Spatial Mental Representations in Interactive Fiction – What is Particular About the Interactive Text?

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1. Introduction

1.1. Background

When humans, as well as many other species in the animal kingdom, move around in the world they gather information about the spatial layout of their surroundings and construct a mental representation of the spatial world (TOLMAN 1948; TAYLOR, TVERSKY 1996). This knowledge is sometimes called a *cognitive map* (KITCHIN, FREUNDSCHUH 2000). The scale of such spatial relations is that of large-scale, geographical space (MARK *et al.* 1999), or environmental space (FREUNDSCHUH 2000), as opposed other spaces, such as the much smaller space around the body, or very large spaces like astronomical spaces. Here, the term *spatial mental representation* will be used for the knowledge a person has, in long-term memory, about spatial relations (*knowledge* refers to information believed to be true by the person, not necessarily actually being true). It is not only from direct experience of surroundings that people form spatial mental representations, but also from viewing maps and listening to and reading verbal descriptions.

Texts come in many forms, and *narrative* is one shape they may take, as expressed, for instance, in novels and short stories. The personal computer – the heart of interactive media – has given rise to new forms of narrative. Texts become interactive in a new sense. Interactive fiction is a type of computerised narrative that the audience can influence. Usually, interactive fiction consists of text only. The computer simulates a world and outputs descriptions of places, objects, and people. The player (i.e., the reader or audience) types commands in the form of actions to be performed. (For more information about interactive fiction, the reader is referred to MURRAY 1997, AARSETH 1997, and BUCKLES 1985).

How do people remember and think about space in interactive fiction? A piece of interactive fiction can be said to contain a fictive spatial world, a *game world*, that is, locations which are related spatially, much in the same way as the fictive spatial world in a traditional novel, for instance, a town where the story is set. Research on reading has shown that readers normally do not construct mental representations in long-term memory of spatial relations described in ordinary text unless the task demands it (ZWAAN, VAN OOSTENDORP 1993; HAKALA 1999). Reading a novel for entertainment would be a case where readers normally do not construct spatial mental representations in long-term memory. The reader's task determines what kind of inferences are made on-line during reading (VAN DER BROEK *et al*. 2001) and what kind of mental representations are created (WILSON *et al*. 1993).

The results from reading of ordinary texts raise the question: Is spatiality spontaneously encoded in long-term memory by players of interactive fiction? Spatiality is sometimes noted to be a central property of “digital environments” (MURRAY 1997). Considering the nature of interactive fiction, there is reason to believe that the construction of spatial representations differs from traditional texts. In these works it is necessary for the player to move around in the game world in order to make progress (to "consume" the work). This navigational demand may drive players to construct spatial mental representations. On the other hand, it could be that players move around in the game world randomly, without forming any global spatial mental representation. Or, a more situated scenario may be the case: Players could read descriptions of directions available in the text at each place locally, and use this information to navigate, avoiding the need for any global spatial mental representation.

Research on reading of traditional texts also show that readers are unlikely to construct spatial mental representations when the narrative is indeterminate, poorly organised or has overly difficult descriptions (MANI, JOHNSON-LAIRD 1982; PERRIG, KINTSCH 1985; DENIS, DENHIERE 1990). Interactive fiction has often been described as an indeterminate and fragmented narrative. It often seems that coherence is missing in the textual fragments that make up the physical object of a work of interactive fiction. If this is the case, it would be another reason to suggest that players perhaps do not form spatial mental representations.

The question of spatial mental representations in interactive fiction has not been thoroughly investigated. TROMP (1993) studied the experience of spatiality and performance of users of MUDs (*multi user dungeons*). MUDs are very similar to a typical work of interactive fiction, the main difference being that many players are active at the same time in the game world. Using an electronic questionnaire, she concluded that MUD players construct elaborate and highly accurate spatial mental representations. DIEBERGER (1994) interviewed users of a MUD about their opinions on how spatiality was designed in the MUD. However, both studies relied on players introspecting on their abilities and memories, and it would be desirable to further study the question of spatial mental representations using more valid methods.

1.2. Outline of paper

In the present study, four participants used a work of interactive fiction. Afterwards, participants took part in a semi-structured interview, containing, among other things, questions on the spatial layout of the work of interactive fiction. The interviews were recorded and transcribed. As a control group, four other participants read a special, non-interactive version of the work of interactive fiction, and were interviewed in the same way. In the following, participants who used the work of interactive fiction will be called *players*, and the participants who read the non-interactive version will be called *readers*.

The issue of spatial cognition in interactive fiction was explored in two separate but connected themes. First, we analysed how people talked about space from interactive fiction. To study language is one way of approaching the question of spatial mental representations. A series of questions guided the analysis of the interview data of players of the computer game and readers of the non-interactive version of the computer game: What terms – *referents* and *verbs* – are used when talking about space? How are *spatial references* made? Which *perspectives* are used when giving descriptions of spatiality from the game?

In the second theme on spatiality, we move from the descriptions of spatiality to the spatial mental representations themselves. First, we will consider what the order in which participants describe places can tell us about the spatial mental representations. Secondly, to what extent do players' and readers' spatial mental representations reflect the true state of affairs? This question is examined by looking at the completeness, accuracy, consistency, and integration of the spatial mental representations. We also investigate the property of hierarchical organisation of the spatial mental representations. Finally, to the extent that the participants make mistakes, we explore the question whether these errors are systematic. For instance, is there evidence for distortions that are common in memory for graphical maps, such as alignment and rotation?

First, we turn to the question of how players talk about space in the game world.

