The Impact of Narratives on Update and Change of an Existing Cognitive Map

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Abstract

People are able to construct a representation of an environment based on verbal information; this has been shown for straightforward textual descriptions (eg. Taylor & Tversky, 1992a, b; 1996) and for narrative texts (eg., Morrow, Greenspan, & Bower, 1987). Are there differences in the relative impact of these two types of verbal information on the construction and update of cognitive maps? This study is based on a framework postulating the mediation of a situation model developed by narrative readers (Zwaan, Magliano & Grasser, 1995) in facilitating and enhancing changes to a previously acquired cognitive map. The participants were presented with a map, followed by texts (either narrative or descriptive) that describe changes to the environment in the map. While all groups succeeded in updating their cognitive map, the results showed that the description groups were generally more successful at their tasks than the narrative groups. Considerations of issues related to updating spatial information from text are discussed, including the overdeterminacy of the narrative text form.

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Introduction

Narratives and the narrative structure help us shape and interpret our environment by showing cause and effect relations, describing past events along a temporal dimension, and conveying a sense of spatial setting and environment (e.g., Bryant, Tversky & Franklin, 1992; Goldman, Graessar & van den Broek, 1999; Morrow, Greenspan & Bower, 1987; Rinck & Bower, 1995; Sarbin, 1986; etc.). Throughout history, humans have used the narrative form to pass information to younger generations, in the form of folklore and legend (Rubin, 1995; Tonkin, 1992). Even in present day, Inuit tribes in northern Canada use narrative to transfer knowledge of hunting trails and paths through the frozen terrain; this is their preferred method of transferring knowledge from one hunter to another (Aporta, 2004). This thesis addresses the impact of narratives on spatial knowledge, and the degree to which readers can use information in a narrative to update their existing spatial knowledge.

As our environment changes, narratives can provide a context to allow us to easily incorporate this information into our existing spatial knowledge of the world. For example, the Inuit hunters must change their routes according to the freeze and thaw of the ice, and therefore the narratives they use will reflect the changes in their route (Aporta, 2004). In another example, a disaster causing the collapse of structures inside a building, creates a changed environment, and the stories told by survivors can help rescue workers to navigate, or help authorities recreate the events. Here is an excerpt from a story from a survivor of the 9/11 attacks; he belonged to a group of people who escaped from the Marriott hotel, which is located on the bottom floors of the first Tower:

> Searching for another way out, the group traveled west toward another side exit in the hotel's restaurant. As it was designed to, the fire door had come down. The firemen lifted up the door, but it too was blocked by a grisly amalgam of glass shards, twisted steel, and chunks of concrete. [...]
> As they mounted the pile of debris, they realized that holes in the rubble were open several stories down to the basement, creating the risk that one of them would fall through. The survivors had to jump carefully over these holes until they finally reached solid flooring. (Anderson, 2002)

This survivor story contains details that are highly spatially relevant, but they are given in a context that describes the events as they unfolded, and what people in the situation were doing and thinking at the time. Although this thesis used a different story, the current research attempts to determine if the narrative context allows the listener to update or change their mental representation of the environment in a way that is easier or more detailed than a simple descriptive text.

There is one instance where researchers have empirically demonstrated that readers can use narratives to change their existing knowledge of words. The study, by Foroni and Mayr (2005), examined the influence of a narrative on the evaluation of categorical associations of words. Participants were instructed to categorize the word 'flowers' as negative and 'insects' as positive (which is opposite to how one would normally categorize these words). The instructions were given to them either in the form of a narrative or as specific instructions. These two researchers demonstrated that the participants who read the narrative were able change their associations of these words, and those who were given the specific instructions outside of the narrative were unable to change their implicit associations. These results support the idea that the narrative structure may possesses unique qualities that provide us with the possibility to change our existing knowledge more effectively than other forms of text.

Although Foroni and Mayr (2005) used narratives to change the reader's associations with words, readers are exposed to a great deal of information in a narrative. While Foroni and Mayr were measuring positive and negative associations with objects, readers of narratives learned information about the protagonist, the point in history when the narrative took place, and the environment the protagonist inhabited. The information about the environment includes spatial information about internal or external environments, locations of objects in those environments, etc. Previous researchers have examined the spatial mental models that readers derive from narratives (e.g., Johnson-Laird, 1983; Morrow et al., 1987; van Dijk & Kintch, 1983; Zwaan, Magliano & Graesser, 1995). However, there is little published research that compares narratives with other text forms, in regards to their influence to change or alter an existing mental model of a reader, in the same way that Foroni and Mayr (2005) showed that reading a narrative can change our existing associations of words. How narrative influence existing spatial mental models remains an important area to be explored, and the research contained within this thesis attempts to empirically answer this question.

In order to address the question of how readers of narratives incorporate new spatial information into their existing spatial knowledge, the introduction to this thesis is composed of the following sections. The first section is a review of the methods of how people create mental models of an environment, this is referred to as a *cognitive map*. The research presented has a focus on environments described in texts, both descriptive and narrative. The second section is an exploration of the narrative, its structure and the elements of which it is composed. The third section is a presentation of current theories of how cognitive maps can be created from reading a narrative; this process happens via a *situation model* (van Dijk & Kitnsch, 1983; Zwaan & Radvansky, 1998; Zwaan et al., 1995). The literature review served as the basis for the research design of this thesis, which was an attempt to measure the influence of the narrative structure over our existing spatial representations of the world.

Cognitive maps

To better understand the concept of cognitive maps, the research presented in this section reviews the acquisition of cognitive maps, how they are stored in memory and retrieved, and the process by which cognitive maps can be changed.

