Navigation and immersion of blind players in text-based games

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Abstract

Text-based games offer a compelling opportunity for sighted and non-sighted players to interact. Studies on navigation show that spatial mental models are encoded differently across both groups of players. While sighted people tend to view the environment from an overview representation (allocentric), non-sighted people more frequently do so from an egocentric perspective. We investigate whether a text-based game's navigation system should be presented using both perspectives to support immersion for sighted and non-sighted players alike. An evaluation of the fit of both systems using a between-subject user study supports the hypothesis that egocentric directions are easier to use and more immersive for non-sighted players, while sighted players perform better with allocentric directions. The discussion offers insights into how these results can be interpreted and operationalised for the design of text-based games or other inclusive software.

Keywords: **text-based games, immersion, blind players, allocentric, egocentric, study, participants**

Article Information

Received: October 2014
Accepted: October 2014
Available: online November 2014

1: Introduction

Creating an interesting and immersive game without an exclusively visual interface requires methods for development that cater to other modalities. Elements in games can be enriched in their representation if presented along multiple modal axes (pictures, sound, etc.). There are also different ways in which navigation can be presented (e.g., in visual 3D games: first person, eagle eye perspective, and so on). Text-based online role-playing games attract blind and sighted players alike. However, these two groups of players frequently navigate using different systems in their everyday lives, and hence might encounter different levels of difficulty with different systems of navigation. Such difficulties can directly influence the immersive game experience of a player. This contribution investigates whether text-based games can benefit from allowing players to navigate in their most commonly used system, and if this can additionally improve the game's immersive quality.[1 - 3]

Multi-player variants of text-based online games can be explored as virtual spaces, where the abilities and disabilities of a player might not matter as much as they do outside the game world. Sighted and non-sighted players can interact and compete on a relatively even playing field. Text based games and especially IF (Interactive Fiction) and MUDs (Multi User Dungeons) are still actively played by a loyal community worldwide. There also have been blind programmers and staff members developing several games. Despite the potential that text-based environments have with regards to equal opportunities of interaction, the needs of visually impaired users are often not addressed as well as they could and should be (according to Woolcock (2013), who explained how text-based games can be improved with mostly graphical additions). Research into immersion, a factor especially relevant to worlds where fictive text is the key element of representation, seldom incorporates the possibility of limited perceptive abilities of an audience. Furthermore, in some studies that have previously been conducted on this topic, a visual bias could be identified with regards to sighted researchers. Sighted researchers have conducted the research discussed in this paper as well, but the assistance of blind and visually impaired players has been actively sought out throughout the entire process in order to address potential bias issues.[4 - 6]

The two different navigation systems through a textual world are egocentric directions (such as left, right, forward and backwards) and allocentric directions (such as north, south, east and west). Primarily, text games with map based navigation use the latter, although use of the former is not unknown. When looking into the differences between these two ways of navigating through a textual world, the following question arises: which of these navigation systems in text based games is easier use and is more immersive for blind players, and which is more immersive for sighted players?

2. Navigation and Immersion for Sighted and Blind Players

The issues of text-based games, immersion, blind players and navigation have often been discussed separately or in pairs in previous research. Combining these issues, however, gives more insight into how different aspects of game influence certain player groups. Academic research referring to MUDs has so far tended to focus on social effects during play. If blind players are mentioned at all, only their existence is noted. Other work dealing with text-based games discusses the principles of creating them, developer frameworks, or the philosophical implications.[7 - 14]

1.1. Perception in Navigation

The terms 'allocentric' and 'egocentric' are used here in reference to Klatzky (1998), and Meilinger and Vosgerau (2010). According to Brunye and Taylor (2008), spatial descriptions can be encoded as an overview ('survey') or as situational ('route'). A survey can be seen as an extrinsic frame of reference with a third-person (allocentric) perspective, while a route description can be seen as an intrinsic frame of reference with a first-person (egocentric) perspective. Both descriptions lead to abstracted and comprehensive spatial mental models, in which participants encode the information about the relationships of objects in space. Increased experience with the environment creates a more accurate model. A route description written from an ego-perspective and a survey description suggests an overview or eagle eye perspective. An egocentric navigation system can be interpreted as a route representation, whereas an allocentric system works as a survey description.[3, 15 - 17]

The orientation of an avatar in relation to the room it is standing inside is not directly provided if an allocentric frame is used for navigation. Münzer *et al*. (2006) described the cognitive process of mental rotation with the goal of aligning a map to a position in an environment. They also referred to the recall of route descriptions from memory as being visually dominated. If non-sighted individuals would have been included, the results might have been different, since for blind participants the memory would have been dominated by a different modality.[18]

A definition of landmarks that is useful for the current purposes was provided by Sorrows and Hirtle (1999). They saw the process of navigation as driven by a goal, like finding a supermarket, or in the context of our study, finding the bathroom. Landmarks can be interpreted as a concept for organising the environment as well as a navigational tool. These two interpretations can overlap and often do. Landmarks have also been adopted for navigation through hypertext, and are a way of describing web content within a city framework. A landmark has to show a certain level of significance in both physical and electronic spaces. Singularity is important for a landmark to be established and recognised by the navigator. There are three forms of landmark: visual, cognitive (= meaningful), and structural (= positional) landmarks.[19, 20]