2. How do people talk about space from interactive fiction?

How do we express in language our recollection of some objects located in space? In LEVELT's (1996) model, describing a spatial scene requires selecting a referent, a relatum (what it is to be related to), their spatial relation and also applying some perspective system that will map spatial relations onto lexical concepts. Information that resides in the mind's many representational systems, for instance, the spatial representational system, needs to be translated into a semantic code that can be formulated in the language. Levelt identifies three perspective systems: *relative*, *intrinsic*, and *extrinsic*. The relative system is deictic and relative to the describer's current position and orientation, for example, *the pig is to the left of the tree*. The intrinsic perspective system relies on the relatum's intrinsic axes, for example, *the cow is in front of the horse*, where the horse has an intrinsic front. Finally, the extrinsic perspective system is an absolute system, for example, *the cat is north of the house*. The choice of perspective system is linguistically free (LEVELT 1996); that is, there is no unique or fundamental choice. It is not biologically determined and cultures have ended up using just one or a mix of the perspective systems. For instance, on the island of Vava'u in Polynesia, the inhabitants mainly use an absolute frame of reference (BENNARDO 2002). English uses all three perspective systems, although the relative perspective system is favoured (LI, GLEITMAN 2002). The choice of perspective system can also depend on individual factors as well as on the task at hand.

When giving verbal descriptions of a spatial arrangement of landmarks, such as a landscape, a town, or a building, people can use any of three perspectives, called *route*, *gaze*, and *survey* (TAYLOR, TVERSKY 1996). These descriptive perspectives are linked to Levelt’s perspective systems. A route description takes the addressee on a mental tour of the surroundings, commonly using a relative reference system, such as *if you turn left and walk two blocks, you have a big red house on your right*. A gaze description is given from a fixed position outside the scene and usually describes a small sized area, for example, *the bed is to the left of the window*. Finally, a survey description is made from above, using an extrinsic reference system, for example, *the church is north of the forest*. Although it was first claimed that people select one descriptive perspective and keep it fixed throughout the description, later research has shown that people often switch perspectives within one and the same description, usually without signalling the switch (TVERSKY, LEE, MAINWARING 1999).

The purpose of this first part of the paper is to investigate how players and readers talk about spatiality of the game world. The main motivation was to study the descriptive perspectives of the players, and compare these with descriptive perspectives found in earlier research of people learning spatial layouts in other situations. The readers serve as control group when the interactive property is left out.

2.1. Method

2.1.1. Participants, material, and procedure

Eight participants, university students, four males and four females, aged between 20 and 36 years, took part in the study for pay. The participants who played the computer game, *players*, were experienced with using interactive fiction. The participants who read the story, *readers*, were experienced with reading stories. All participants were ensured to have sufficient proficiency in Swedish and English to take part in the study.

Players were instructed to play the first part of an authentic work of interactive fiction called *Anchorhead* (GENTRY 1998) and later talk about their opinions of it. During the playing session, they were left alone in a situation as close as possible to a real playing situation. *Anchorhead* ran on the WinFrotz emulator (LAWRENCE 1999) on a standard personal computer running Microsoft Windows 98. Players received help if they needed it.

Readers were left to read a specially prepared, non-interactive version of *Anchorhead*. It consisted of the same text as the real interactive version, somewhat stylistically modified to be readable, and printed in large, clear typeface on 19 sheets of paper, stapled together. They were told they were going to be asked their opinions of the text later. The printout of the non-interactive version was in some sense similar to a traditional short story, functioning as a direct case of comparison against the computer game. However, it should be noted that the non-interactive version was somewhat artificial and not typical of a short story (for instance, the text was written from the unusual perspective of second person singular – *you*).

No instructions to memorise the spatial layout of the game was given, and it is unlikely that participants memorised the spatial layout because they suspected a memory test. The first four participants simply played the computer game in the way they would normally do it. Agreeingly, the non-interactive version was somewhat artificial, and the other four participants could have been prepared for a memory test. However, as was seen from the data, readers remembered less of the spatial layout than the players, which makes it unlikely that readers anticipated a memory test. Thus, there is reason to believe that the study conditions were close to realistic situations.

After playing or reading, participants, one by one, took part in a semi-structured interview, carried out in Swedish. Participants were asked if they could tell which places were present in the game world, and what the relative locations of these places were. The conversations were recorded and transcribed.

2.1.2. Analysis

In analysing how players talk about space in the computer game, the procedure followed the outline of TAYLOR and TVERSKY (1996). First, the overall *perspective* was judged for each description made by the participants (route, survey, or gaze, or a mixture of these). Then, a more detailed analysis of language use was made on three types of elements which make up the perspective: what *relational terms* were used (e.g., *left*, *north*), what *referents* were used (e.g., the addressee, landmarks), and the occurrence of *active* and *stative verbs* (e.g., *enter* and *to be*, respectively).

2.2. Results

Below, the results of analysis are presented for *descriptive perspectives*, *relational terms*, *referents*, and *verbs*, and under each point, for the players followed by the readers. For players, data from three participants were analysed (participant 1-3) (data from the fourth participant on an explicit instruction to describe places was missing). For the readers, data from four participants were analysed (participants 5-8). Descriptions were available for the overall layout of the game (referred to as *City*) as well as for the layout of a smaller part of the game (referred to as *House*).

2.2.1. Descriptive perspectives

Following TAYLOR and TVERSKY (1996), each landmark description in the descriptions was coded according to perspective type (route, survey, or gaze). Landmarks were mainly locations (places possible to move between in the computer game), but sometimes what was technically a single location had multiple landmarks (e.g., the square, which was a landmark in itself, also had an obelisk in its centre). Based on the landmark coding, the entire descriptions were classified into route, survey, gaze, or mixed depending on the dominant perspective (mixed means a mix of more than two occurrences of different perspectives).

The results (Table 1) show that players use survey descriptions exclusively (i.e., an extrinsic reference system using *north*, *south*, etc.) when describing the spatial layout of the game world. All descriptions were started at the same place, *Outside the Real Estate Office*, where the game begins.

	Descriptive perspective			
Spatial area	Route	Gaze	Survey	Mixed
City	0	0	3	0
House	0	0	3	0
Total	**0**	**0**	**6**	**0**

Table 1: Occurrence of perspective in the descriptions of the computer game for participants 1-3.

The results show that readers mainly used survey descriptions when describing the spatial layout of the game world (Table 2). In some cases, the participants did not relate landmarks spatially at all. Two descriptions were started at the location where the game begins (*Outside the Real Estate Office*), while three descriptions had other starting places (*The Pub*, *The house*, and *The University*)[1].

