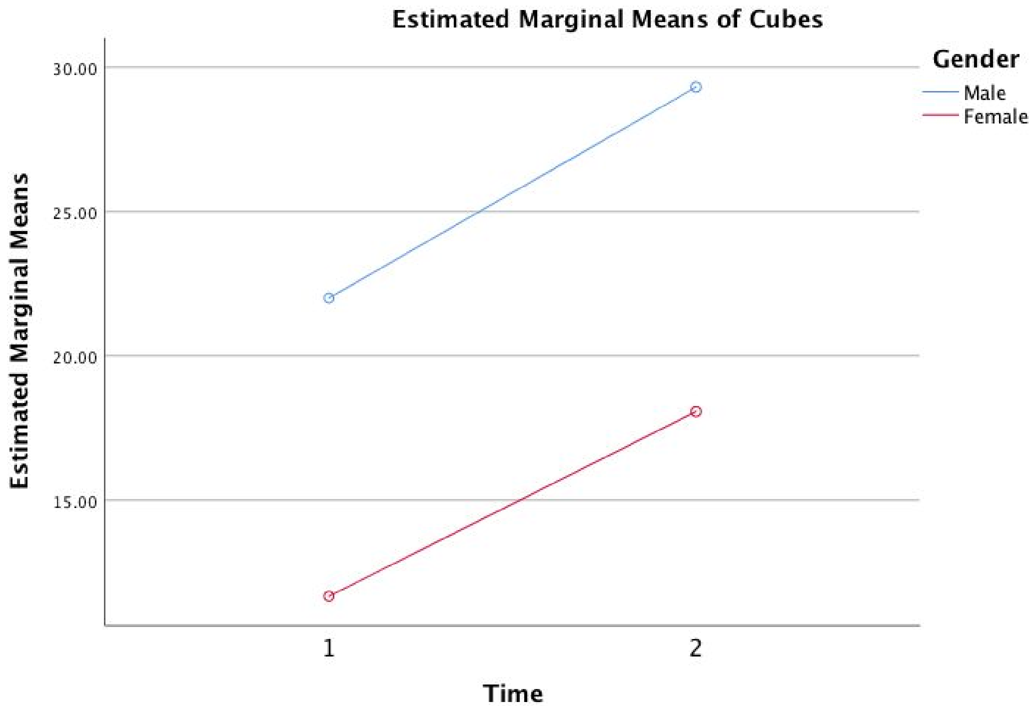

Figure 4.24. *Gender - Cube Comparisons*

Self-Reported Sense of Direction

A one-way repeated measures ANOVA was conducted to determine whether gender was a statistically significant factor on pre-study and post-study spatial ability test scores. Gender was not a statistically significant factor in performance on self-reported sense of direction, $F(1, 26) = .232$, $p = .634$; Wilks' $\Lambda = .993$; partial $\eta^2 = 0.009$. Although they were not statistically significant, there were several trends. Male participants had the highest self-reported sense of direction on both questionnaires. Male participants' self-reported sense of direction remained almost unchanged from the first time to the second, while female participants' self reported sense of direction decreased.

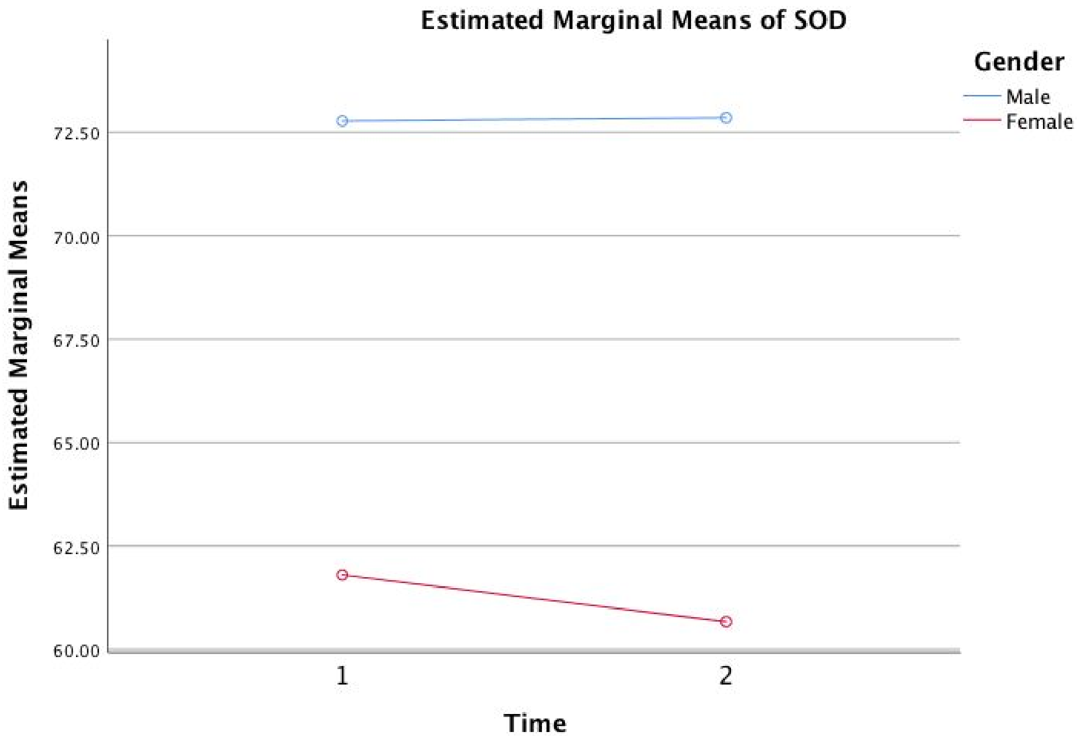

Figure 4.25. *Gender - Sense of Direction (SOD)*

Classification

Card Rotation

A one-way repeated measures ANOVA was conducted to determine whether classification was a statistically significant factor on pre-study and post-study spatial ability test scores. Classification was not a statistically significant factor in performance on the card rotation test, $F(2, 25) = 1.028$, $p = 0.372$; Wilks' $\Lambda = 0.346$; partial $\eta^2 =$

0.076. However, although they were not statistically significant, there were several trends. Undergraduate students and graduate students had similar scores on the first test, although graduate students had the highest scores on the second. Graduate students also had the highest rate of improvement between the two tests. Staff had the lowest scores on both the first and second tests.