Only cognitive and structural landmarks can be used in text games, since the game does not provide images. Cognitive landmarks are presented along with their meaning in room and object descriptions, whereas positional landmarks are presented more indirectly through the room layout. Rooms in text-based games could profit from be improved with textual landmarks in their descriptions in order to support a spatial mental model for the players. An individual spatial mental model is also influenced by the degree of fictionality or literality in a distance estimate description, as has been shown by Richardson and Matlock (2007). A fictional description in their understanding involves an active verb such as "go" or "follow", and suggests a larger space compared to the one described by place verbs such as "be" or "lie" [down]. Fictive or actual motion induces an ego-moving perspective.[21]

Developers of text-based games should consider that the language used in room descriptions conveys information that influences the spatial mental model, if this concept is to be adapted into text-based games.

Kosslyn *et al* (1978) described how the time taken to analyse an object or several objects in relation to one other increases over perceived distance and size. Hence, an egocentric system influences perception so that the environment is perceived to be smaller than in an allocentric system. An egocentric system also influences the player’s mental rotation of their avatar, since the information is given as well and can be changed by actually turning around in the environment.[22]

Loomis *et al* (1993) compared the performance of blindfolded (sighted), adventitiously blind and congenitally blind players, who were asked to complete navigational tasks. The players used proprioception and internal cues to sense self-motion path integration. The (non-conclusive) results showed that congenitally blind subjects had more difficulties with navigational tasks than the adventitiously blind or blindfolded (sighted) participants, because visual experience was a factor in the tasks themselves.[2]

Previous research has shown that navigation processes for blind and sighted players are structured by different cues. These cues directly influence the spatial mental models of blind and sighted people alike. In text-based games, different navigation systems probably add to this influence and then create different levels of interaction difficulties for players who encounter diverging systems of navigation in real (physical) life. Encountering a less familiar navigation system might lead to a disrupted gameplay experience that frustrates certain players. Capitalizing on the difference of real life experiences of players by adapting the navigation system of a text-based game to the physical abilities of players might lead to more immersive gameplay.

2.2. Immersion

The terms immersion and presence have been explored in some depth within the fields of media studies and computer science. In media studies, experimental films produced around the year 1900 (e.g. train rides) and the audience’ reaction to them sparked a vibrant field of investigation into immersion. Lehmann (2008) described the three bodies of immersion in relation to film. They are equally, if not more so, relevant to the topic of immersion within video games as well as text-based games:[23, 24]

1. the physical body of the player;
2. the projected body or avatar that is being manipulated within the game world; and,
3. the body between the physical and projected bodies.

The body between connects the physical player body with the avatar, and is the point at which immersion happens. All three types of bodies have to be addressed and considered in order to create minimally disruptive and maximally immersive gameplay. Within the immersive process, the space of the avatar takes over the space of the physical body of a player, while the space around the body is the shared space of avatar and physical body.[25]

This understanding of immersion overlaps in parts with the concept of presence experience (as described by Wirth and Hofer, 2008), in that presence can be understood as an aspect of immersion, i.e. the feeling of being in a world that is different from the physical disposition of a player. Voss (2008) described the necessity of voluntary involvement in order to establish immersion. This is even more important in the context of games. The rules provided by a game have to be accepted by the players in order to make any gameplay happen. This acceptance must also be given for the navigational frame of reference in text-based games. If a player does not accept the perspective given to them, they may find their gameplay frustrating and stop playing altogether, or may fail to adopt the immersion necessary to fully appreciate the game.[26 - 28]

The term immersion has been the subject of much discussion in the field of Human-Computer Interaction (HCI), specifically in with a focus in relation to digital games. The concept of 'flow' by Csikszentmihalyi (1991) is often a foundation for the analysis of immersion. However, the focus of the analysis of immersive qualities of digital games is often pointed mainly at the visual aspects of a game, whilst neglecting other modalities and their different impacts on different groups of players.[29 - 35]

2.3. Playing Blind

Currently there three types of games available to blind players: inclusive games, universally accessible games, and games specifically designed for the visually impaired. These types are not completely distinct from one other, since sighted players can successfully play a game specifically designed for the blind, while a game that was not designed with a focus on blind players can be played by blind players as well.[36 - 43]

Text-based games cannot be subsumed into one of these types. They are accessible to blind players, but only if they solely consist of text and avoid any kind of atypical textual output such as ASCII or ANSI art. It is theoretically possible to make text-based games that are universally accessible, by providing optional settings to individual players. However, while games developers have explored some of the ways in which this can be achieved, there has been little empirical or quantitative work done on identifying best practises for including blind players across the set of text games.