	Descriptive perspective				
Spatial area	Route	Gaze	Survey	Mixed	None
City	0	0	3	0	1
House	0	0	3	0	1
Total	**0**	**0**	**6**	**0**	**2**

Note: "None" means no description perspective could be determined because no spatial relations were present in the data.

Table 2: Occurrence of perspective in the descriptions of the game world for participants 5-8.

2.2.2. Relational terms

In the descriptions made by players, only extrinsic relational terms (e.g., *north*, *south*) were found, shown in the left part of Table 3.

Players		Readers	
Relational term	Occurrences	Relational term	Occurrences
south	14	*east*	4
north	9	*north*	1
down	8	*up*	1
up	7	*west*	1
west	6		
southwest	5		
east	4		
close to	3		
southeast	2		
northwest	1		

Note: In the data, *up* (upp) was found to be used similarly to *above*, and is treated as an extrinsic relational term, although it is strictly relative to, e.g., the body.

Table 3: Frequencies of all relational terms from the participants' descriptions.

Two occurrences of *fram* 'front' were found. The first one was *komma fram till* 'arrive at', which suggests an orientation towards the thing that one arrives to. However, since this was a single isolated case, it was not considered further. The other occurrence was *rakt fram var masters bedroom* 'straight ahead was the master bedroom' (see the discussion in section 2.3.1. below).

In the spatial descriptions made by readers of the non-interactive version, relational terms were sparse. It was more common to name locations without giving a spatial relation than to relate locations spatially. The few relational terms that occurred were extrinsic, shown in the right part of Table 3.

[1] One participant gave two separate descriptions, thus the total sum of five.

2.2.3. Referents

In talk about spatiality from the computer game, the occurrences of referents were about equally split between using a landmark as referent and using canonical directions (*north*, *east*, etc.). For the landmarks, a mixture of English and Swedish terms was used, even within one and the same participant and within one and the same utterance.

In the non-interactive version, landmarks were used as referents by all four participants. In the description of one participant, six occurrences of canonical directions were present.

2.2.4. Verbs

For players, the stative verbs were about twice as many as the active verbs, as shown in the left part of Table 4. The class of active verbs, used to describe, for example, the path of a road, called *fictive motion* by TALMY (1996) only had a single occurrence in the descriptions: *gå* ‘go’:

(1) Participant 2: (a period within parentheses indicate an noticeable pause)
därifrån nånstans så kom man till en väg som gick (.) i nord sydlig riktning
‘from somewhere around there one came to a road that went (.) in a north south direction’

The relational term *up* always occurred together with an active verb, the single exception being *där uppe låg huset* ‘up there was the house’.

Players				Readers			
Stative verbs		Active verbs		Stative verbs		Active verbs	
finnas ’be’	22	*gå* ’go’ 21	21	*vara* ’be’	11	*gå* ’go’	3
vara ’be’	16	*klättra ner*	1	*ligga* ‘lie’	10		
ligga ‘lie’	5	’climb down’		*leda* ‘lead’	1		

Table 4: Number of occurrences of stative and active verbs from participants’ descriptions.

Stative verbs dominated the descriptions from the readers, as shown in the right part of Table 4.

2.2.5. Summary of results

A summary of the results of spatial descriptions and comparison between computer game and non-interactive version is shown in Table 5. In the table, *dominant* means *most frequently occurring* which serve as the basis for classifying descriptive perspectives (TAYLOR, TVERSKY 1996).

	Source condition	
Topic of spatial description	Computer game	Non-interactive
Dominant descriptive perspective	Survey	Survey
Dominant relational terms	Extrinsic	None
Dominant referents	Landmarks, canonical directions	Landmarks
Dominant verbs	Stative	Stative

Note: *Dominant* means most frequently occurring.

Table 5: Summary of the results of spatial descriptions and comparison between computer game and non-interactive version.

2.3. Discussion

2.3.1. Descriptive perspectives

Descriptions of the spatial layout of a work of interactive fiction was analysed with respect to reference system, referents, and verbs, in order to determine if a gaze, route, or survey description was used. The results show that players as well as readers used a survey description throughout the descriptions: the relational terms were all extrinsic, referents were either landmarks or the canonical directions and the dominant verb class was stative verbs – all characteristics of a survey description (TAYLOR, TVERSKY 1996). The addressee (i.e., the interviewer) was never used as a referent (i.e., no participant used the interviewer as a spatial referent by saying, e.g., *to* your *right*). In one description, there was one possible instance of one landmark being described according to a route description:

(2) Participant 3:
utan jag följde med Michael upp för trappan direkt (.) så det var (.) foajé
'but I followed Michael up the stairs directly (.) so it was (.) foyer'

trappa upp och sen rakt fram var masters bedroom
'up a staircase and then straight ahead was the master bedroom'

This occurred in the description of the house. This fact could have influenced the switch to route perspective, since a small environment influences the description towards route descriptions (TAYLOR, TVERSKY 1996). However, an alternative explanation could be that *forward* might mean *north*, considering that north is up (forward) on a two-dimensional map (the influence that the game is to be thought of as such a map is very strong – using the reference system of a map, and within the genre of these kinds of games it is frequent to draw these maps). In support of this idea, *down* was sometimes used to mean *south*, such as in this example from participant 1:

(3) Participant 1: (colons indicate prolonged speech)
uppdelad i två bitar eh jag man började i den norra bi-
'divided into two parts eh I one started in the north pa-'

den norra delen (.) o:ch sen så skulle man gå ner till söder
'the north part (.) a:nd then one was supposed to go down south'

The players used the canonical directions (*north*, *south*, etc.) as landmarks to a greater extent than readers. The reason for this may be that players to a large extent used the canonical directions for movement when playing the game – this is how most of the movement in the game works. But it could also be that the players were more prone to think of spatial issues because of the navigational demand, and this made them more aware of how the game world was configured in terms of the canonical directions. As will be seen in the second part of this paper, the players had superior knowledge of the spatial layout, compared to readers.