Acquisition of spatial information. Human spatial cognition refers to our knowledge and internal representation of the structure, entities and relations of space (Hart & Moore, 1973). In 1948, Tolman was one of the earliest researchers to examine the mental representations of a particular environment. Tolman observed rats running through a radial arm maze, and he suggested that the spatial information the rats were learning from the maze was being stored in the nervous system and could be used to predict spatial behaviour. Indeed, the stored spatial information was termed a *cognitive map* (Tolman, 1948) and was later shown to activate the hippocampal area of the brain (O'Keefe & Nadel, 1978; O'Keefe & Burgess, 1996; Shelton & Gabrieli, 2002). The term *cognitive mapping* was formally defined by Downs and Stea (1973) as the process of acquiring, forming, and maintaining spatial information and spatial knowledge. The cognitive map can also be referred to as a spatial mental model

(Taylor & Tverksy, 1992a, b; 1996), or mental map (Johnson-Laird, 1983), although the term cognitive map is used in this thesis. A cognitive map aids our navigation of our immediate and familiar environment by storing spatial information for later retrieval.

A cognitive map is created, and later retrieved, in a way that reflects the type of spatial information provided. Two types of spatial knowledge commonly studied in spatial cognition research are route knowledge and survey knowledge (e.g., Shelton & McNamara, 2004; Taylor & Tversky, 1992b, 1996; Thorndyke & Hayes-Roth, 1982). Route knowledge is acquired as a person travels a route, or follows a path, through an environment (Thorndyke & Hayes-Roth, 1982). Survey knowledge is acquired as a person studies an environment from a 'bird's-eye view', or from above, looking down on the environment (Thorndyke & Hayes-Roth, 1982). This latter type is most commonly acquired by studying a map of the environment. The two researchers who demonstrated the differences between these types of knowledge are Thorndyke and Hays-Roth. In 1982, their experiment required two groups of participants to study the same environment; they required one group to explore the environment by walking around, and the other group to study a map of the space. Differences in the cognitive maps formed by participants in either group were evident in their performance on the tasks that followed. The group who explored the environment (i.e., who acquired route knowledge) gave more accurate estimations of travel time between objects in the environment, and of the degree of orientation required to see hidden objects. The group who studied the map (i.e., who acquired survey knowledge) gave more accurate estimations of distance between objects in the map, and were better able to judge the relative positions of objects to each other. Thorndyke and Hays-Roth's results support the idea that the type of knowledge the learner received affects the way they construct their cognitive map.

The method of physically exploring of an environment (*primary learning*) provides more information than the method of only studying visual information (*secondary learning*). Allothetic information is a form of ambient information derived from primary learning (i.e., acoustic and visual flow) and this provides both perception and orientation information (Carlson, 1997; Gibson, 1998). Locomotion, which provides proprioceptive and visual feedback, also plays an important role in perception and egocentric orientation (Simons & Wang, 1998; Wang & Simons, 1999). Because of all the information gathered from physical exploration, as well as the route knowledge of the environment, researchers have shown that cognitive maps acquired from exploration are more accessible and require less effort upon recall than information about environments acquired through secondary learning (i.e., map study or imagined environments) (Loomis, Da Silva, Fujita, & Fukusima, 1992; Reiser, Guth, & Hill, 1986). In fact, the sequential model of spatial knowledge acquisition supports the idea that survey knowledge can be developed through extensive navigation at the route level (Seigel & White, 1975). Physical exploration of environments is common both in research and in daily life, and can provide a significant amount of spatial information, however there are other methods of acquiring spatial information that do not involve physical exploration, such as reading a text passage.

The creation of a cognitive map can be accomplished by means other than physical exploration of an environment: a person can study a map of the space, as demonstrated by Thorndyke and Hays-Roth (1982), or they can read a text about the space. Language can be used to create a representation comparable to those derived from experience with the real world (Johnson-Laird, 1983; Taylor & Tverksy, 1992a, b, 1996; van Dijk & Kintsch, 1983); the creation of a cognitive map allows the person to experience that environment by proxy. Readers can use the spatial relations in the language of a text passage to create their own mental model (Morrow et al., 1987; Taylor & Tversky, 1992a, b, 1996; Wilson, Rinck, McNamara, Bower, & Morrow, 1993). This text passage may do nothing more than describe the environment but will give the reader enough information to imagine what the environment might look like (Taylor & Tversky, 1992a, b). Alternatively, the text passage may be in a narrative form describing a series of related events and the actors of these events. In this case the reader will also develop a mental model of the environment described within (Morrow et al., 1987; Perrig & Kintsch, 1985; van Dijk & Kitsch, 1983; Zwaan & Radvansky, 1998). The differences between descriptions and narratives are explored further in this research, but regardless of its form, previous researchers have shown that text does provide another source of spatial information from which readers can build a cognitive map.

In much the same way that cognitive maps differed depending on whether the learner explored the environment or studied a map (Thorndyke & Hayes-Roth, 1982), cognitive maps acquired by readers differ depending on the spatial perspective provided by the language in the text. Taylor and Tverksy (1992b) gave participants text passages that described particular environments (i.e., a conference centre, a small town). One group received a text passage that described the environment from a route perspective. The language used denoted an egocentric perspective (i.e., "as you walked to the end of the hall, the VCR room was on your right"). The other group received their text passage in survey perspective. In this passage, directions were no longer relative to an egocentric perspective, but were given according to fixed cardinal points (i.e., 'the VCR room is in the south-west corner of the conference centre'). In their research, Taylor and Tversky (1992b) found that those who learned in route perspective were better able to judge relative positions within the environment and route travel times, whereas those who learned in survey perspective were better able to judge absolute distances – a similar result to that observed by Thorndyke and Hays-Roth upon assessing their participants' cognitive maps. Therefore, it seems our mental models behave in similar ways according to the perspective in which spatial information is learned: by exploration, learning a map or reading text.