Sighted games developers usually write text-based games with a focus on an explicit textual representation of the visual features contained within the game world. A rare exception of this rule is the game Blind, which was an entry to the Interactive Fiction Competition 2011. Blind relies heavily on the textual representation of sounds and feedback given through sound and touch, instead of that which may be perceived visually by the player character. The representation of multiple modalities are rarely emphasised in text-based games, but this could be incorporated to enrich elements of the game, increase immersion for different player groups, and provide additional information to every player. However, the focus here lies on the textual representation relevant to navigation.

Scientific research focuses on more general obstacles that are imposed on a blind person by certain technologies. Research with a focus on game-related accessibility for blind players mostly relates to audio-based games or general multi-modal enhancement of games. There is some general research into text-based games, but not with a focus on blind players. However, there has been research into accessibility for blind players in video games, and how certain disabilities can be handled in game design. Bierre *et al* (2005) presented a list of assistive technologies and detailed how they support individual groups. There also exist industry checklists such as those provided by Inclusion and the Game Accessibility Guidelines, which attempt to provide easy rules that developers could use without being experts in the area. However, there is still a lack of research into universally accessible games for a range of player abilities within already existing frameworks.[5, 40, 44 - 46]

3. Study Setup

3.1. Selected Hypotheses

Survey and route knowledge play different roles in the everyday navigation by non-sighted and sighted people. Therefore, these groups possibly show different reactions to an egocentric or allocentric system of navigation in virtual realities. Non-sighted people are more familiar with navigation by focusing on route knowledge, and so they are likely to perform better when confronted with an egocentric system. By contrast, sighted people are more likely to perform better than non-sighted players in an allocentric system, and also perform better in an allocentric system than in an egocentric system.[3]

The following hypotheses were proposed and tested:

- **H1** - Blind players experience higher immersion in the egocentric system (1), whereas sighted players experience higher immersion in the allocentric system (2).
- **H2** - Blind players learn navigation through the environment more easily with an egocentric system (1), whereas sighted players learn navigation through the environment more easily with an allocentric system (2).
- **H3** - Blind players tend to make fewer errors in the egocentric system (i), whereas sighted players tend to make fewer errors in the allocentric system (ii).
- **H4** - Blind players tend to explore more widely in the egocentric system (1), whereas sighted players explore more in the allocentric system (2).

3.2. The Game

In order to test for these hypotheses, we extracted an area called *Death's Domain* from the *Discworld MUD*, which is based on the Discworld fantasy series by Terry Pratchett. The layout of the area players navigated within can be seen in Figure 1. In order to encourage players to navigate throughout the whole area (consisting of indoor and outdoor areas of roughly equivalent sizes), they were given a task that requires the player to navigate through the whole setup at least twice in order for the game to be completed successfully.

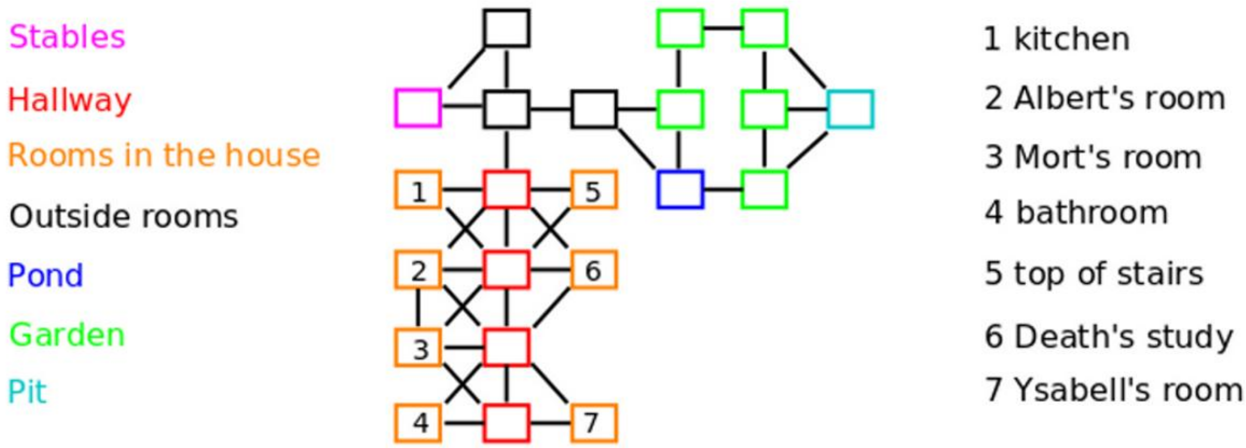

Figure 1: general layout of the test game map

3.3. Measurements

In order to measure performance and immersion, several metrics were recorded. These were: (i) time spent on the task, (ii) audio recordings, and (iii) logs of the interactions during the sessions. Furthermore, participants in the study answered a specifically designed set of questionnaires, which have been adapted from Witmer & Singer (1998) in order to be adequate for text-based games without a visual interface. Taking both parts - the Immersion Tendency Questionnaire and the Game Experience Questionnaire - an Immersion Value (IV) was extracted thus:

$$IV = Average\ Game\ Experience \div Average\ Tendency$$

If the IV is greater than 1, the feeling of immersion is supported. If IV is below 1, the game does not support more immersive qualities than other experiences, at least from the perspective of the participants.