Interestingly, active verbs were commonly used in the survey perspective description using an extrinsic reference system, and also more so for the players compared to the readers. The usage of active verbs is not common in spatial descriptions made from a survey perspective (TAYLOR, TVERSKY 1996). The explanation for this could be that the players performed movements in the game, and this makes the active verbs more salient compared to readers, who probably did not focus on the movements described in the text they read (the non-interactive version).

2.3.2. Why not a route perspective?

Why didn't players adopt a route perspective when describing the environment? This would be expected from the fact that players learned the environment by exploration. TAYLOR and TVERSKY (1996) obtained experimental results that when learning an environment by exploration (in contrast to learning it from verbal descriptions or from maps), people are more likely to adopt a route perspective in their descriptions of that environment. However, there are at least three factors present in the current situation that speak against using a route description. First, the choice of perspective has been shown to be influenced by certain features of the described environment. If the environment features a single path or has landmarks of roughly the same size, it is more likely to be described using a route perspective (TAYLOR, TVERSKY 1996). The game world, in contrast, has multiple paths and feature landmarks of various sizes (e.g., a bathroom, a deserted lane, a square). Second, the conventional usage of extrinsic referential terms (*north*, *south*, etc.) within the genre of interactive fiction most likely influenced participants' choice of perspective. The fact that the game used an extrinsic reference system may have forced participants into adopting a survey perspective. Third, related to this, is the fact that in the game, *you*, the player character, cannot change orientation. *You* move from place to place, always facing the same direction. There is no information of a particular direction in the location descriptions from the game. Even if orientation changes are sometimes implied, such as when a description is given of possible paths of movement, the orientation is always returned to an unspecified state. The following example of a description of a location from the game illustrates this point:

(4) Outside the Real Estate Office
A grim little cul-de-sac, tucked away in a corner of the claustrophobic tangle of narrow, twisting avenues that largely constitute the older portion of Anchorhead. Like most of the streets in this city, it is ancient, shadowy, and leads essentially nowhere. The lane ends here at the real estate agent's office, which lies to the east, and winds its way back toward the center of town to the west. A narrow, garbage-choked alley opens to the southeast.

Further, there are at least two major methodological differences between the present study and that by TAYLOR and TVERSKY (1996). First, there is a difference in task instructions. In their study, participants were told to give descriptions "so that someone who was unfamiliar with the environment and had never seen the map could read the description and know where all the landmarks were" (TAYLOR, TVERSKY 1996: 378). This may have influenced Taylor and Tversky's participants to use a route perspective more frequently in order to guide another person around the landmarks. A second difference is that the participants supplied their descriptions in *writing*, while in the present study, participants used *speech*. It is unclear how spatial descriptions are affected by this difference, but it is conceivable that it may have an effect on perspective choice, especially since this choice takes place in the later stages of language production (LEVELT 1996).

2.3.3. Starting points of the descriptions

Even though the players gave survey descriptions of the computer game, they all started their descriptions with the same landmark – the place where the game begins. Among the readers, it was as likely to start descriptions at the starting point of the game, as at some other significant location. The reason for this difference may be that players see the starting point as more important, since they worked on a puzzle in the game of how to enter the office. Both kinds of starting points are consistent with TAYLOR and TVERSKY's (1996) observation (although they were speaking about route descriptions) that starting points typically were entrances or large landmarks (*large* is translated into ‘important’ in the present study).

2.3.4. Single perspective

Participants used a single perspective throughout their descriptions. In contrast, TAYLOR and TVERSKY (1996) found that perspective switches were frequent. Probably, participants felt they could adequately describe the environment using a single perspective. This suggests that the environment was perceived as homogenous by the participants or that perspective switches would require too high cognitive effort to be worth the while (TVERSKY, LEE, MAINWARING 1999).

A final question is what descriptive perspectives tell us about the underlying long-term memory representation of spatiality. According to LEVELT (1996), it tells us very little, since perspective is not part of the mental representation of space but is chosen at a late stage in the verbalisation process. But the study of descriptive perspective does tell us two things. First, as has been discussed, the descriptive perspective used by the participants in the present study tells us something about how the spatial descriptions are made when a spatial layout was learned in a work of interactive fiction. This case can be compared to other cases, such as learning from maps, from written instructions, from exploration, etc. So, even if descriptive perspectives do not tell us directly about the memory representations, they do reflect parts of the ongoing cognitive processes at the time of giving the description. Second, the fact that players gave *elaborate* spatial descriptions suggests that they were indeed drawing their descriptions from long-term memory spatial mental representations. The following section investigates this issue in detail.

3. What is the nature of people's mental representations of spatiality from interactive fiction?

3.1. Introduction

We now turn to investigations of the nature of the spatial mental representations constructed by players of the computer game. But before proceeding, we need to discuss the fundamental question of whether players at all form spatial mental representations of the game world in long-term memory.

3.1.1. Do players form spatial mental representations?

Two lines of criticism of the claim that people construct mental spatial representations are that i) spatial representations are not truly spatial, and ii) spatial representations are spatial, but they may not be constructed in situation X.

The first line of criticism concerns the very nature of mental representation and questions whether spatial representations are truly spatial. Even though everyone may agree to that there are mental representations of spatial facts about the world, one can disagree on the question whether the representations themselves are actually spatial. After all, also mental representations in the form of propositions can represent spatial facts about the world, without themselves being spatial in nature. The issue of mental imagery has had a long history of debate within the field of cognitive psychology. Note, however, that *image* is not synonymous with *spatial mental representation*, because the latter has non-image-like features, such as being non-metric and combining information from several sense-modalities (TVERSKY 2000). For the purpose of this paper, however, this fundamental question bears little relevance. The controversy does not concern the issue of *differences* in mental representations of spatial facts about story texts and interactive fiction. If one claims that spatial mental representations cannot be spatial, then this holds irrespectively of whether the mental representations are about stories in traditional media (such as novels and films) or interactive media (such as interactive fiction). If one accepts that mental representations can be spatial, then this of course is a possibility for both cases.