Taken together, researchers have demonstrated that cognitive maps can be created through a variety of means: exploration, studying a map, or reading a text about the space. The element that differentiates these cognitive maps is the perspective in which a person learns that information. Studying a map will allow a person to create a cognitive map and use it similarly to a person reading a text passage in survey perspective (Taylor & Tversky, 1992a). Although exploration provides additional physical information, studying images taken along a route will allow a person to create a cognitive map and use it in the same way as a person who read a text passage in route perspective (Shelton & McNamara, 2004; Taylor & Tversky, 1992a). Once new spatial information is learned, it needs to be stored and this is addressed by the subsequent section.

Retaining and storing spatial information. Cognitive maps, acquired from exploration, map study, or reading, can be stored in long-term memory in the same way that other types of visual information are stored. Dual-coding theory, as originally proposed by Paivio (1986), accounts for how humans process and store verbal and visual information. Paivio's theory presents two cognitive subsystems: the verbal processor, which encodes speech or text as units of linguistic information; and the non-verbal processor, which encodes visual and spatial information such as events, images, and pictures as holistic, graphic representations of the entire image. Verbal information may activate stored image information in the non-verbal system (e.g., the word 'chair' may activate an image of a chair in memory), and vice-versa. This cross-activation of systems is called *referential processing*. According to dual-coding theory, spatial information in image form (i.e., a map) is stored in the non-verbal cognitive system, and spatial information in text form (i.e., a description) is stored in the verbal cognitive system. Therefore, the dual-coding system is responsible for processing a cognitive map, regardless of whether the spatial information is acquired in image form or text form. While this theory addresses how cognitive maps are processed, it does not account for the methods by which the cognitive map is stored for recall.

The way a cognitive map is represented in long-term memory is the focus of two theories. One theory suggests that the way a cognitive map is stored may have more to do with the content of the map (i.e., what the map is depicting) rather than its spatial and geometrical properties, as one may expect. Studies by McNamara have shown that stable, long-term representations of environments in memory are organized categorically (McNamara, 1986; McNamara, Hardy, & Halpin, 1992). For example, object locations are organized in clusters, and these clusters may be subjectively organized in a hierarchy (i.e., a cook may first recall the kitchen in a house, then the dining room), or semantically organized (i.e., all objects within the kitchen). Another theory suggests that cognitive maps reflect a temporal organization. Curiel and Radvansky (1998, 2002) demonstrated that participants recalled locations within an environment according to the order in which they were learned, and not necessarily according to their spatial proximity in the environment. Therefore, these two theories present different ideas of how cognitive maps are represented in long-term memory, and this difference in storage may affect the way in which cognitive maps are retrieved.

The question of how spatial information is mentally represented raises the following question on spatial information acquired from text: upon retrieval, does the reader remember the words he read, or the environment he read about? Mani and Johnson-Laird (1982) suggested that what is represented may depend on the determinacy of the text. If the description in the text is clear and easy to understand, the reader will be more likely to remember the cognitive map of the space. If the text is unclear or vague, the reader will be more likely to recall the words used, and not the image described. This conclusion suggests two possibilities: either (a) a vague cognitive map is difficult to recall, or (b) the reader simply did not create a cognitive map from the description and recalls only the text he read. This research about determinacy of text was replicated by Payne (1993), and he used the results to develop the episodic-construction-trace hypothesis. He suggested that readers recall the mental operations by which the mental representations were constructed, and not necessarily the mental representations themselves. These previous researchers have shown that the answer to the question asked at the beginning of the paragraph is, 'it depends'. Cognitive maps can be recalled in image form from long-term memory, as long as the text used to describe the space was specific enough for the reader to have created a cognitive map

In conclusion to this section on cognitive maps, researchers have shown that cognitive maps can be acquired through exploration of the environment, studying a map, or reading text passages about an environment. Dual-coding theory (Paivio, 1986) accounts for how non-verbal and verbal information about space is processed and represented in long-term memory. These cognitive maps may be stored according to categorical clusters (McNamara et al., 1992; McNamara, 1986) or according to the temporal order in which the information was learned (Curiel & Radvansky, 1998, 2002). Finally, readers will be more likely to remember the cognitive map itself rather than the words used to describe it, if it is learned from a detailed and specific text passage (Mani & Johnson-Laird, 1982). Once a cognitive map is stored in long-term memory, it may need to be updated to reflect changes in the environment due to construction, renovation, or simply the displacement of objects. The degree to which one can update or change their cognitive map can be useful for navigation and coping with changing environments.

Updating or changing previously stored spatial information. Once spatial information is stored in long-term memory, the next step in understanding the capacities and limitations of a cognitive map is to understand how and under what circumstances it can be updated or changed to accommodate new information. The most obvious way of changing a cognitive map is to explore the changed environment; then, the methods of acquiring new information would resemble the methods described earlier as a person explores their environment. Exploration of the changed environment provides visual information, along with allothetic and proprioceptive information from locomotion, which allows the explorer to incorporate any new information. However, exploration is not always possible, and one may have to learn new spatial information by studying a map or reading a text that describes the changed spatial information. Some conditions may need to be in place to ensure a person can successfully update their cognitive map, and three of these conditions are explained here.

First, studying a map that depicts changed spatial information, such as a newly built road or an addition to an existing building, may allow the viewer to incorporate this new information, although the success of doing so may depend on semantic relevance of the objects or spatial relations that have changed. Mandler & Ritchey (1977) showed that participants were less likely to remember a change from one picture to another if the change was to an object unimportant or peripheral to the main idea of the picture. They were more likely to recognize a change in details that were highly relevant to the image. Therefore, if the changes to the environment are peripheral to the individual, he or she may not incorporate the changed spatial information into their cognitive map.