4. Study Results

4.1. Participants

Blind and sighted test participants took part in our study in a between-subjects setup. Since a previously conducted pilot study indicated that there existed a bias for the commonly used allocentric system for experienced players (of both groups), only inexperienced players were allowed to participate in the study. 6 blind players (B) and 6 sighted players (S), 3 of each for either the allocentric (A) or egocentric (E) system, participated. 4 of the blind players were native English speakers. (Blind players, who had already participated, either in conceptualising the game versions in the study setup or in the pilot study, were excluded from the main study.) All other participants had studied English at school for least six years and were able to play the game without any help. Participants were aged between 22 and 41 years (at a median of 24 years). Most of them reported that they played computer games on a regular basis, but not text-based games; 4 participants (1 per group) did not play computer games regularly.

Since the data is based on a small group of individual players, our analysis largely focuses on an interpretation of data trends and means as well as some qualitative aspects.

4.2. Effect of the Navigation System on Immersion

In order to investigate the effect of the navigation system on immersion (hypothesis H1), we analysed the self-reported values, which test participants supplied by filling in questionnaires (see appendices).

The average value of the answers in the Out-Of-Game Questionnaire (Appendix A) ranged from 1.91 to 3.27. (A smaller value suggests that the person finds it less difficult to immerse themselves in activities.) The average values for groups of test subjects are closer to each other (minimum = 2.64 (SE), maximum = 2.70 (BE)) and the complete test group with an average of 2.67 (median = 2.82, standard deviation = 0.35) can be seen as almost homogeneous with regards to their ability to immerse themselves in general.

The data produced by the In-Game Questionnaire (Appendix B) is not conclusive. Differences between the groups are too small to report a difference, as the data ranged from 1.00 to 1.09 (median = 1.03, standard deviation = 0.04). (A greater Immersion Value (IV) indicates that the player became immersed in the game played in the test setup.) The variance between the groups (0.0016) was smaller than the variance within the groups (BA = 0.0459, BE = 0.0868, SA = 0.0229, SE = 0.0548). Only 2 participants (1 from the BA group and 1 from the BE group) were above the threshold of 1.2, which has been defined before tests were conducted in order to avoid researchers' biases on reporting miniscule effects. (This threshold is the numeric expression of a desired support of immersion exceeding general immersibility by at least 20%.) The 2 participants reporting the lowest IVs were found in the BE and in the SE group (Figure 2).

As seen in the figure below, 1 blind player was strongly immersed in the egocentric game, whereas another 2 blind players were less immersed (1 for each system). In addition, 1 sighted player was weakly immersed in the egocentric game. Due to such variations from a small sample, we cannot report conclusive results. It may be suggested that the navigation system might not have an influence on immersion, or that only certain players are influenced by the navigation system. A larger group of participants in a study of the relationships between play style, immersibility and navigation could yield more insight into this matter. The data obtained in this study is too insufficient to support or discredit hypothesis H1.

4.3. Learning to Navigate

The participants completed three navigation tasks in the game. The first task was to find different parts for assembling a rod in various rooms in a house. This was specifically a 'house navigation' task. The second navigation task was to find a location (the pond) outside the house in order to go fishing, and hence was termed a 'garden navigation' task. The last process of navigation required the player to go back into the house via a previously explored route in order to deliver the fish to the character, Death. The three navigation tasks are set up to reflect three different problem-solving procedures within the process of navigation through an environment. The purpose of the first one was for the player to become familiar with the environment and the navigation commands. The second task required the player to navigate through an unknown area, but with more knowledge about the commands. The third navigation task used previously acquired knowledge about the explored area.

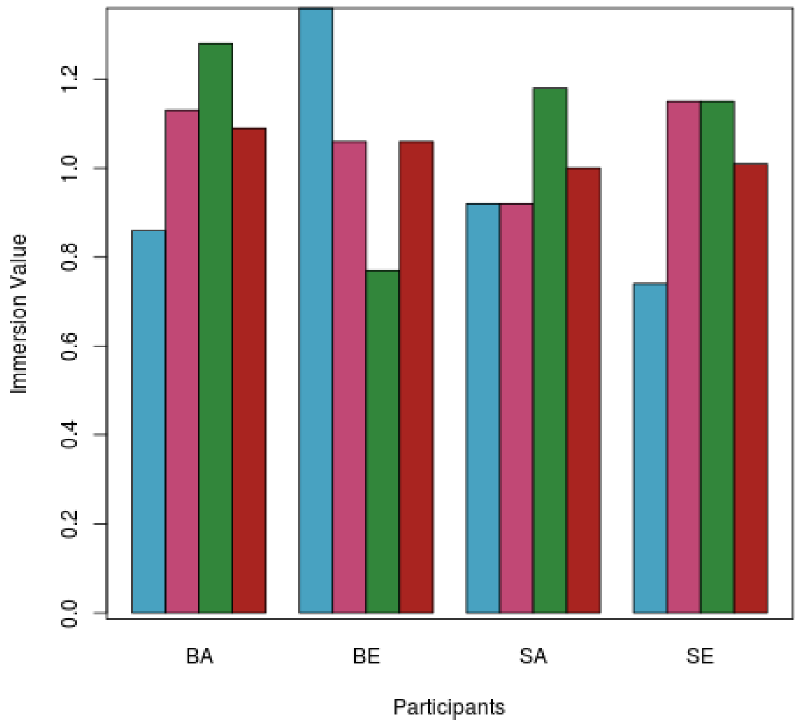

Figure 2. Immersion Values.
(The first three bars of each group show the values of the individual participants; the last bar presents the average value for that group) (B = Blind, S = Sighted, A = Allocentric, E = Egocentric).