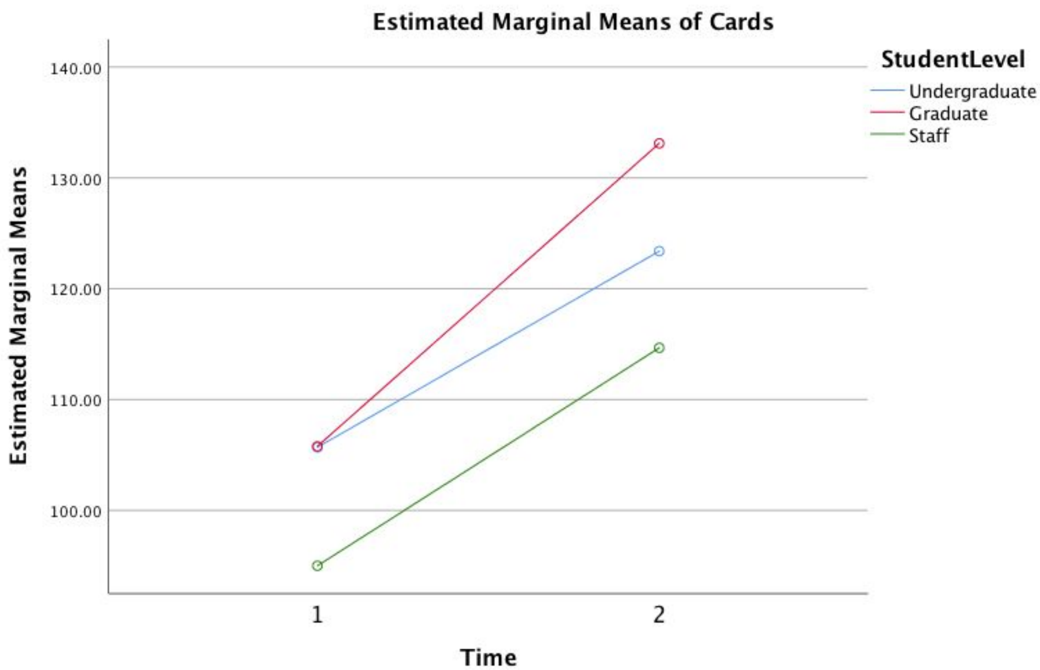

Figure 4.26. *Classification - Card Rotation*

Cube Comparisons

A one-way repeated measures ANOVA was conducted to determine whether classification was a statistically significant factor on pre-study and post-study spatial ability test scores. Classification was not a statistically significant factor in performance on the cube comparisons test, $F(2, 25) = 2.361$, $p = 0.115$; Wilks' $\Lambda = 0.391$; partial $\eta^2 = 0.159$. However, although they were not statistically significant, there were several trends. Graduate students had the highest scores on both tests. Staff had the lowest scores on the first, but had the highest rate of improvement from the first to second test. Undergraduate students had the lowest scores on the second test.

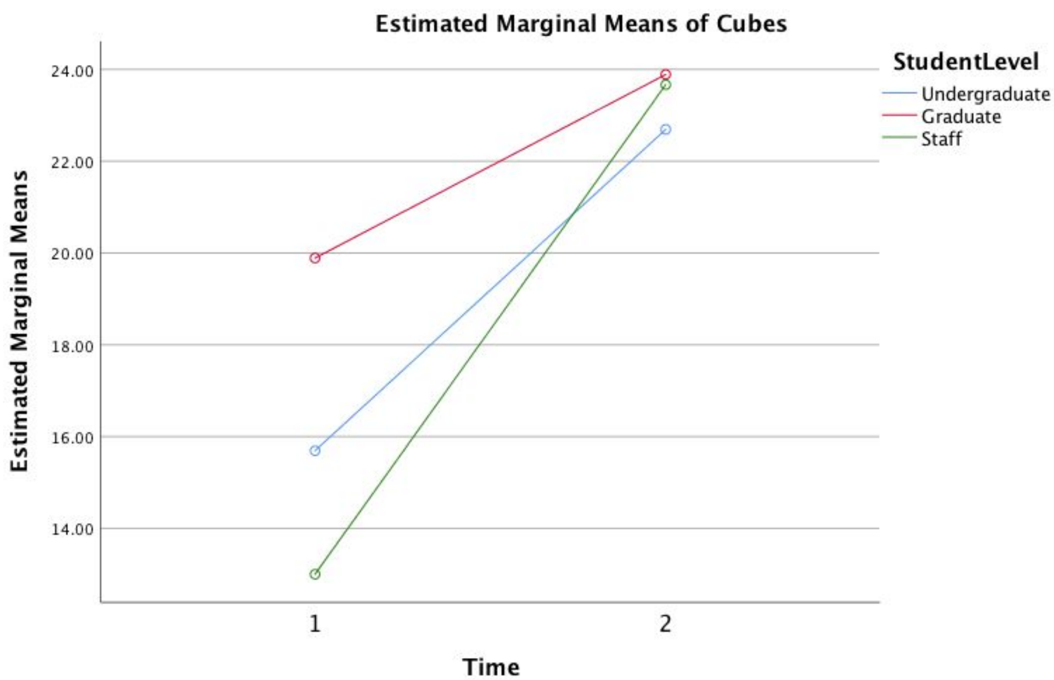

Figure 4.27. *Classification - Cube Comparisons*

Self-Reported Sense of Direction

A one-way repeated measures ANOVA was conducted to determine whether classification was a statistically significant factor on pre-study and post-study spatial ability test scores. Classification was a statistically significant factor in self-reported sense of direction, $F(2, 25) = 4.141$, $p < .05$; partial $\eta^2 = .249$. Staff had the highest self-reported sense of direction on both questionnaires while undergraduate students had the lowest self-reported sense of direction on both. However, undergraduate self-reported sense of direction increased from the first test to the second while staff and graduate students' self-reported sense of direction decreased. The scores of graduate students decreased more than those of staff.