Turning to the second line of criticism, even agreeing that spatial mental representations are possible, there is still the question of under what circumstances people actually construct spatial mental representations. TAYLOR and TVERSKY (1992) found that when given descriptions of fictive places to read, without explicit instructions to remember the spatial layout, people did construct spatial mental representations spontaneously. However, this conclusion can be criticised on methodological grounds. It was an artificial laboratory situation, and not a real story. Even if participants were not told they were later going to draw a map, because of the situation, they could have anticipated a memory test of the contents of the text. As was discussed above, it has been found that readers of normal texts in naturalistic settings do not normally construct long-term memory representations of spatial relations. Neither do readers construct spatial mental representations when the narrative is indeterminate, poorly organised or contains overly difficult descriptions. The present study is arguably naturalistic when it comes to playing of the computer game. So, do players construct spatial mental representations of the game world in normal game playing, and what evidence would let us determine this?

3.1.2. Determining spatial mental representations

Starting off with audiovisual data of players talking about the computer game after having played it, there are several types of evidence that would support the claim that participants form spatial mental representations of the game world in long-term memory:

i) *Elaborate spatial descriptions.* The basic observation that players actually give lengthy descriptions, spatially relating various places from the game is intriguing. This observation does not tell us whether any spatial mental representations reflect the actual spatial layout of the game, but even taken alone, it makes it probable that players drew their spatial descriptions from a spatial mental representation – truthful or not.

ii) *Description order*. If the order in which places from the computer game are mentioned by the participants matches the order in which the places were visited, participants may simply recall places off a list that was memorised at the time of encoding. This would suggest that no spatial mental representation was formed. On the other hand, if participants mention places that are spatially proximate when considering the spatial layout as a graphical map – in other words, an order that is consistent with doing a sweep across a map – we are inclined to think that a spatial mental representation is the source of these descriptions.

iii) *Completeness and accuracy*. Another evidence is correspondence of the talk about spatiality to the true spatial layout of the computer game by the description being complete and correct.

iv) *Consistency and integration*. A fourth piece of evidence is if descriptions present a consistent and integrated picture of the spatial layout.

v) *Other features of spatial mental representations.* We expect to find expressed in the descriptions properties that spatial mental representations have been shown to have in other studies, such as hierarchical organisation. The presence of systematic distortions that is common in memory for graphical maps would also be revealing.

The first point has already been discussed in the first part of this paper. We will now investigate the other points by analysing the verbal descriptions of spatiality made by the participants.

3.2. Method

See section 2.1. for descriptions of participants, material, and procedure.

3.2.1. Analysis of description order

For each participant, a list of places from the computer game world (*locations*) was constructed, in the order they were mentioned in the descriptions. Synonyms and translated names of locations were considered in order to resolve referential ambiguities. References that still were uncertain were marked as such. Some place names could not be mapped directly to locations in the game. These were marked and listed by the name used by the participant in the description. For each of the players, a second list of locations was constructed. The lists were arranged in the order in which the participants visited the locations, resulting in a unique list for each player. For the readers, a single list was made from the order the locations were mentioned in the text of the non-interactive version of the computer game.

From the same transcriptions, for each player, a graphical map was constructed by interpreting the player's description using a set of drawing conventions. For instance, *north of* was drawn above on the map, and *east of* was drawn to the right. The graphical maps thus represented the information in each player's description. The purpose of constructing the graphical maps was to use them when comparing mentioned order of locations as well as investigating the truthfulness of the descriptions by comparing them to actual maps from the computer game. Note that the constructed maps did not represent *distance*, because this information was not available from the descriptions.

As a final step, the order of mentioning the locations was compared to the order the locations was visited as well as to spatial proximity on the constructed graphical maps.

3.2.2. Analysis of properties of spatial mental representations

In order to compare how well the given spatial description actually corresponded to the true spatial layout of the game world, four measures were employed. *Completeness* of the spatial mental representation was calculated by the number of described locations divided by the number of locations actually visited (to count, the mentioned locations had to be locations actually occurring in the game). *Accuracy* was calculated by number of correct descriptions of spatial relations between two locations divided by the total number of descriptions of spatial relations between two locations. *Consistency* was judged by the absence of contradictions. A contradiction was said to have occurred if the participant gave incompatible spatial relations between two locations, for example, first saying the pub was north of the church, then later saying that it was south of the church. A low number of contradictions suggest a stable mental representation of the spatial layout. *Integration* concerns the question of whether the participant's description of the spatial layout formed a connected whole, or if the description consisted of a number of separate, spatially unconnected regions. A region was defined as at least two locations related spatially.

Hierarchical organisation was investigated by looking for super-ordinate categories in a part-relationship to location categories. For instance, a forest would be a super-ordinate category to a clearing, and a hospital would be a super-ordinate category to a waiting room (sub-ordinate categories were not considered, since locations are instances of categories, and thus already at the lowest level).

The participant's descriptions were searched for errors, and these were compared to known distortions for graphical maps, such as alignment bias (*cf.* section 3.3.4.) (TVERSKY 1981).

3.3. Results

Here, the results will be presented concerning the analysis of description order, completeness, accuracy, consistency, integration, hierarchical organisation, and systematicity of errors.

Participant 4 was not explicitly asked to describe places and their locations, as were the other participants, but nonetheless spontaneously gave lengthy descriptions when asked on a different question. This data was analysed in the same way as the three other participants, but one should keep in mind that the circumstances under which the data for participant 4 was collected differed from the others.

3.3.1. Description order

The order in which locations were mentioned in the descriptions made by the players sometimes, but not always, matched the order the locations were visited. In the same way, mentioned order sometimes, but not always, was consistent with scanning a graphical map of the locations.

Participant 1 gave three consecutive descriptions, where each description started over from the beginning, containing varying amount of details in each version. Participants 2 and 3 gave two separate descriptions each. It is the order within each of these descriptions that were compared to the order the locations were visited. There was insufficient data for participant 4 from which to construct a list.