Figure 3 shows that (on average) participants in every group (except BA) learned the game commands, leading to faster interactions with the game after completing the first navigation task. However, the curve for the SE group flat-lined after the second navigation task, indicating that those participants were unable to utilise their knowledge about the environment productively in order to find their way back. The curves for the BE and SA groups improved with every step, which may be interpreted as a steady improvement of performance following a constant learning process.

Since the blind players were able to navigate more easily in the egocentric systems, and the sighted players performed better with the allocentric systems, hypothesis H2 is supported by the data in Figure 3. Sighted players also performed better than blind players in the allocentric system, whereas blind players performed better than sighted players in the egocentric system.

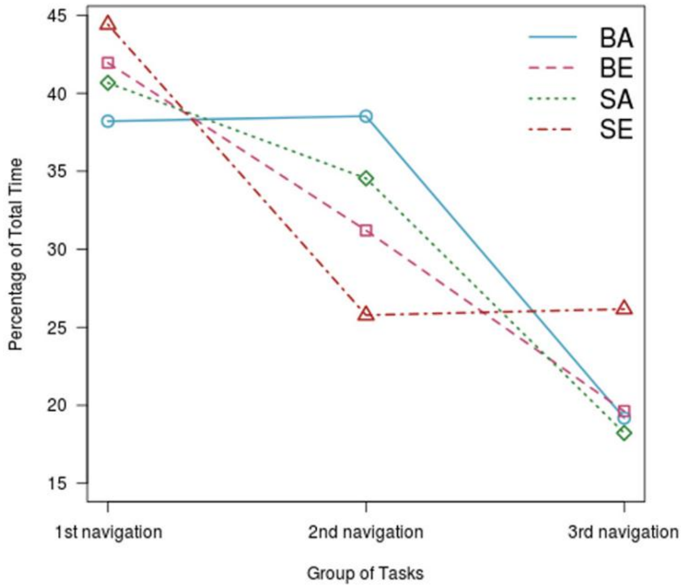

Figure 3. Navigation Learning Curves. Shown is the average of times needed to navigate through an area in percent of time taken for a subtask

4.4. Error Rates

Within the logs for each session, every command a player typed and executed was recorded. From these, the Command Error Rate (CER) was calculated as:

$$CER = \frac{n(\text{typos})/2 + n(\text{wrong}) + n(\text{not implemented})}{n(\text{total commands})}$$

Typos were only counted during half of the time session, since they were usually corrected within another try. Typos and wrong commands are classified as player-side errors. Neglected commands (or 'not implemented' errors) are classified as game-side errors, which are ignored by the formula of the Player Side Command Error Rate (PSCER), which in turn is defined as:

$$PSCER = \frac{n(\text{typos})/2 + n(\text{wrong})}{n(\text{total commands})}$$

An analysis of the logs shows that blind players in the allocentric system experienced more problems with the test setup than any other group (Figure 4). Their Player Side Command Error Rate (PSCER) was twice as high as it was for other groups. Their total Command Error Rate (CER) was even higher than the PSCER, an indication that they were also trying to interact with the game on a higher level and were more adventurous by doing so. However, it could also be that the blind players in the allocentric system encountered so many problems in interacting with the game, that they tried several different strategies. In general, the setup appears to have been more problematic for them than for any other group in the test setup. This may support part (i) of hypothesis H3, but does not support part (ii).

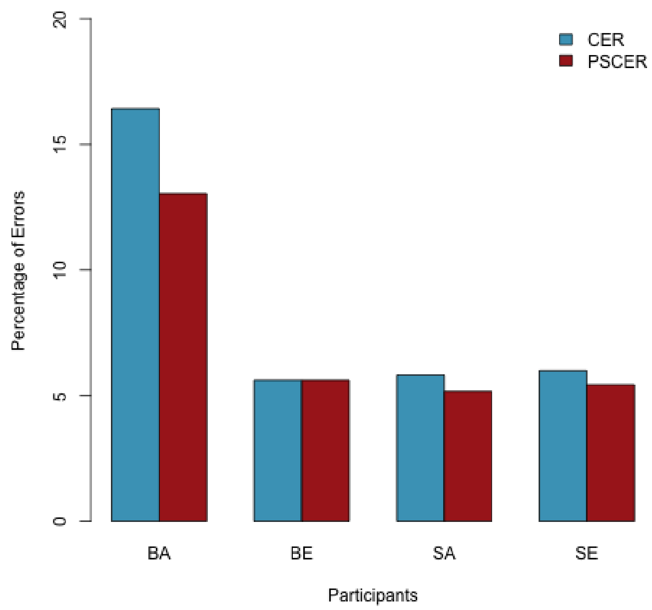

Figure 4: Command Error Rate (CER) and Player Side Command Error Rate (PSCER)