Second, the degree to which a person incorporates new information may depend on the completeness of his or her original cognitive map, as demonstrated by the following study. Blanc & Tapiero (2001) had three groups of participants: the first group was given detailed information about the environment, the second was given less detail, and the third was given vague, general details about the environment. Participants then read a text passage that described changes to the environment. The group who began with the most detailed information about the space showed the greatest degree of success when updating or changing their cognitive map. This result is similar to the research previously discussed which showed people who read clear and specific text were more likely to recognize the image of the description versus those who received unclear text (Mani & Johnson-Laird, 1982). It seems likely that those who read unclear or vague texts had difficulty creating a cognitive map, and therefore had more difficulty incorporating information about changes to that environment.

Finally, the degree to which a person can change his or her cognitive map when reading a text passage can also be influenced by task demands. Wilson, Rinck, McNamara, Bower & Morrow (1993) demonstrated the role of explicit instruction updating one's cognitive map. Participants were far more likely to attend to spatial details and incorporate new information into their pre-existing cognitive map if they were given instructions to do so. Therefore, many elements, such as semantic relevance, complete prior knowledge, and task demands, can influence the degree to which one incorporates new information into their pre-existing cognitive map.

In summary, cognitive maps can be changed with new information. Exploration can provide this new information, as well as maps or text passages describing the environment. Some conditions may need to be in place for a successful update, such as changes to semantically relevant objects or locations, a complete cognitive map of the environment before the change, or explicit instructions to attend to new spatial information. Another condition not fully explored by previous research is the degree to which the type of text passage can support the ability of readers to change their cognitive maps upon receiving new information. This thesis assessed the differences in readers' cognitive maps upon reading either a narrative or a descriptive text that describes changes to a previously-studied environment. The next section elaborates on the narrative, its structure, and the situation model, which is what readers form while reading narratives. The situation model serves as a basis for the measures the narrative's impact on changes in the cognitive map.

The Narrative

"Narratives translate knowing into telling." (White, 1981)

Throughout time, humans have demonstrated a capacity to translate their history into narrative structure. This capacity dates as far back as humans who drew their stories in image form on cave walls (see White, 1981 for a review). Names, places, and culture have been passed through generations in the form of fairytales, legends, and fables. Some researchers have said this demonstrated a universal need for the narrative structure to act as "metacode", to continuously substitute meaning for straightforward copy of events recorded (Barthes, 1977). The narrative structure has been a method of organizing information used for thousands of years, and all narratives contains common elements which allow a clear definition of what composes a narrative.

Many researchers have contributed to the definition of a narrative, from the general definition to more detailed, specific definitions. At its most minimal, a narrative is defined as at least two events organized in a temporal order (Wilson, 2003), and whose order has some meaningful structure (White, 1981). However, for the purposes of this research, the definition above does not allow a clear distinction between narratives and other forms of text passages. A more specific definition entails that a narrative is an account of actions of human beings that have a temporal dimension (i.e., a beginning, middle, and an end), a spatial dimension (i.e., an environment), and these actions are held together by recognizable patterns of events called plots. Central to these plots are human predicaments and attempted resolutions (Sarbin, 1986). This definition accounts for the location in time and space, the presence of characters, their actions, and cause and effect relationships that are central to the plot (which Sarbin calls human predicaments and resolutions). This definition is used both by narrative researchers (Barthes, 1977; Coste, 1989; Gerrig & Murphy, 1992; Hobbs, 1990) and also by narrative psychologists as a framework to help people understand human behaviour (Bruner, 1991; Gergen & Gergen, 1986; Sarbin, 1986). This latter definition has been adopted in this research, as a means to identify the qualities of a narrative, and distinguish it from other types of text passages.

Another type of text passage, and the one used in this research, is the descriptive text passage, or simply: a description. A description presents details of settings, scenes, objects, machines, and people (Brewer, 1980). A central feature of descriptive texts is that they primarily contain static descriptions rather than changes in states (events or actions) (Millis, King & Kim, 2000). A description may sometimes be referred to as an expository text, although expository texts contain other elements such as persuasion, classification, sequence, etc., (Graesser, McNamara, & Louwerse, 2003) which are not relevant to this research. Using Brewer's definition, the only element that a description has in common with the narrative is the description of the environment; a narrative adds the context of time, characters and plot that the description does not.

The context added by the narrative structure can act as a convenient vehicle for people to represent historical events or changing environments from their own culture and surroundings. As described by one researcher, the narrative is providing an implicitly spatial modeling of a temporal form (Coste, 1989); in other words, the narrative provides a spatial context to illustrate the passage of time. The Inuit hunting culture of northern Canada is one example of how narratives can be useful to illustrate changes to an environment as time passes. As mentioned previously, Inuit hunters tell each other a narrative of their journey as a means to describe the routes they used to travel the ice and snow (Aporta, 2004). As the seasons get warmer, the sea ice melts and becomes impassable. The narratives of the journey change to reflect the melting terrain, and when it gets colder, the narratives change again. These Inuit hunters only use narratives to explain their journeys; upon attempting to describe the route without the narrative context, they were unable to do so (Aporta, 2006). It seems that narratives, and the structure they provide, allow the learner to understand and absorb information that the structure of a description does not. This is perhaps why psychology and the study of human behaviour have attempted to use the narrative structure to their advantage.

Narrative psychology ascribes human understanding of the world to the understanding of stories told by others who have come before us, or who are from different places (Sarbin, 1986; White, 1981). We can understand the motivations of others and empathize with them to the extent that we can understand their stories, however exotic or foreign (Coste, 1989). According to Sarbin (1987), the organizing principle for human action follows a narrative structure; we incorporate time and place, motivations and causes for behaviours, and organize episodes of actions and accounts of these actions in the same way as a narrative does. The narratory principle of narrative psychology explains that humans think, perceive, imagine and make moral choices according to narrative structure (Sarbin, 1989). In other words, people generally behave in the world based on their own story, the cause-and-effect relationship of their own emotions and their perceptions of the motivations of others. Therefore, the way readers interpret these narratives can provide insight into human behaviour in general.