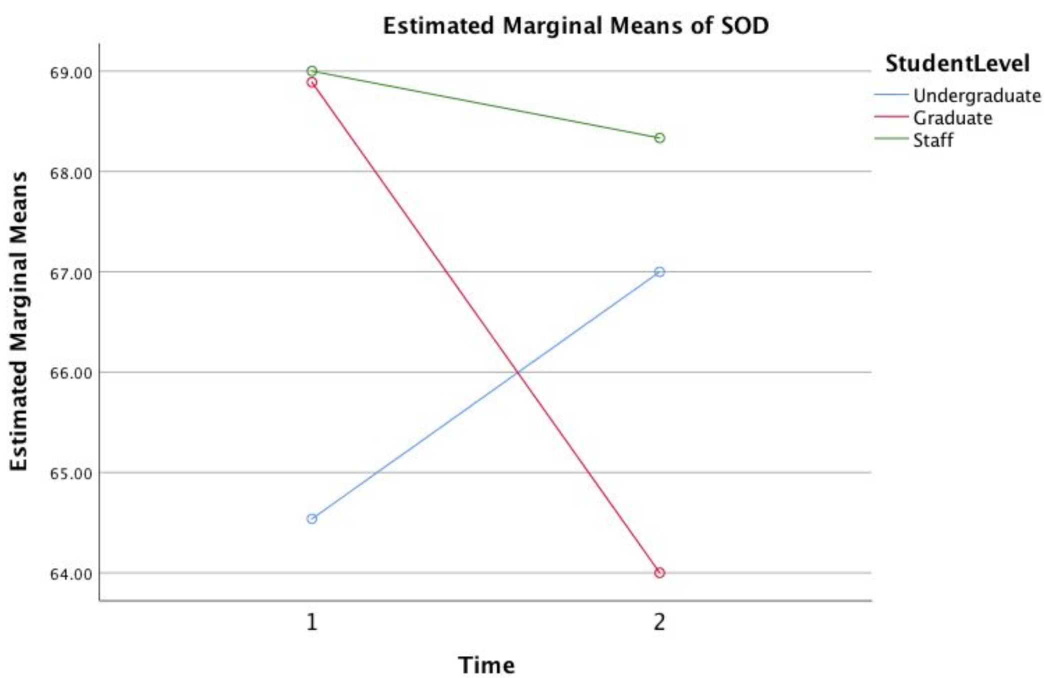

Figure 4.28. *Classification - Sense of Direction*

5. DISCUSSION

5.1 Discussion

The goals of this study and the analysis of its collected data were to develop an understanding of the implications of the data in regards to the following main research questions:

1. Does engaging in interactive fiction games increase spatial ability?
2. Does engaging in progressively harder interactive fiction games increase spatial ability?
3. What types of spatial encoding strategies do people use to engage in interactive fiction?
4. What are the effects of engaging in interactive fiction on story understanding?

The study provided data about the effects of interactive fiction and engaging in progressively harder interactive fiction games on spatial ability. It also investigated spatial encoding strategies in interactive fiction, as well as the effects of interactive fiction on story understanding. This section will interpret and go into more detail about the results.

5.1.1 Interactive fiction and spatial ability

The results of the study show that playing interactive fiction games, despite their navigational demand, does not increase spatial ability. Although the test scores for the experimental group did improve from pre- to post- intervention on both the Card Rotation and Cube Comparison tests, the scores of the control group also saw a similar level of improvement. Because of this, it is not possible to say conclusively whether or not interactive fiction has any effect on spatial ability test scores from our study.

There are several ways this may be further investigated in the future in order to obtain more conclusive data. This study took place over only three days, although it is possible that testing over a longer period of time could provide more certain results. Additionally, another version of the Card Rotations and Cube Comparisons tests could be created in order to minimize the effect of episodic memory on participants' spatial test scores, as was also the case with the results of Lohman and Nichols in 1990. In both cases, since the pre-intervention and post-intervention tests were the same, participants may have remembered specific details about questions. Answer choices were randomized, but participants were already familiar with the questions from the first test and may have remembered information that could have possibly contributed to the increases in scores even in the control group. Creating two separate tests for pre- and post would eliminate this as a possible factor would most likely lead to the collection of more reliable data.

5.1.2 Engaging in progressively harder interactive fiction and spatial ability

Since there was no evidence in the study that engaging in interactive fiction games increases the spatial abilities of players, there was also no evidence that engaging in progressively harder interactive fiction games increases spatial ability either. Results indicated that sense of direction in IF and map multiple choice over time first decreased before then increasing again towards the end of the study. Performance on both of these measures was lowest on IF number 4, which is the game in which the difficulty was increased one level. After IF number 4, performance on map multiple choice and self-reported sense of direction in IFs number 5 and number 6 increased, seeming to suggest that IF players were adapting to the higher level of spatial difficulty. Based on this trend, it is likely that the spatial abilities of IF players would continue increasing and eventually surpass those of non-IF players in a longer intervention. However, this was not reflected in any statistically significant results on the spatial ability test scores in this study. This study also had a relatively small sample size, and increasing the number of participants may lead to collection of more conclusive data.