4.5. Exploration and Movement

Navigation in text-based games can be split into two parts: exploration and movement. During an exploration phase, a player tries to find orientation within the world before executing a move into a certain direction. An analysis of the Movement Exploration Ratio (Figure 5) shows that blind players in the egocentric system (average = 1.36, median = 1.27, standard deviation = 0.28), and sighted players in the allocentric system (average = 1.43, median = 1.68, standard deviation = 0.65), used exploring commands more often to navigate through the game than the players of other groups (BA average = 0.90, median = 0.91, standard deviation = 1.13; SE average = 0.67, median = 1.02, standard deviation = 0.70). BE and SA players probably felt more confident using the commands they were presented with to accomplish their goals, because the navigation system within the game was more in line with how they navigate in their physical life. Additionally, they moved through the world along a grid more quickly than players in the other groups. (In the allocentric system the directions 'north', 'south', 'east' and 'west' were defined as grid navigation, whereas in the egocentric system the directions 'forward', 'backward', 'left' and 'right' were defined as grid navigation.) This indicates that these (BE, SA) players used more right angle-oriented paths to navigate through the environment. Their navigation in general seemed to be more goal-oriented than that of players in the other groups.

More direct navigations within the environment than orientation tasks also hint that the use of direct navigation supports the player in developing a more accurate spatial mental model of the environment. According to Figure 5, this is more the case for players in the BE and SA groups, than for players in the BA and SE groups. This pattern lends support to hypothesis H4.

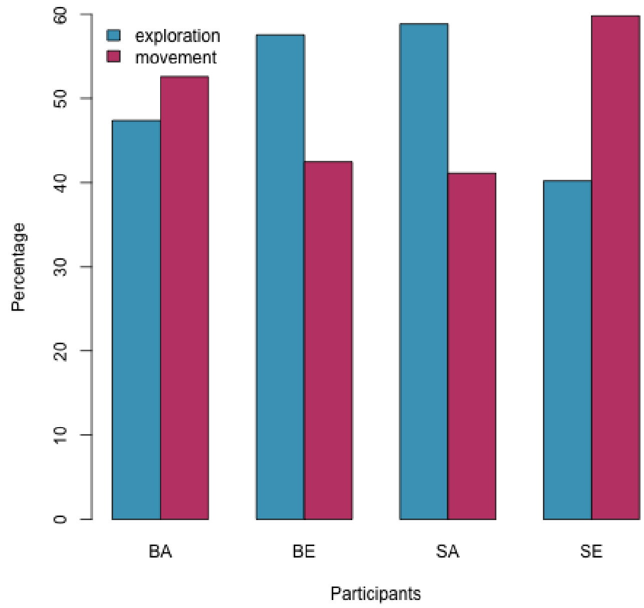

Figure 5: Movement Exploration Ratio

5. Discussion

5.1. Elimination of Bias

Throughout all stages of this research, active blind players of text-based online games were consulted in order to prevent any shaping of results by visual bias, be it via certain phrasings in questionnaires or presentation of tasks. This does not mean that visual references were avoided altogether, but wherever they were used, they were carefully tested and discussed. This was achieved by semi-structured interviews and play-testing sessions with experienced blind players. We are convinced that the participatory approach chosen for the testing of the game, in the conceptual stages of the study as well as during the tests, eliminated most visual biases.

5.2. Analysis of Results

Taking all four hypotheses into account, we can report that none of the null hypotheses were supported according to recorded data. Using either an allocentric or an egocentric navigation system in a text-based game does make a difference to the players' sense of immersion, as can be seen by the learning curves extracted from the protocols (Figure 3) as well as by the data analysis performed on the logs (Figure 4).

Blind players in the egocentric system and sighted players in the allocentric system showed the best linear learning process. While players in the BA group took longer to get accustomed to the navigation processes provided, sighted players in the egocentric system (BE group) did not seem to be able to transfer the knowledge to the later processes of navigating the same area. The results seem to indicate that players find it easier to use a navigation system they are accustomed to in their everyday lives. This supports the theories of Loomis *et al* (1993) and Noordzij *et al* (2006), who stated that blind players cope better with the representation of an area given in a route description and sighted players cope better with the representation of an area given in a survey description.[2, 3]

While we tried to create a comfortable setting for all test participants, it is likely that they were still aware of their surroundings. This awareness might influence their answers due to a general positivity bias where participants want to answer questions in a perceivably correct way. Even though we cannot report conclusively on our questionnaire data, we believe that further research into immersion, navigation and play styles could help with answering questions that we raised about these topics.