Mentioned order was compared to visited order and spatial proximity on the maps for each participant. Participant 1 made four descriptions, the first three describe the overall layout of the game, and can be considered three versions of the same description (the participant can be seen starting over from the beginning in each description). The fourth description is of the *House*. In the first short description of places, the order of mentioning is the same as the order visited. In the second, longer description, the mentioned order of descriptions partly matches the order visited. One exception is the occurrence of *University Court* and *Library*, which appear much earlier in the description than in the order visited. This suggests that the description was generated by some other means than going through the locations in the same sequence they were visited while playing the game. Comparing the list of mentioned locations with the constructed map for participant 1, it was seen that the description order was consistent with doing a mental sweep on a spatial representation from east to west. The other exception is the occurrence of *The house* before the occurrence of *The sea*, where the latter was added at the end. One explanation for this could be that the participant inspected the spatial mental representation when talking about *The house*, and found that, around that area, *The sea* was located. The last exception is the mentioning of *Town square* (although this reference is uncertain; participant uses the term *a square*), which is not consistent with the order visited. It may be represented closely to *Twisting lane* in the participant's spatial mental representation, and in that case it is consistent with reading off a spatial representation, although it is not located in the place described by participant 1 on the objective game map.

The order of locations in the description made by participant 2 roughly followed the order the locations were visited. Two positions in the orderings were sometimes switched, sometimes three. One exception is that *University Court* is mentioned last, after *The house*. On the map, these two places are located in two separate ends. This makes it unlikely participant 2 came to focus on *University Court* by reading off a spatial mental representation.

For participant 3, the order mentioned does not match the order visited for the most part.

Analysing the order in which readers mentioned the locations revealed that it did not generally match the order locations occurred in the text, as shown in the bottom half of Table 6. An exception was participant 8 who, while mentioning the highest number of locations, also did so in the order they occurred in the text. No graphical maps were constructed for participants 5-8, since the spatial relations were either very vague or missing completely. Thus, a graphical map would in those cases be just a list of locations. Because of this, it was not possible to compare mentioned order to maps.

Table 6 summarises the results of matching the mentioned order to visited or read order and spatial proximity. Players are listed in the upper half of the table. There was an artefact of the matching method: As can be seen in the table, in the cases where a description consisted of few locations (say, below 5), matches were very frequent.

Spatial description	No. of locations mentioned	Matches	
		Visited/read order	Spatial proximity
Players:			
Participant 1: Description 1	6	yes	yes
Participant 1: Description 2	14	no	yes
Participant 1: Description 3	2	yes	yes
Participant 1: Description 4	4	yes	yes
Participant 2: Description 1	14	no	no
Participant 2: Description 2	5	no	yes
Participant 3: Description 1	13	no	no

Spatial description	No. of locations mentioned	Matches: Visited/read order	Matches: Spatial proximity
Participant 3: Description 2	3	yes	yes
Readers:			
Participant 5: Description 1	5	no	–
Participant 5: Description 2	6	no	–
Participant 5: Description 3	5	no	–
Participant 6: Description 1	3	no	–
Participant 6: Description 2	2	no	–
Participant 7: Description 1	7	no	–
Participant 7: Description 2	2	yes	–
Participant 7: Description 3	4	no	–
Participant 8: Description 1	9	yes	–

Table 6: The results of matching the order in which locations were mentioned to i) the order in which locations were visited/read and ii) spatial proximity on the constructed graphical maps.

3.3.2. Completeness, accuracy, consistency, integration

The left part of Table 7 reveals that the players' descriptions of spatiality were relatively complete, to a high degree accurate, consistent, and in most cases integrated. No locations that were not in the game were described (i.e., there were no occurrences of made up or falsely remembered locations). It should be noted that the results for participant 4 differ as a result of differences in the eliciting conditions. The fact that participant 4 was not explicitly asked to describe the spatial layout likely had the effect that the description was less complete, accurate, and integrated than would probably have been the case if this question would have been asked explicitly.

The results of the readers present a contrasting picture, as can be seen in the right part of Table 7. Readers gave descriptions that were mostly incomplete. Very few spatial relations were mentioned, but the ones that did occur were about 50% accurate. Because of the low number of spatial relations, the consistency and integration measures were not calculated for readers (see further the discussion below).

	Players (Computer game participants)					Readers (Non-interactive participants)				
Measure	1	2	3	4	Mean	5	6	7	8	Mean
No. of described locations	14	21	17	21	18	10	3	10	9	8
No. of encountered locations	26	33	26	42	32	25	25	25	25	25
Completeness of locations	54%	64%	65%	50%	57%	40%	12%	40%	36%	32%
No. of accurate spatial relations	7	13	15	16	13	1	0	3	0	1
No. of described spatial relations	8	16	16	24	16	3	0	5	0	2

	Players (Computer game participants)					Readers (Non-interactive participants)				
Measure	1	2	3	4	Mean	5	6	7	8	Mean
Accuracy of spatial relations	88%	81%	94%	67%	80%	33%	-	60%	-	50%
No. of spatial contradictions	0	0	0	0	0					
No. of regions	1	1	1	6	2.25					

Note: The overall accuracy figure is lowered by the fact that the total number of spatial relations consist of the categories *correct*, *incorrect*, and *uncertain*, the last category including, e.g., spatial relations that may be correct but where no destination location was mentioned.

Table 7: Measures of the completeness and accuracy of participants' mental spatial representations of the layout of the game world.

3.3.3. Hierarchical organisation

The players' descriptions expressed hierarchical organisation of elements. Participant 1 talked about the northern and the southern parts, and places were located in each part. All players talked about the house and rooms within the house. Participant 4 talked about the upper floor of the house and what rooms it contained, expressing a two-level hierarchical organisation. Participant 1 also used a two-level hierarchy when talking about the rooms in the house, and that the house was located in the southern part.

Descriptions by readers also showed a hierarchical organisation. Participant 5 expressed a hierarchical organisation by talking about the town and places within it. Participant 6 talked about the first floor of the house, and that the bedroom was located there. Participant 7 also gave a similar description of the first floor, and also described the town square and what places it contained. Participant 8 mentioned that the foyer and the master bedroom were inside the house.

3.3.4. Distortions and errors in spatial mental representations

Although the players' spatial descriptions were highly accurate, two kinds of systematic errors were found in the player's descriptions: a possible case of alignment bias and confusions of the canonical directions *east* and *west*.