The structure of a narrative seems to allow information to be understood easily by the human mind. Narratives are a unique form of a text passage, and they are qualitatively different from a description. Readers not only learn about a location in time and space, but also about characters, their challenges and resolutions, whereas descriptions only explain objects or space. Narratives also appear to be a useful form of passing information between people and generations. The narrative form is so effective that a branch of psychology, called narrative psychology, uses the narrative to its advantage and encourages people to understand vague or confusing events by placing them in the narrative context. For researchers interested in the narrative, it seems to be a useful method of framing various types of information that allows the human mind to understand it easily. The example of the Inuit hunters demonstrates that spatial information is one of these types of information. As described earlier, when people acquire spatial information, whether it is from a map or from a text passage, they use it to form a cognitive map. Spatial information can be framed in the narrative context, like the stories of the routes taken by Inuit hunters, and it follows that the readers build a mental representation of this spatial information.

The Situation Model

Narratives allow the reader to create a mental representation of what is being described. In fact, Jahn (2004) showed that readers spontaneously create a mental image of the situation with the presentation of a single sentence that illustrates a cause and effect relationship between two characters. Readers were able to use this mental representation to answer questions about the spatial relations in the environment of the narrative (Jahn, 2004). The mental representation acquired from the narrative is what discourse psychology literature refers to as a *situation model* (van Dijk & Kitsch, 1983; Zwaan, Magliano & Graesser, 1994; Zwaan & Radvansky, 1998), and the situation model comprises all types of information the reader has taken from the narrative.

The situation model is a necessary element in the reader's comprehension of the narrative. As the reader understands the information presented in a narrative, they construct a mental image depicting the content of what they are reading (Johnson-Laird, 1983; van Dijk & Kintsch, 1983). The situation model can be described as a "microworld" (Graesser & Wiemer-Hastings, 1999), and the reader ascribes all the elements of the narrative to this microworld: the core plot, characters, events, conflicts and resolutions, emotional reactions, spatial setting, style of actions, props and objects, and even character traits. Many researchers agree that the reader's comprehension of a narrative depends on their construction of this situation model; if the situation model is improperly constructed or, more often, if there are inconsistencies or discontinuities which occur during its construction, it will negatively affect the reader's comprehension (Morrow et al., 1987; van Dijk & Kintsch, 1983; Zwaan et al., 1995; Zwaan & Radvansky, 1998). This in line with the earlier findings of Mani and Johnson-Laird (1982) who showed that readers who received unclear or vague information had difficulty recognizing the image of what was being described. According to the researchers of narrative comprehension cited above, a reader who understands the narrative has developed a situation model -- a mental representation of the narrative. The situation model is the final product of a well-understood narrative, and the development of this situation model is done in stages.

A well-established theory of situation model development is the *event-indexing model* (Zwaan et al., 1995). Readers parse clauses of a narrative into separate events: bounded regions of space and time (Quine, 1985). During comprehension, readers connect these events on three situational dimensions: spatiality, temporality, and causality (Zwaan et al., 1995; Zwaan & Radvansky, 1998). Spatiality accounts for the spatial relations of objects within the environment and the general surroundings of the characters. Temporality locates the characters and the locations in a specific point in time, or along a timeline as the plot develops. Causality refers to the causal links of characters to actions in the narrative; this includes the characters, their motivations, and the causes of their actions and reactions. If the event currently being read overlaps with the previously-read event on any one of these three dimensions, a link between those events is established and stored in memory. In other words, if the event currently being read contains a character named Sarah, and she is also involved in the previous event, the events are indexed as relating to the same character, and the current event updates the situation model. To recap, overlap is determined by a shared element of spatiality, temporality, and causality. The event-indexing model accounts for the development of the situation model, which in turn contains all information in a narrative.

Of the three dimensions of a narrative responsible for the development of the situation model, the causality element seems to have the strongest effect. As described by van den Broek (1990), the *causal inference maker model* suggests that in the absence of overtly strong causal links between characters and their actions, the reader will simply infer their own causal link so as not to leave it missing. Readers can comprehend a narrative passage with missing spatial or temporal information, but they require either strong causal links to show the actor's motivations, or they will create their own (van den Broek, 1990; Zwaan & Radvansky, 1998). Incoherent or incongruent links will results in miscomprehension of the narrative. Causality appears to have the strongest effect on the development of the situation model.

Based on the strong effect of causality, spatiality in the situation model can be emphasized or strengthened by introducing a causal element. In fact, spatiality is one element that is not unique to the narrative structure; descriptive texts can describe environments and places with no mention of time, characters or events. But the spatial relations in an environment become more salient to the reader when causality is introduced. In a study by Jahn (2004), readers were given one sentence to read. The sentence described three turtles in relation to another animal; in the causal condition, the animal was a predator, and in the non-causally linked condition, the second animal was non-predatory. Participants were then tested on their comprehension of the text, and what their situation model resembled. The participants in the predator condition showed significantly faster recall, and the locations described in the predator conditions were primed, showing faster response times than the locations and spatial relations described in the non-predatory condition. This study demonstrated that the stronger the causal link in the text, the more detailed and well-developed the reader's situation model will be, and that includes the causality and spatiality elements.

In summary, situation models are the mental representations of all the information presented in the narrative. To have developed a complete situation model is to have understood the narrative being read (van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). The process of developing a situation model can be explained in terms of the event-indexing model (Zwaan et al., 1995), which explains that readers draw links between events that overlap elements of spatiality, temporality, or causality. Particularly, the presence of causality can help to strengthen the element of spatiality, and thereby strengthening the reader's situation model. Because readers were able to answer questions about spatial relations within their situation models (Jahn, 2004), this introduces the idea that readers were able to use their situation models as cognitive maps.