As stated in the previous section, further research could include a longer intervention with more participants playing more interactive fiction over a greater period of time in order to obtain more conclusive results. A longer intervention could also benefit from having have more than 3 levels of difficulty in order to better examine the potential effects of engaging in progressively harder interactive fiction on spatial ability test scores.

It is also possible that there was not a large enough gap between different difficulty levels of IFs utilized in this study. The number of rooms only differed by 2 in each level of difficulty, which may not have been enough of a difference. It is also possible that even in the most difficult version of the games, in which there were 10 rooms, were still within the users' zone of proximal development as laid out by Vygotsky (1978). His theory states that there are 3 zones: what a learner can currently do, what they will be able to do with guidance, and what they cannot do. It is possible that all of the levels of difficulty of the games used in this study may have fallen within the first category and, thus the intervention would not have been effective in helping participants to improve their abilities since they may not have been sufficiently challenged. An intervention such as in this study should ideally fit into the second category, which could achieved with more certainty by adding more levels of difficulty and increasing the differences between levels of difficulty. This too would benefit from a longer period of intervention.

5.1.3 Spatial encoding strategies in interactive fiction

The qualitative results of this study show a wide variety of spatial encoding strategies used by the participants in the interactive fiction games. Post-study interviews were conducted with participants in which they were asked about their sense of direction in the games and any navigational strategies they utilized. Their responses were transcribed and analyzed. The 54 total responses were coded into 13 categories. These codes were then grouped by content into 9 unique sets.

The results of this study further support the conclusion that interactive fiction players are creating spatial mental representations of the environment as discussed by Gander (2004) possibly due to the navigational demand of the medium. Many of these sets included answers that provided evidence that players were using spatial mental models, although not all. For example, the sets “Using Information Provided by the Game,” “Using Paper to Write/Draw,” “Trial & Error,” and “Command

Sequence/Programming" do not provide evidence to support this conclusion. Responses in these categories do not include any spatial information, instead relying on provided information, chance, or command memorization. However, the other 5 sets do include information that supports spatial mental models in interactive fiction and will be discussed next.

Many of the interview responses indicated that participants were utilizing a hierarchical frame of reference (for example, describing some rooms as being "inside the castle") to describe the game space, such as is found when using spatial mental models (Tversky 2000). Some relatively frequent responses, mainly in the "Mental Models/Visualizations" and "Common Sense/Real World Layout" sets supported this when participants were asked which of the games was the most difficult to navigate. Interestingly, despite the fact that all 3 games of the same level of difficulty had the same number of rooms, participants regularly described Beauty and the Beast game as the most difficult to navigate, followed by Cinderella. When prompted about why they had the most difficulty in these games, participants' answers often included comments that they got lost or turned around inside the beast's castle in the Beauty and the Beast game, and in the stepmother's house in the Cinderella game. The fact that players were categorizing the space of the castle or house within the space of the game, and were also grouping rooms by their location within the space of the castle or house shows that they were describing the environment in hierarchical terms. This supports the idea that participants did in fact have some sort of spatial mental representation of the game space.

A set of interest is that of the “Mental Models/Visualization” set. Participants described answers in this category in ways that suggested they had general mental models, or in some cases mental “mini-maps” of the environment. Responses in this set showed that participants were actively trying to create, update, or maintain some sort of mental map of the game environment. In some cases, responses showed that players even attempted to memorize the layout of the rooms they traveled through in the beginning of the game so that they could navigate back to the start efficiently during the final encounter at the end of the game.

Another set of responses, the “Sense of Direction” set, included answers that indicated participants had a vague idea of where rooms were located in relation to each other in a way that did not qualify as a map. They might have had a general overall idea of the layout, but would not necessarily have been able to verbalize the exact sequence of directions needed to travel from one room to another without the provided game information. These responses were classified as participants having a sense of direction within the virtual space and contributes to the theory that they had spatial mental representations whose knowledge had come from reading descriptions of space in IF and navigating through it.

The “Hubs/Room Connections” and “Using Knowledge from Previous Playthroughs” sets also contained some interesting responses. The “Hubs/Room

Connections" set contained answers that also pointed towards a hierarchical organization of space in the IF games. Responses in this set indicated that participants were thinking of rooms in terms of clusters or groups and in terms of their connections. This could be considered hierarchical in that it showed that players were grouping rooms based on their spatial relationship to the hub room. The "Using Knowledge from Previous Playthroughs" set showed that participants had retained some information about the spatial layout of the game from their first playthrough and could recall it during their second playthrough. They used this to their advantage in some cases to complete the game more quickly in spite of the increased difficulty level. This supports the theory of spatial mental models in IF games because it demonstrates that players stored and remembered information about the game environment and were able to utilize it at a later time.

This study did provide further evidence that supports the theory that players may be making use of spatial mental models in order to navigate environments in IF. Despite this, there was not enough data gathered regarding the navigational demand presented by spatiality in interactive fiction and any effects it might have as training for spatial ability test scores. This could certainly be investigated more thoroughly in future work in order to gain more conclusive data.

5.1.4 Interactive fiction and story understanding

The results show that story understanding of interactive fiction players improved significantly after playing the interactive fiction games while the control group did not across all 3 stories used in the games. Familiarity of IF players improved overall for all stories in this study, regardless of gender or classification. In some cases, participants even went from not knowing the story at all pre-study to indicating familiarity and writing an accurate summary post-study. This points to evidence that interactive fiction does help players to become more familiar with stories, and shows that it could have possible applications as a method for improving story familiarity, although this would need to be studied further.