The data does not permit analysis of fine-grained spatial differences between the original map (the one constructed from the participant's game session log) and the map as described (those kind of analyses require distance information in an original map and a map drawn by the person). However, the memory bias called *alignment*, which causes objects in the memory of a map to be lined up horizontally or vertically (TVERSKY 1981), could explain one inaccuracy found in participant 2's spatial representation. The location *Vacant Lot* was aligned with the road south which leads to *The House*. In the original map, the *Vacant Lot* lay more to the east, but this location was probably seen as more important by the participant than the *Riverwalk* which actually lay on the place *Vacant Lot* was described to be.

Another type of error was to confuse certain directions more often than others. The directions *east*/*west* was mistaken more often than *north*/*south*.

Participant 1 described an exit to the east when it actually was located to the west:

(5) Participant 1:
trappan ledde ju till sovrummet (.) å från sovrummet
'the staircase lead to the bedroom (.) and from the bedroom'

fanns det två stycken utgångar en i söder å en (.) i öster
’there were two exits one to the south and one (.) to the east’

In the following example, participant 2 makes two errors. First, a beach is described to be located southwest instead of east or southeast. Second, the pub is described to be located east instead of west.

(6) Participant 2: (text within parentheses indicates uncertain transcription, °h indicates inhalation)
(du) har ju fastighetskontoret (.) sen öh: (.) sen eh: sydvä:st om de så fanns
‘(you) have the real estate office (.) then eh: (.) then eh: southwe:st from that there was’

de nån strand (.) som man kunde klättra ner på (.) där det fanns en ett rör som stack
‘some beach (.) that one could climb down onto (.) where there was a pipe that stuck’

ut (.) °hh (.) å vatten då mm (.) lite mer ö:sterut (.) så fanns det en pub
‘out (.) °hh (.) and water mm (.) a bit more to the ea:st (.) there was a pub’

Speech repairs also suggest that east and west is confusing, as shown in example 7.

(7) Participant 2:
innan man gick ner dit så kunde man ta sig ut på en
‘before one went down there one could get to an’

abandoned lot där det fanns en madrass och så (.)
‘abandoned lot where there was a mattress and (.)’

kunde man gå (.) söderut (.) sydväst! eller sydöst
‘one could go (.) south (.) southwest! or southeast’

därifrån så kom man ner till vatten också
‘from there and one came down to water too’

The failures of the readers consisted chiefly of not mentioning spatial relations. Readers also gave fewer locations than players. No other systematic errors were found in the readers’ spatial descriptions.

3.4. Discussion

3.4.1. Description order

The order in which the locations were mentioned in the descriptions by the players as well as the readers did not match the order in which they were visited or read for the most part. In contrast with this, TAYLOR and TVERSKY (1992) found that the order in which participants drew landmarks matched the order in which landmarks were presented in a text describing a spatial layout. However, the many differences between Taylor and Tversky’s study and the present one make a comparison difficult. The length of the text, the number of landmarks, the time duration that the participants were allowed to study the text, the instructions given to the participants, and the fact that their participants drew a map as compared to giving description in speech are some potentially influencing factors. The order in which the participants in the present study mentioned the locations was not consistent with doing a scan over a spatial representation. Even though some descriptions matched visited/read order and spatial proximity, neither visited/read order nor spatial proximity receives support as a general explanation for why participants mentioned the locations in the order they did. This suggests that participants used some other strategy when recalling the locations than simply remember them in the order they were visited/read, or scan a spatial mental representation.

In the players' mentioning of the locations, there was a primacy effect. The first three locations were given by all players. An explanation for this is that an initial obstacle was presented to the players (how to get into the office) and they spent time on trying to solve this puzzle, thereby elaborating these places during encoding in memory.

3.4.2. Completeness, accuracy, consistency, integration

Players as well as readers mentioned a fair number of the locations from the game world, but players were more complete in their descriptions.

In studies of learning from graphical maps, TAYLOR and TVERSKY (1996) found that a mean of 94.6% of landmarks were mentioned by participants. Of course, this depends on the number of landmarks to be learnt, but the Taylor and Tversky figure is higher than the one obtained here for players and readers. The players should have had plenty of opportunities to learn the locations. The readers, on the other hand, may have made less effort to learn the locations, so the low figure of the readers is more expected. An explanation for the low number can be the presence of a bias in the completeness measure. It describes the spontaneous completeness given by the participants, since they were not instructed to exhaustively describe the places from the game, and no follow-up questions were asked when they gave their descriptions. To some extent, there is a chance element to the completeness measure used here. Whether memory retrieval is triggered in order to further describe the spatial layout in part depends on cues that happen to be available from, for example, the interviewer's utterances or the participant's associations. Thus, it is likely that the completeness measure presents an unfairly low figure. If prompted, participants may have given more locations and the completeness figure would go up. However, there is no reason to believe that this would have affected players and readers differently.

Nevertheless, there is a difference between players and readers concerning completeness. What could be the reason for this? At least three possible explanations suggest themselves. First, players were exposed to the locations a greater number of times, compared to readers. This repetition effect may have increased the strength with which the locations were encoded. Another explanation could be that players were more interested and focused on the locations, since they present an important part of playing *Anchorhead* – players need to move between locations to explore and solve the game. In this way, locations may have been elaborated in memory. The readers, in contrast, may have put less effort into thinking about the locations, and the locations were thereby less elaborated. Finally, consistent with the difference in completeness, players, but not readers, may have formed a coherent spatial mental representation – as a result of the navigational demand – which would make remembering locations easier.

Players provided highly accurate descriptions of the spatial relations, while readers did less so. Both players and readers made mistakes, but players gave fewer inaccurate spatial relations.

The numbers are comparable to studies by TAYLOR and TVERSKY (1992), where map drawings were made from learnt written route descriptions. The means of four experiments showed an 82-90% accuracy, although the conditions were different from the present study.

The reason for the difference in accuracy of spatial relations between players and readers could have an explanation in the processes of repetition and elaboration of single items. However, the fact that the difference between players and readers are even larger concerning spatial relations than concerning locations strongly suggests that the difference depends on the fact that players constructed coherent spatial mental representations.