A situation model can be used as a cognitive map to the extent that the situation model contains the element of spatiality. In a classic experiment by Morrow, Greenspan and Bower (1987), these researchers showed that the reader updates the location of the protagonist in their situation model – which includes the mental representation of the environment - as he or she reads the narrative describing the movement of the protagonist. In the experiment, the researchers gave the participants a map to memorize. The map was of a fictional conference centre; it had eight rooms and various objects were located throughout the conference centre. The participants were asked to study the map and then asked to replicate all the objects in the locations they studied on the map on a blank floorplan. A successful completion of this map constituted a memorized map, and therefore all the participants moved to the next phase of the experiment with similar knowledge of the conference centre map. The participants then read a narrative; the protagonist in the narrative had a goal that led him through every room in the map. Periodically during the narrative, the experimenters would stop the reader and attempt to determine what was happening with the reader's situation model. In order to do this, the experimenters asked about locations of the objects in relation to the protagonist. Because the reader was updating the location of the protagonist in his or her situation model, the reader was able to recognize objects that were in the same room as the protagonist (at the time the narrative was paused) faster than those that were in a different room. These findings support the notion that situation models can be used as cognitive maps.

In review, situation models allow readers to create a mental representation, a cognitive map, of the environment in the narrative. The situation model is created from all the elements of a narrative (temporality, spatiality, and causality). Although other forms of text (such as descriptions) may possess spatial information, the spatial relations described in the text may not be salient to the reader until the element of causality is introduced (Jahn, 2004). Therefore, the situation model, as defined by van Dijk & Kintsch (1983) and Zwaan & Radvansky (1998), is a unique result of reading a narrative, and it contains salient spatial information that makes up the reader's cognitive map of the environment in the narrative.

The objective of this research was to compare the influence of both text forms – narratives and descriptions -- on the degree to which readers can change their cognitive maps. Because little research exists to compare the mental models of readers of narratives to those of readers of descriptions, the following section can only present research about the mental models of narrative readers. The research is presented as such: first, how the narrative reader constructs their situation model; second, the circumstances under which readers incorporate new information into their situation models; and third, the measurable properties of this model.

Construction of situation models. As readers process the information contained in a narrative, they are constructing and updating their situation model

(Morrow et al., 1987; van Dijk & Kintsch, 1983) This process involves three stages, and is well detailed by Zwaan and Radvansky (1998) in their comprehensive review of narrative comprehension. These researchers expanded on the event-indexing model (Zwaan et al., 1995) to describe the specific processes by which situation models are constructed, and their theory is also based on ideas of short-term working memory (Ericsson & Kintsch, 1995). At the first stage, the information currently being read is considered the *current model*, and it is stored in short-term working memory. At the second stage, as the reader continues, he or she adds the next piece of information to the current model, and the model now becomes the *integrated model.* Successful integration of this new information requires a link between this new information and the current model. The reader may draw the link from the current model in their short-term working memory, or they may infer a link by drawing on their long-term memory of similar models. The progression from the current model to the integrated model represents the event-indexing model (Zwaan et al., 1995). The integrated model, with the new information, replaces the current model. As the next piece of information is introduced and new links are made, a new integrated model is constructed. This process continues until the reader reaches the end of the passage, where he or she reaches the third stage. When all the information has been incorporated, the reader now has a *complete model* of the narrative. The framework proposed by (Zwaan & Radvansky, 1998) addresses the construction process of the situation model, although it does not address *when* the reader assimilates new information into their integrated model.

The point in the narrative at which readers assimilates new information into their integrated models is a subject of debate. One theory suggests that readers update their situation models with every new piece of information they receive, or in an "on-line" manner (Avaarmides, 2003; Levine & Klin, 2001). These researchers suggest that the situation model is constantly being updated, and that it is a holistic, continuous process. Evidence for this theory may be seen in Jahn's study of spontaneous construction of mental models (2004). A second theory suggests that readers update their situation models in a "backwards" process (de Vega, 1995). De Vega argues that readers only update their situation models when the new information is relevant to the plot. Readers may receive information about plot-irrelevant objects in the environment, or about a new location of a secondary character, but they will not integrate this information into their situation model. If it is evident that the plot will be altered as a result, the reader then goes 'back' to their current situation model, incorporates the new plot-relevant information, and continues with their integrated situation model. This is a piece-meal process that is not continuous. The backwards-updating model is supported by the event-indexing model (Zwaan et al., 1995), which explains that there must be a clear connection between new information and the previously described situation for the integrated model to be updated. These two theories hold conflicting views about when the reader integrates new information, either constantly as they read, or only when it is important to the plot. However, both theories demonstrate that readers can update their situation model from information contained in the narrative.

In summary, as readers are constructing their situation model, they begin the process of integrating information into their model. Whether they do so continuously, or after the information is deemed plot-relevant, is still controversial. Whichever method readers employ, both viewpoints suggest that readers do arrive at complete situation models. Because this thesis focuses on how a reader updates their cognitive map, the following section addresses the question: once the situation model is complete, how or when do readers update their situation model and therefore update their cognitive map?