When investigating this aspect of information in the future, it would be best to also include a control group for story who would read a non-interactive version of the stories used in the IF games. In this way, the data of the players and non-players could be compared, and any differences in the effect of interactivity on story understanding could be examined. Additionally, future work could also be done to learn more about whether interactive fiction could be used to improve other knowledge bases besides story familiarity, such as with educational or navigational training applications.

6. CONCLUSION

6.1 Conclusion

Research has been done in the areas of spatial cognition, interactive fiction, and developing interventions to improve spatial ability test scores, however, interactive fiction has not previously been examined as a means to improve spatial ability. In this thesis, 9 interactive fiction games were developed using 3 stories with 3 levels of difficulty each. An interactive fiction intervention was implemented over the course of 3 days with study participants playing progressively harder interactive fiction games to examine the effects on their spatial ability test scores.

Both qualitative and quantitative data about participants' performance in IF games and on spatial ability tests was collected and analyzed. The results were presented based on the research questions posed. Results were inconclusive in terms of investigating the effects of engaging in interactive fiction games or engaging in progressively more difficult interactive fiction games on spatial ability test scores. This study was more effective in obtaining data regarding spatial encoding strategies in IF and using interactive fiction games to increase story familiarity.

Based on the results of this study, it is not possible to say conclusively if the navigational demand present in interactive fiction can function as spatial cognition training. However, the data does further support the theory that players have spatial mental models of the environment in interactive fiction. The results also show that interactive fiction can be an effective method for increasing the story familiarity of its players.

6.2 Study Limitations

This study had several limitations. Duration and sample size were two of the limiting factors, as the study intervention was only implemented over a 3 day period and the study only included 20 participants in the experimental group and 8 in the control group. This study also only had participants play 6 games in total, with only 2 different levels of difficulty each. Another limitation of this study may have been the spatial ability tests used. This study utilized the same spatial ability tests both pre-study and post-study. Although the answer choices were randomized, it is possible that familiarity with the questions from the first test affected performance on the second test. Lastly, this study did not have a control group that read a non-interactive version of the stories, so there was no way to examine the effects of interactivity on story familiarity.

It is also important to note that this study and its conclusions are limited to the spatial-style IF games utilized. There is a wide variety of IF games, and this study only investigated one type. It is possible that features of other types of IF games, that included additional elements such as puzzles to solve, would have different effects, although we hypothesize that this may detract from spatial understanding in the games.

6.3 Future Work

There are many potential areas for future work relating to spatial cognition in interactive fiction. Some of these could involve expanding upon the study presented in this thesis, such as by addressing some of the study limitations above. This could lead to gaining more reliable data about the effects of playing interactive fiction games on spatial ability test scores. One aspect of this study that could also be examined further would be that of game transcripts, which could be captured as users play and then later be analyzed. The number and type of movement-based commands could help to further inform our understanding of how users were approaching the games and navigating through the game environment. This study also utilized games with stories with which most players would be familiar. It would be interesting to examine the the differences between performance in IFs with familiar stories and those with original unfamiliar stories. It is possible that story familiarity could play a role in engagement or enjoyment, for example.

Another area that would be interesting to examine would be the effects of experience with a visual-spatial language, such as American Sign Language, on spatial cognition in interactive fiction. As a visual language, American Sign Language relies on space itself to convey meaning and grammatical structure. Previous research has shown that experience with certain linguistic requirements of a visual-spatial language like ASL such as assigning meaning to space may lead to an enhancement of mental image generation ability. (Emmorey et al., 1993). ASL also necessitates the use of mental rotation and perspective shift, and research suggests that experience with this characteristic of ASL leads to an improved ability to evaluate and generate mirror images. (Emmory et al., 1993). It would be interesting to examine how such enhanced imagery abilities would affect navigation in unseen virtual environments such as in interactive fiction.

REFERENCES

Barrett, James. *The Ergodic revisited: spatiality as a governing principle of digital literature*. Diss. Umeå University, 2015.

Bryant, Kendall J. "Personality correlates of sense of direction and geographic orientation." *Journal of personality and social psychology* 43.6 (1982): 1318.

Cadre, Adam. "9:05." *9:05 by Adam Cadre*. N.p., 2000. Web. 23 Apr. 2017.

Douglass, Jeremy. *Command Lines: Aesthetics and Technique in Interactive Fiction and New*. Diss. UNIVERSITY OF CALIFORNIA Santa Barbara. (2007)

Ekstrom, Ruth B., et al. "Manual for kit of factor-referenced cognitive tests." *Princeton, NJ: Educational testing service* (1976).

Emmorey, Karen. "Visual imagery and visual-spatial language: Enhanced imagery abilities in deaf and hearing ASL signers." Cognition 46.2 (1993):139-181. Web.

Gander, Pierre. "Spatial Mental Representations in Interactive Fiction: What Is Particular about the Interactive Text?." *L'Unitétexte Pleyben, France: Perspectives* (2004): 96-124.

Gillner, Sabine, and Hanspeter A. Mallot. "Navigation and acquisition of spatial knowledge in a virtual maze." *Journal of Cognitive Neuroscience* 10.4 (1998): 445-463.

Gittler, Georg, and Judith Glück. "Differential transfer of learning: Effects of instruction in descriptive geometry on spatial test performance." *Journal of Geometry and*

Graphics 2.1 (1998): 71-84.

Guilford, J. P. "Thurstone's primary mental abilities and structure-of-intellect abilities." *Psychological Bulletin* 77.2 (1972): 129.

Hegarty, Mary, et al. "Development of a self-report measure of environmental spatial ability." *Intelligence* 30.5 (2002): 425-447.

Koenitz, Hartmut. *Interactive Digital Narrative: History, Theory and Practice*. Routledge, 2015.

Lohman, David F., and Paul D. Nichols. "Training spatial abilities: Effects of practice on rotation and synthesis tasks." *Learning and Individual Differences* 2.1 (1990): 67-93.