In general, the results indicate that an allocentric system supports the immersive game-play of sighted players more than an egocentric system, which on the other hand supports the immersive game-play of blind players (more so than an allocentric system). Sighted players also performed better than blind players in the allocentric system, whereas blind players performed better in the egocentric system (compared to sighted players, by an even larger margin). The data we recorded and presented here lends some support to our hypotheses, but tests with larger groups of test participants should be conducted before the hypotheses can be confirmed.

5.3. Limitations of the Present Study

It is important to discuss some of the limitations of the current study. First, the size of the study group (N = 12) was small. It was difficult to find blind test participants. This arose not only from the fact that only inexperienced players could take part in this study, but also from the fact that the game was written in a language which was not primarily spoken in the country in which the main research was conducted. Developing completely new game areas of the necessary depth is time-consuming, and in the context of a research study, that may have resulted in a subconsciously skewed world. As such, an existing area within Discworld MUD was used to eliminate these biases.

When potential volunteers decided to participate in the study, non-native speakers were asked to show a level of proficiency in the English language to be able to play the test game on their own. However, their proficiency level was not established with objective criteria. In future studies there should be a standardised measurement for the language skills, e.g. the Common European Framework of References for Languages. Another solution could lie in translating the game for different participants. However, other problems with differences of meaning that occur while translating a text might emerge.

The questionnaires used in many other studies about immersion in games concern test sessions of visually represented games. They do not account for different sets of abilities. As a result, there is an implied consensus of as to what constitutes a ‘typical’ user (i.e., sighted), and this does not account for temporarily or permanently non-sighted players. It might be an idea for further research to create questionnaires that are carefully tested and validated for coherence, and which are aimed at generalising game-play experience beyond the perceived standard of visual experiences.

6. Outlook

The findings presented here indicate that a player’s spatial mental model of a text-based environment depends on the effort required to navigate through the environment. This effect is more pronounced for blind players than for sighted players. The results imply an effect of navigation systems in text-based games on sighted and non-sighted players. Different navigation systems seem to have intrinsically different levels of difficulty for different groups of players.

6.1. Applications of Research

In terms of accessibility, this exploratory research implies several new approaches that can be investigated with regards to navigational software. For example, in city navigation software or with digital maps for larger indoor structures, this study could help direct research into how the representation of navigation commands and directions works best for groups with different visual abilities.

Text-based games offer a compelling option for the provision of truly universally accessible games. This study is a pioneering one into the area of blind players' ability to play text-based games. Such games may also offer an environment for players with other impairments, if different situations are considered during the design phase. Protocols like the MUD eXtension Protocol (MXP) provide substantial possibilities for creating a truly universally accessible game genre.

Developers of text-based games could use the results of this study to decide whether they want to enhance their game with individual settings for different navigation systems. In offering these, the player could decide on his/her own which system to use and maybe even change the settings for 'inside vs. outside' areas. However, due to everyday priming with cardinal coordinates, players might not actually look for such an option or think about it unless prompted.

The findings presented here can also be used to create better game-play experiences for players with different abilities. Should game developers want to create an environment in a mainly allocentric system (which is harder for sighted players to navigate, but easier for non-sighted players), this could create previously unexplored game dynamics for players. It has been done already, for example in within the larger system of Discworld MUD (outside the area being tested by the players in this study), where certain areas are egocentric systems, in order to create a greater challenge. The findings of this study indicate that the degree of difficulty experienced by players varies among individuals. On the other hand, since this particular game mostly relies on an allocentric system, the simple change of the navigation system may indeed have affected both the sighted and non-sighted players similarly, due to the cognitive cost of switching between navigation systems.

It might also be worthwhile to investigate whether (for the scope of inclusive gaming) it is sufficient to simply infer an individual player's preference of navigation systems based on whether they are sighted or not. One might well expect the strength of such system preference (and, consequently, the costs of switching from one system to the other) to vary between individuals within the same group. This would only be similar to findings about other players' preferences in connection to reasoning about spatial information, e.g. by Schultheis et al (2014). There exists general population preferences for certain forms of spatial mental model construction and reasoning exist. However, a minority of players do construct alternative spatial models. An assumption that there are differences in blind players' preference strengths might also relate to research into the differences between adventitiously and congenitally blind subjects (e.g. Loomis et al, 1993). It would also be insightful to investigate specific cost-benefit trade-offs in the navigation performance of players using different navigation systems. It is also worth investigating the difference between average preferences of player groups, and individual players' preferences (see Bertel (2014) for a recent discussion of related challenges).

The findings in this study may be used for the development of educational and serious games, and for aiding blind people (especially blind children) in learning how to navigate through different navigation systems. This could be accomplished with semi-random changes between navigation systems. For example, it may be possible to explore the implications of a player exploring a familiar area with an unfamiliar navigation system. While this might help blind players to become familiar with the dominant representation used by a mainly sighted society, playing such games could also aid sighted people in gaining a deeper understanding into the societal assumptions that impact on the visually impaired.

6.2. Future Work

Text-based games offer many possibilities for research into developing inclusive games for visually impaired players. They can be used as a tool to quickly test non-visual game mechanics. Furthermore, they can be the subject of research themselves to further development this unique game genre.