Changing the situation model. The circumstances under which the situation model will change are similar to the factors that support the change of a cognitive map (semantic relevance, complete prior knowledge, and task demands). The semantic relevance of new information requires the reader to evaluate it in comparison with the rest of the narrative. Albrecht & O'Brien (1993) presented readers with consistent or inconsistent information about the protagonist. The researchers found that if the inconsistent information was deemed important, or relevant to the protagonist, the changes were incorporated into the situation model. If the changes were irrelevant, or had no bearing on main plot, then the changes were more likely to receive less attention and less likely to be remembered. Van Oostendorp (1996) found a similar result in his research on readers of newspaper articles. He gave readers an article about a criminal trial. Later, he gave readers a "correction notice" regarding the article. If the correction notice was highly relevant (i.e., the person in the story was actually charged with fraud, not armed robbery) then the readers were more likely to remember this information and change their situation model. However, if the information was not highly relevant (i.e., it was raining the day of the trial, not sunny as previously reported), the readers were less likely to remember those details. With similar findings to Mandler & Ritchey (1977), the semantically relevant details were incorporated into the situation model, and the non-relevant details were ignored in favour of the original situation model.

Complete prior knowledge of the situation model also contributes to whether or not the reader incorporates the inconsistent information in their situation model. In a study by Blanc and Tapiero (2001), participants were divided into three groups. In the first group, participants were given a complete description of a set, assembled on stage in a theatre. The participants read descriptions of each room, and learned the rooms as well as the objects within each room. In the second group, the participants read a description of the rooms, but with less detail and no mention of the objects within. The third group was given a description of the theatre, and told there was a set on stage. All groups read the script of the play, which involved the characters moving between rooms, and the characters picking up objects and moving these between rooms as well. Then all participants were tested on the updated layout of the set and locations of all objects. They found that participants in the first group, who had the complete and detailed prior knowledge of the set, were better able to integrate the information about characters and objects moving, and were better able to manipulate their cognitive maps. Although the participants in the second and third group (who had low-specific or no-detail prior knowledge, respectively) were able to comprehend the new information, they showed longer response times and poorer performance on inference judgement tasks of the space. These findings were similar to earlier studies

(Zwaan et al., 1995; Zwaan, Radvansky, Hilliard & Curiel, 1998) where researchers presented readers with spatially inconsistent information. In the conditions where the readers had a previously existing cognitive map (i.e., when the readers studied a map of the space before reading the narrative), they showed slower reading times for sentences that presented spatial information that was inconsistent with the map. However, if the reader was simply reading the narrative with no previous exposure to the environment described, their reading time for the sentences with inconsistent information was the same for those with consistent information. These results may suggest that the readers who did not have prior knowledge of the space simply did not create a cognitive map and therefore did not have to resolve spatial inconsistencies. Prior knowledge of the environment does support the ability of readers to incorporate new information into their situation model and to update their cognitive map.

Finally, task demands can also affect whether readers incorporate inconsistent information into their situation model. Both Wilson et al. (1993) and Zwaan et al. (1998) found that, upon explicit instructions, readers used the information in the narrative to change their situation model, despite that information within the narrative contradicted previously learned spatial information. The research presented in this section is similar to that in the previous section regarding how people change their cognitive maps in general; the presence of task demands will have a positive effect on whether or not readers can update their cognitive maps by reading text.

In conclusion, a situation model seems to behave the same way as a cognitive map, to the extent that the circumstances under which a person will change their cognitive map are the same as the circumstances under which a reader will change their situation model. A major aspect of a situation model is the reader's cognitive map of the environment in the narrative. Therefore it follows that a cognitive map in the situation model and a cognitive map acquired from other sources would be affected by similar factors. However, cognitive maps contained in the situation model are also linked to the other factors of the narrative (temporality and causality), and these factors can serve to enhance the cognitive map (e.g., introducing causality into spatiality (Jahn, 2004)). Therefore, the narrative structure may serve to enhance the cognitive map by constructing the situation model. In order to assess if the situation model does enhance the reader's cognitive map, it is necessary to measure the reader's situation model throughout a narrative. This measurement will also allow a comparison between the situation model developed by readers of narratives with the mental models, if any, being made by readers of descriptions, and determine if the situation model gives readers of narratives an advantage when updating their cognitive map.

Measuring a situation model. The measurement of a situation model involves the manipulation at least one of the three main elements of a narrative: spatiality, temporality, or causality (Zwaan & Radvansky, 1998). If the information in one of these elements is presented without an overt link to the current model, the reader must decide to incorporate or ignore this new information. When the reader is presented with an inconsistency, they may demonstrate difficulty incorporating it into their integrated model and therefore spend more time reading these inconsistencies (Albrecht & O'Brien, 1993; Givon, 1992; Graesser, Singer & Trabasso, 1994; Myers, O'Brien, Albrecht & Mason, 1994; Trabasso & van den Broek, 1985; vanOostendorp, 1996). This is the premise behind the measurement and empirical evaluation of situation models. In an experiment by Albrecht and O'Brien (1993), the reader began reading a narrative that contained the three elements: spatiality, temporality, and causality. The reader would then be exposed to a "discontinuous stimulus"; the next sentence he or she read would give information that was inconsistent. The information could be about a different location, a different time, or information about a character that did not fit with what the reader already knew (i.e., Bob was an elderly man; Bob sprinted to the finish line.). Consistent statements were read at a normal pace, but readers spent more time on inconsistent statements. This suggests the readers had developed an integrated situation model up to that point, but they could not draw a link between the existing model and this new information. This consistent/inconsistent paradigm provides a method to measure all three elements of a narrative, and how they are incorporated into the situation model.

The spatiality element of the narrative is unique and can be measured with a different method, which more specifically targets the reader's cognitive map. The procedure to measure the development of spatial elements of a situation model was first used by Morrow, Greenspan, and Bower (1987), and replicated often since (Blanc & Tapiero, 2001; Millis & Cohen, 1994; Morrow, Bower, & Greenspan, 1989; Rinck & Bower, 1995; Wilson et al., 1993). While participants were reading the narrative, they were periodically stopped and asked about the location of various objects in the environment or about the location of the protagonist. All of these above-cited researchers have found that readers can use their situation model as a cognitive map, and can answer questions about the spatial relations in the environment. Furthermore, these researchers have found that participants respond faster to objects that are closer to the protagonist at that point in the plot versus objects that are farther away. This suggests that readers are integrating the information they have read to reflect the action that is happening in the narrative. The spatiality element of the situation model can be measured by asking about locations, and this method specifically targets the reader's cognitive map.