Maher, Jimmy. "Let's Tell a Story Together: A History of Interactive Fiction." (2006).

Malone, Thomas W., and Mark R. Lepper. "Making learning fun: A taxonomy of intrinsic motivations for learning." *Aptitude, learning, and instruction* 3.1987 (1987): 223-253.

Mitchell, Alex, and Kevin McGee. "Reading again for the first time: a model of rereading in interactive stories." *International Conference on Interactive Digital Storytelling*. Springer Berlin Heidelberg, 2012.

Moffat, Scott D., Elizabeth Hampson, and Maria Hatzipantelis. "Navigation in a "virtual" maze: Sex differences and correlation with psychometric measures of spatial ability in humans." *Evolution and Human Behavior* 19.2 (1998): 73-87.

Nelson, Graham. "The Craft of Adventure: Five Articles on the Design of Adventure

Games." *IF Archive* (1995).

Osberg, Kimberley. "Spatial cognition in the virtual environment." (1997).

Plotkin, Andrew C. "Rating Systems." 22 July 1996. E-mail.

Roussou, Maria. "Learning by doing and learning through play: an exploration of interactivity in virtual environments for children." *Computers in Entertainment (CIE)* 2.1 (2004): 10-10.

Schaie, K. Warner. *Intellectual development in adulthood: The Seattle longitudinal study*. Cambridge University Press, 1996.

Short, Emily. "Geography." *Emily Short's Interactive Storytelling*. N.p., 24 Jan. 2007. Web. 12 Apr. 2017.

Siegel, Alexander W., and Sheldon H. White. "The development of spatial representations of large-scale environments." *Advances in child development and behavior* 10 (1975): 9-55.

Stevens, Albert, and Patty Coupe. "Distortions in judged spatial relations." *Cognitive psychology* 10.4 (1978): 422-437.

Corbin, Juliet, and Anselm Strauss. "Basics of qualitative research: Techniques and procedures for developing grounded theory." (2008).

Thurstone, L. L. "Some primary abilities in visual thinking." *Proceedings of the American Philosophical Society* 94.6 (1950): 517-521.

Tversky, Barbara. "Cognitive maps, cognitive collages, and spatial mental models." *Spatial information theory a theoretical basis for GIS* (1993): 14-24.

Tversky, Barbara. "Levels and structure of spatial knowledge." *Cognitive mapping: Past, present and future* (2000): 24-43.

Tversky, Barbara, Paul Lee, and Scott Mainwaring. "Why do speakers mix perspectives?." *Spatial cognition and computation* 1.4 (1999): 399-412.

Vinson, Norman G. "Design guidelines for landmarks to support navigation in virtual environments." *Proceedings of the SIGCHI conference on Human Factors in Computing Systems*. ACM, 1999.

Vygotsky, Lev. "Zone of proximal development." *Mind in society: The development of higher psychological processes* 5291 (1987): 157.

Wolf, Mark JP. "Inventing space: Toward a taxonomy of on-and off-screen space in video games." *FILM QUART* 51.1 (1997): 11-23.

APPENDIX A

Cinderella Playthrough Transcript

You awaken at dawn to the sound of a rooster crowing. You should probably **go to the kitchen** to get breakfast for your stepsisters.

This is the bedroom of the small cottage your stepmother allows you to live in.

To the South is the living room.

You can see a bed.

A small living room. It's not much, but your stepmother and stepsisters don't bother you here.

Your bedroom is North and the courtyard is West.

You can see a chair.

You are in the courtyard.

Your cottage is East and the mansion's grand entryway is West.

You can see chickens.

The grand entryway of your late father's mansion.

The parlor is to the North, the courtyard is East, and the village is West.

You can see a mop and a broom.

You are in the parlor.

The kitchen is West, the hall is North, and the entryway is South.

You can see a cat, a sofa and a harp.

You are in the kitchen. Your unfortunate nickname comes from the soot that covers your clothes from tending to the fire in here.

The parlor is East.

You can see a sink and a stove.

You make omelettes for your stepsisters. You should probably **take them to your stepsisters.**

You are in the parlor.

The kitchen is West, the hall is North, and the entryway is South.

You can see a cat, a sofa and a harp.

You are in the hall.

The parlor is South and your stepsisters' room is East.

You can see a painting.

You are in your stepsisters' room. No matter how often you tidy up, it always looks like a tornado has just passed through.

The hall is West.

You wake up your stepsisters and they devour the omelettes, all the while chattering excitedly about the ball at the castle tonight. You say nothing but are secretly hopeful that you'll be able to attend as well.

Maybe if you **mop the entryway** your stepmother will let you go to the ball!

You can see dirty dishes and your stepsisters.

You are in the hall.

The parlor is South and your stepsisters' room is East.

You can see a painting.

You are in the parlor.

The kitchen is West, the hall is North, and the entryway is South.

You can see your stepmother, a cat, a sofa and a harp.

The grand entryway of your late father's mansion.

The parlor is to the North, the courtyard is East, and the village is West.

You mop the floors until they practically sparkle. It will be worth if if you get to go to the ball!

You stepmother and stepsisters arrive in the room dressed in their finery and your stepmother surveys your work.

"You have done a lovely job cleaning the floor, Cinderella. You could certainly come to the ball with us... if you had something suitable to wear." She smiles coldly.

"Make sure to have omelettes ready when we come back!" demand your stepsisters. They slam the door, leaving you standing alone with the mop.

You really thought you might get a chance to go to the castle… Maybe you should just **go back to your room.**

You are in the courtyard.

Your cottage is East and the mansion's grand entryway is West.

You can see chickens.

All of the sudden, a woman appears in a blinding flash of light!

"Hello, Cinderella," she says. "I am your fairy godmother. And I think you should go to the ball!"