There were no occurrences of contradictions in spatial relations in the descriptions made by players, even though a large number of spatial relations were mentioned. Readers gave very few spatial relations which made it unlikely that contradictions could occur (the consistency measure does not reveal much in the case of the readers).

The consistency of the players' descriptions goes well with the idea that they were using a spatial mental representation as a source for their descriptions.

Players spontaneously gave descriptions that consisted of integrated wholes. Participant 4 was an exception, describing six unconnected regions, but considering the different eliciting conditions, this is expected (he was not asked to give a description of the spatial layout, but gave spatial descriptions when answering other questions).

Because the readers gave few or no spatial relations, their descriptions can be said to show a very low degree of integration, if the measure could at all be meaningfully applied.

Taken together, these four measures support the conclusion that players were indeed making their descriptions from spatial mental representations, and the readers were not.

3.4.3. Hierarchical organisation

Players as well as readers expressed in their descriptions a hierarchical spatial organisation of the game world. However, this finding does not support the conclusion that players and readers had hierarchical spatial mental representations in long-term memory. As BROCKMOLE and WANG (2002) point out, when using verbal descriptions as a measure of the spatial representation, it will proceed in an ordered and hierarchical way, because of demands of the communicative situation. So, this could be attributed to the retrieval and production processes and is not necessarily a property of the underlying mental representation. On the other hand, hierarchical organisation is something we would expect to find in the descriptions if they were indeed made from spatial mental representations, because hierarchical organisation is a fundamental property of spatial mental representations (TVERSKY 2000). If no signs of hierarchical organisation were to be found in the descriptions, we would be reluctant to conclude that the descriptions were made from spatial mental representations.

3.4.4. Errors

Two types of systematic errors were found in the players' spatial descriptions: a probable case of alignment bias, and confusion between the directions *east* and *west*.

As demonstrated by TVERSKY (1981), and many after her, it is typical of spatial mental representations to be biased in a number of ways. One type of error, alignment bias, seemed to be present in the data. Given that it is indeed a case of alignment bias, this suggests that the spatial description was made from a spatial mental representation.

There were other errors in the spatial descriptions which suggest a spatial mental representation. It was found that *east* and *west* were confused more often than other pairs of directions. This suggests a mapping of the terms *east* and *west* to a spatial organisation, because people tend to more often confuse symmetrical axes than asymmetrical ones in spatial arrangements (TVERSKY, LEE, MAINWARING 1999). The explanation given by Tversky, Lee, and Mainwaring is that "north-south are absolute directions, anchored at the poles, whereas east-west are relative terms" (TVERSKY, LEE, MAINWARING 1999: 7). They also present findings that *left* and *right* are confused more than *front*/*back* or *head*/*feet.* Here, the case of symmetry versus asymmetry seems more obvious. Then, another explanation for the confusion of *east* and *west* – not mentioned in their article – would be that they are spatially mapped onto *right* and *left* respectively. This is the standard way of reading a map and may therefore influence the spatial experience of the game world. Regardless of whether *east*/*west* are inherently confusing, or whether they are confusing because they are mapped to *right*/*left*, the presence of these errors strongly suggest an underlying spatial mental representation.

The occurrences of mistaken directions, be it confusion between *east*/*west* or other errors in directions, were associated with signs of audible hesitation. Vowels were noticeably longer in cases of mistaken spatial relations than in cases of correct spatial relations. This observation suggests that, to the extent participants were using spatial mental representations as a source for their descriptions, they were at least partly constructing the spatial mental representation at the time of giving the description. The reason is this: If participants on the other hand did construct a spatial mental representation at the time of playing the game, the incorrect directions would be part of the spatial mental representation in just the same way as the correct ones. When retrieving directions from the spatial mental representation, all directions – correct as well as incorrect ones – would be treated equally. But instead, as was seen, many of the incorrect directions were reported in a different manner than the correct ones. Thus, at least part of the construction of a spatial mental representation had to be performed at the time of making the descriptions.

4. Conclusion

In summary, the present study provides evidence that there is a difference in audience cognition between interactive fiction and non-interactive fiction. Participants who played the computer game *Anchorhead* supplied longer, more elaborate verbal descriptions of spatiality of the game world than participants who read the non-interactive version of *Anchorhead*. Players remembered spatial facts better. This was supported by more complete descriptions of locations and more accurate descriptions of spatial relations. It is suggested that the reason for this improved memory performance is that players formed coherent spatial mental representations in long-term memory. This was supported by the findings that their verbal descriptions of spatiality were highly consistent and presented an integrated spatial whole. The forming of spatial mental representations by players were to some degree supported by confusion of the symmetrical axis *east*/*west*. Consistent with spatial mental representations, players' verbal descriptions showed spatial hierarchical organisation.

Consequently, it seems that despite the often claimed fragmentation of interactive fiction, players were able to form a coherent spatial mental representation.

It could be argued that the non-interactive version of *Anchorhead* that was constructed for this study may be an atypical text and not like a usual short story. It has an uncommon perspective (second person pronouns) and may be less interesting than an authentic short story. However, although the non-interactive version acted as a point of comparison, the weight of evidence for the construction of spatial mental representations in authentic reading situations of non-interactive fiction can be found in other studies, such as those by ZWAAN and VAN OOSTENDORP (1993) and HAKALA (1999).

Nevertheless, the results of the present study give strong support to the conclusion that players did construct spatial mental representations of the game world. The reason is probably that they did so because they needed to. There is a need to move around – a navigational demand – in *Anchorhead*, as in almost all works of interactive fiction. Thus, we can refute the hypothesis that players only use information locally in each situation in order to navigate. As the navigational demand is present in most interactive fiction, we conclude that it is likely that the audience constructs spatial mental representations also in other works of interactive fiction.

By telling us something about the conditions of experiencing narrative in interactive media, they also tell us about the nature of narrative – both in interactive media and in general. The results also provide understanding of cognition in general, and how the flexible human cognitive abilities adapt to new domains.

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