Other work could investigate whether the navigation system has different effects on outdoor areas, compared to indoor areas. It could be that certain navigation systems support navigation in different types of spaces. There may be a certain level of intrinsic difficulty attached to a certain combination of the type of area (outside, inside) and navigation system. Developers of text-based games could use this information to actively shape their players' experiences further.

Another area of possible future work lies in the representation of maps in a text format with the support of different navigation systems. Developers or players of text-based games tend to create and offer maps for other players. Some of these even offer advanced functionality such as searchable maps and route finders. This is mostly done with a visual representation. The impact of location and route descriptions on text-based maps is that it offers another route of inquiry, with the likely benefit of aiding players with navigation within spatially complex environments.

Only inexperienced players took part in our study. In order to assess the specific cognitive costs of switching between navigation systems, future studies could include players who are more experienced in either navigation system, and investigate whether or not the reported effects in this study still hold for that player group.

Acknowledgements

The authors would like to thank the test participants for taking part in the study, Jakob Gomoll and Jake Sebastian Greenwald for technical support, Greg Bataard for giving us the rights to his maps, and Kearsley Schieder for valuable input and proof-reading.

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APPENDIX A: Out-Of-Game Questionnaire

- I can easily switch my attention from the task in which I am currently involved to a new task.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I frequently get emotionally involved (angry, sad, or happy) in the news stories that I read or hear.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I feel well today.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I rarely become so involved in a book that people have problems getting my attention.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I currently feel mentally alert.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I rarely find myself identifying with the characters in a story.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I feel physically fit today.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I am not good at blocking out external distractions when I am involved in something.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer ○

- I concentrate well on enjoyable activities.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

- I concentrate well on disagreeable tasks.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

- I sometimes become so involved in something that I lose all track of time.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

APPENDIX B: In-Game Questionnaire

- I had the feeling that the environment was responding to my actions.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

- Navigating through the world felt natural to me.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

- I forgot about the events ocurring around me that were not related to the game.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

- I didn't have to think much about what commands to type.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

- I didn't feel that the feedback the game gave me for my actions was consistent.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

- The system reacted to my actions as expected.

  strongly agree ○ ○ ○ ○ ○ ○ strongly disagree || no answer○

APPENDIX C: Navigation questionnaire

For the following questions, imagine that you are actually in the world and performing the actions yourself:

- You're standing in front of Albert's room in the first corridor room, facing the door straight ahead of you. How long - in time - do you think it would take you to get to the pit, where you found the worm-like soul?

  Answer: ____________________

  Time: ____________________

- Now you're standing by the pit, and you want to go to the stable. How long - in time - do you think it would take you until you are there?

  Answer: ____________________

  Time: ____________________

- Standing inside the stable you are wondering, what Mort might be up to. How long - in time - would it take you until you are in his room?

  Answer: ____________________

  Time: ____________________

- You have to go back to the pit. How long - in time - do you think it would take you until you are there?

  Answer: ____________________

  Time: ____________________

- You want to go from the pit back to Death's study, How long - in time - do you think it would take you to get in front of his door, in the first corridor room.

  Answer: ____________________

  Time: ____________________

I will now guide you through the same route again. This time I want to know how many rooms are between the start and end point. Please count the starting room and the destination room as well. Try to give the correct answer as fast as possible.

- You're standing in front of Albert's room in the first corridor room, facing the door straight ahead of you. How many rooms would you have to walk through to get to the pit?

  Answer: ______________________

  Time: ______________________

- Now you're standing by the pit, and you want to go to the stable. How many rooms do you have to walk through until you are in the stable?

  Answer: ______________________

  Time: ______________________

- Standing inside the stables you are wondering, what Mort might be up to. How many rooms do you have to walk through until you are in his?

  Answer: ______________________

  Time: ______________________

- You have to go back to the pit. How many rooms will you walk through?

  Answer: ______________________

  Time: ______________________

- You want to go from the pit back to Death's study, how many rooms would you have to walk through until you are right in front of his door in the first corridor room?

  Answer: ______________________

  Time: ______________________

Now two general questions to give you a pause.

- When you're imagining the whole game environment, are you doing so from a first person or a third person view?

  Answer: ____________________________________

  ____

- Would you have preferred a different way to navigate through the world? If so, what would that be?

  Answer: ____________________________________

  ____

Now four final tasks:

- You are standing in front of Death's study, facing the door. Which direction is Mort's room in? Please answer in terms relative to your body. (That means that Death's study would be forward.)

  Answer: ____________________________________

  Time: ____________________________________

- And in which direction is the kitchen in?

  Answer: ____________________________________

  Time: ____________________________________

- Where, do you think, Albert's room lies?

  Answer: ____________________________________

  Time: ____________________________________

- You are in the room outside of Death's house, in which direction is the kitchen in now? This time, please answer in cardinal directions like north, south, northeast and such.

  Answer: ______________________________

  Time: ______________________________

- And where is the room on top of the stairs?

  Answer: ______________________________

  Time: ______________________________

- Where would you locate the entrance hall?

  Answer: ______________________________

  Time: ______________________________