She waves her wand and your clothes and shoes are magically transformed into a beautiful dress and glass slippers.

"The spell will only last until midnight," she warns. "But until then, you should **go to the ball at the castle** and enjoy every moment!"

The grand entryway of your late father's mansion.

The parlor is to the North, the courtyard is East, and the village is West.

You can see a mop and a broom.

The quaint village near your home.

The mansion's entryway is East and the prince's castle is South.

You can see a clocktower and a fountain.

You are at the castle

The village is North.

The ball is every bit as wonderful as you'd hoped it would be! The prince even asks you to dance!

You dance with him for a while, then look at the clock and notice that it's almost midnight! Oh no!

"Is something wrong?" asks the prince.

You exit the dance floor. The prince follows you, but you've started running. You hardly notice when one of your glass slippers comes off.

You have to **get back to the kitchen** before midnight!

The clock chimes once. You can't believe it's already almost midnight!

The quaint village near your home.

The mansion's entryway is East and the prince's castle is South.

You can see a clocktower and a fountain.

The clock chimes twice more. You have to hurry!

The grand entryway of your late father's mansion.

The parlor is to the North, the courtyard is East, and the village is West.

You can see a mop and a broom.

The clock continues chiming. You don't even want to think about what will happen if you're not home when the spell breaks.

You made it home in time! Just as you enter the parlor, the spell is broken and your beautiful gown turns back into soot-covered rags.

You rush to the kitchen to get the omelettes ready for your mother and stepsisters. You can't give them any reason to believe you weren't here the whole time they were gone! You try to look as innocent as possible when they get back, but they don't seem suspicious.

Press any key to continue

The next day, the prince and his servant knock on the door. The prince is looking for the girl who lost the glass slipper last night. He is going to try the shoe on every girl in the kingdom to find its owner.

Your stepsisters both try on the slipper, but it doesn't fit. Then it's your turn.

"There cannot be any reason for Cinderella to try on the shoe!" laughs your stepmother. "She wasn't even at the ball!"

The prince and the servant look at you for the final decision.

Do you **insist** on trying on the shoe or **accept** your stepmother's words?

"I think I will try on the slipper," you say.

Of course, it's a perfect fit!

You marry the prince, move to the castle, and live happily ever after!

The End.

Little Red Riding Hood Playthrough Transcript

You wake in the morning ready to start your day. You're going to visit Grandma today!

This is the home you live in with your family. It is quaint and cozy, and has a lovely fireplace that keeps it warm in the winter.

To the West is the village square.

You can see Mother, a fireplace, a broom and a table.

The village square is normally filled with people, but it's quite empty this early in the morning.

The bakery is to the North, the bridge is South, and home is East.

You can see a fountain and a clocktower.

Mother gives you a basket as you leave the house. You should probably **stop at the bakery** before you go to Granny's house.

You are in the bakery.

The village square is South.

You can see a the baker, a counter and a bag of sesame seeds.

The baker puts a bunch of yummy goodies into your basket, still hot and steaming.

It's time to **go to Grandmother's House!**

The village square is normally filled with people, but it's quite empty this early in the morning.

The bakery is to the North, the bridge is South, and home is East.

You can see a fountain and a clocktower.

You find yourself on a charming stone bridge that arches over a gentle river.

The village square is North and Grandmother's house is West, through the woods.

You can see a frog.

You are in the Woods. At night they are dangerous and foreboding, but in the bright sunshine today, they are really quite lovely. Birds chirp merrily up in the tree branches.

The bridge is East, Grandmother's house is West, and there is a flower field to the North.

A wolf blocks your path. He looks hungry. Maybe if you give him some of you goodies he won't bother you?

Will you **share** with the wolf or **refuse**?

You are in the Woods. At night they are dangerous and foreboding, but in the bright sunshine today, they are really quite lovely. Birds chirp merrily up in the tree branches.

The bridge is East, Grandmother's house is West, and there is a flower field to the North.

"Thank you kindly," says the wolf as he crunches a cookie. "Listen, there's a lovely little flower field just to the north of here. I know if I were sick in bed a colorful bouquet would certainly brighten my day."

The wolf slinks back into the deep forest and you let out a breath you didn't realize you'd been holding. That was a close one!

You should probably **go get some flowers.**

You can see trees.

You emerge from the woods and stumble into a field full of flowers. You look uncertainty back towards the path. But really, you aren't that far from it, you reason with yourself.

The woods are South.

You can see bees and a flowers.

You pick some flowers for Granny.

Now you're all ready to **go to Granny's house!**

You are in the Woods. At night they are dangerous and foreboding, but in the bright sunshine today, they are really quite lovely. Birds chirp merrily up in the tree branches.

The bridge is East, Grandmother's house is West, and there is a flower field to the North.

You can see trees.

You are in a peaceful clearing.

The woods are East and Granny's front yard is South.

You can see a bird.

You are in Granny's front yard. The aging stone cottage that Granny calls home is surrounded by the picturesque scenery of the woods. Granny must be home, for you can see smoke coming from the chimney.

The clearing is North, and the way in to Granny's house is South.

You can see a garden gnome and a picket fence.

You are in Granny's living room.

Granny's front yard is North and her bedroom is East.

"Granny? It's me, Little Red Riding Hood. I've brought something for you!" you call as you shut the door behind you. Only silence greets you. That's strange. Maybe Granny is taking a nap?

You can see an end table (on which there is a photo and a doily) and a sofa.

You are in Granny's bedroom.

Granny's living room is West.

You can see a bed.

Oh no! Granny isn't here! It's the wolf from before!

Your only hope is to **run back to the village before the wolf catches you!**

You take off running. The wolf is off to a slow start, but that won't last for long. You have to get back to the village!

You are in Granny's living room.

Granny's front yard is North and her bedroom is East.

You can see an end table (on which there is a photo and a doily) and a sofa.

You hear a howl from behind you. The wolf is starting the chase!

You are in Granny's front yard. The aging stone cottage that Granny calls home is surrounded by the picturesque scenery of the woods. Granny must be home, for you can see smoke coming from the chimney.

The clearing is North, and the way in to Granny's house is South.

You can see a garden gnome and a picket fence.

You hear a commotion behind you. The wolf must be picking up your scent!

You are in a peaceful clearing.

The woods are East and Granny's front yard is South.

You can see a bird.

You can see the wolf now as he charges towards you. Your only hope is to make it back to the village!

You are in the Woods. At night they are dangerous and foreboding, but in the bright sunshine today, they are really quite lovely. Birds chirp merrily up in the tree branches.

The bridge is East, Grandmother's house is West, and there is a flower field to the North.

You can see trees.

The wolf is getting closer!

You find yourself on a charming stone bridge that arches over a gentle river.

The village square is North and Grandmother's house is West, through the woods.

You can see a frog.

The wolf is gaining on you! Hurry!

The village square is normally filled with people, but it's quite empty this early in the morning.

The bakery is to the North, the bridge is South, and home is East.

You can see a fountain and a clocktower.

You made it to the safety of the village! Your fellow villagers help you save Granny from the wolf.

Beauty and the Beast Playthrough Transcript

You wake in the morning to discover your father has not returned home. You decide to **look for him in his workshop.**

This is the home outside of the village where you live with your father.

To the East is the village square.

You can see a fireplace, a table and a sofa.

The village square is bustling with activity as usual.

Home is West, Father's workshop is South, and the forest is North.

You can see the baker and a fountain.

You are in Father's workshop.

The village square is North.

Your father isn't here, but you see the note he left you 3 days ago. The note reads:

"Belle,

I've gone to the next town on business.
Please don't worry, I will be back in the morning.

Love,

Papa"

You're starting to get worried. You take the note with you and decide to **go look for your father in the forest.**

You can see Father's inventions and a workbench.

The village square is bustling with activity as usual.

Home is West, Father's workshop is South, and the forest is North.

You can see the baker and a fountain.

You are in the forest outside of the village.

The village square is South and there are gates to the East.

Maybe you should **see what's through those gates**. Father might be nearby!

You are standing in front of a set of iron gates. They appear to be open.

The forest is West and you can see a castle to the East.

You can see the gates.

You are in what was once a grand entrance hall.

The castle gates are West, there appears to be a tower to the North, and large double doors suggest a ballroom to the East.

You can see a clock.

You are in a grim cell-like room in a tall stone tower.

The entryway is South.

Your father is here! Unfortunately he appears to be locked behind iron bars and he doesn’t look well.

"Father, I have to get you out of here!” you say. “Who has the keys?" You tug as hard as you can on the cell bars, but they don't budge.

"I think he’s in the West Wing... But never mind that now..." He starts muttering nonsense to himself. You have to do something!

You should **go to the West Wing** to find whoever locked up your father and give him a piece of your mind!

You can see bars and Father.

You are in what was once a grand entrance hall.

The castle gates are West, there is a tower to the North, and the ballroom is to the East.

You can see a clock.

You are in a ballroom.

The entryway is West and there is a library to the South.

You can see a chandelier.

You are an impressive library. Bookshelves stretch up to the ceiling.

The ballroom is North and the west wing is West.

You can see bookshelves, books and a candelabra.

You are in the west wing.

The library is East.

You enter the West Wing and see a large figure obscured by shadows. This must be the one who imprisoned your father.

"Who do you think you are, keeping my father here like this? You must let him go at once!" You furiously march closer to the figure.

Suddenly the figure turns and you can't help but gasp.

It's a beast. He's got fangs, razor sharp ones.

"He came into my home without invitation," growls the beast. "As did you. One of you will stay as my prisoner."

Do you **trade** yourself for your father or **stand up** to the beast?

You look the beast in the eyes. "Take me instead."

The beast sets your father free and you remain in the castle to live with him.

You are in the west wing.

The library is East.

Time has passed and you have begun to grow fond of the beast. He's not nearly as bad as you first thought.

Eventually you were no longer a prisoner, but a guest. You are free to come and go as you like and you visit your father whenever you want.

In fact, you think you will **go and visit your father at home** today.

You can see the beast.

You are in the library. You've spent a lot of time here, but there are still so many books left to read!

The ballroom is North and the west wing is West.

You can see bookshelves, books and a candelabra.

You are in the ballroom.

The entryway is West and your library is to the South.

You can see a chandelier.

You enter the entrance hall.

The castle gates are West, there is a tower to the North, and the ballroom is to the East.

You've spent a lot of time in the castle and you've found that you actually enjoy your time here.

So when you see an angry mob marching up to the castle gates, you know you have to do something.

Father and his inventions can help! You need to **go home and get your father** before the mob takes over the castle!

You can see a clock.

You are standing in front of a set of iron gates. They appear to be open.

The forest is West and you can see a castle to the East.

You can see an angry mob and the gates.

You reach the gates, and you can see the mob approaching. You have to get back to your house before it's too late!

You are in the forest outside of the village.

The village square is South and the gates are to the East.

The mob has reached the gates.

The village square is bustling with activity as usual.

Home is West, Father's workshop is South, and the forest is North.

You can see the baker and a fountain.

The mob is through the gates and is approaching the entrance hall

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This is the home just outside of the village where you live with your father.

To the East is the village square.

You can see a fireplace, a table, a sofa and Father.

You made it home in time, and you and your father rush back to the castle. With the help of his inventions, you chase the angry mob from the castle and save the beast, who is actually a prince. He has transformed back into a human and you live happily ever after.