To review, measuring situation models can be done by manipulating inconsistencies in any one of the three elements of narratives: spatiality, temporality, or causality. Using another method, the spatiality element has often been measured by simply stopping the readers, and asking them about the spatial relations in the environment. This method allows researchers to measure the extent to which readers use their situation model as a cognitive map, and how readers can incorporate new spatial information into their situation model.

To conclude the section on situation models and the narrative, it is clear that readers can acquire spatial information and create cognitive maps by reading any form of text (Johnson-Laird, 1983; Levine & Klin, 2001; Morrow et al., 1987; Shelton & McNamara, 2004; Taylor & Tversky, 1992a, b,1996; van Dijk & Kitnsch, 1983). One particular form of text is the narrative; the narrative presents spatial information to the reader, but also temporal and causal information (Sarbin, 1986; Zwaan & Radvansky, 1998). Upon reading a narrative, a reader who understood the passage will have developed a situation model (Zwaan & Radvansky, 1998; van Dijk & Kitnsch, 1983), which also contains a cognitive map. Therefore, the reader of a narrative not only has a cognitive map, but a situation model with elements of temporality and causality.

Other text forms, such as descriptions, lacks the element of causality, but there is little existing research to compare the mental processing of readers of narrative to the mental processing for readers of a description. There is also little research done to evaluate whether there are functionally equivalent mental processes for both readers. This research attempts to empirically evaluate the differences between the cognitive maps of readers of both types of text forms and attempts to contribute to the lack of research outlined above. In order to compare the cognitive maps of both types of readers, it is first necessary to determine the perspective in which the spatial information was provided. As outlined in the previous section on how people construct cognitive maps, spatial perspective plays a large role in the way people construct and use their cognitive maps.

Spatial Perspective in Text

The language in a text also reflects what type of spatial knowledge the reader is receiving; the language used could impart route knowledge or survey knowledge. It is common for narratives to be written in route terms (i.e., Bob walked through the door on his left). In order to experimentally control for irrelevant differences between description and narrative, then the description should be in the route perspective as well. However, this may introduce another problem. A description in route perspective is similar to route instructions; for example, a person who is lost may be told, "Walk three metres to your left. Turn right at the stop sign." This is a description, not a narrative, but route instructions can introduce the issue of imagining oneself in the instructions. In order to not confuse the form of text with the type of spatial knowledge acquired by the reader, two other text passages were created using language that reflects survey information. The spatial language in each text passages was created according to Taylor & Tversky's route and survey descriptions (1992b). The following section elaborates on the issues associated with a descriptive that conveys route knowledge.

The problem of route instructions. Readers can build cognitive maps by receiving information in a route perspective, or a survey perspective. This can be achieved through studying images with either perspective (Millis & Cohen, 1994; Shelton & McNamara, 2004), or through reading text in either perspective (Taylor & Tverksy, 1992b; Tversky, Taylor, Franklin & Bryant, 1994). Text written in route perspective presents a unique issue to this study. In daily life, instructions of how to get from point A to point B are usually in descriptive form. There are no characters exploring the environment, and there are no cause and effect relationships present. However, route descriptions or instructions are so similar to a story that researchers have often called them narratives, despite not actually conforming to the definition of a narrative structure (i.e., Linde & Labov, 1975; Taylor & Tverksy, 1992b). The question arises: why is this confusion made so easily?

Route instructions are often told addressing the second person, or in the imperative tense, both of which imply that the instructions are to be followed by the reader. Therefore, despite the absence of any explicit instruction, readers tend to place themselves as the main character in these instructions. This results in the *imagined ecological frame of reference* (Avraamides, 2003), where the reader imagines that he or she is following the route instructions, and develops a cognitive map from the imagined route. A text description in survey perspective is not likely to have this issue. The issue of an ecological frame of reference can have a confounding effect when attempting to separate the differences between narratives and descriptions: a description where the reader is likely to imagine themselves as the protagonist introduces an element of narrative, without any experimental control.

The tendency for readers to place themselves in the route instructions may affect the cognitive map they develop. Shelton and McNamara (2004) examined the influence of changing the perspective (i.e., route or survey perspective) while participants are reading. One group of participants read a text passage written in route perspective (eg., “the VCR room is on your right”), and the other read the passage in survey perspective (eg., “the VCR room is in the south-west corner”). Then, the participants were tested in the both perspectives (participants who read the text in route perspective were asked questions from route and survey perspective, and vice-versa). Participants in the route condition showed a preference for an egocentric perspective. That is to say, those who read in route perspective performed faster and more correctly when asked questions based on the same starting point from where they first read. This tendency was shown in both recognition questions and in inference questions[1]. Participants who learned the environment in survey perspective did not show this preference, and showed no difference in their performance when

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[1] Shelton and McNamara (2004) used ‘Judgements of Relative Direction’; they would ask the participant to imagine the environment and make a judgement of relative position of an object. These were used to better assess the participants’ understanding of spatial relations without confounding this with possible memorization and recognition.

tested from a different vantage point. This preference for egocentric perspective in route learning suggests that route perspective encourages egocentric encoding or learning and that route instructions may affect the development of the reader's cognitive map.

Due to the nature of route instructions (i.e., when you get to the tree, turn left.), there is also a temporal element underlying these instructions. One must arrive at each object in the description in the prescribed order, otherwise the route will not make sense. Although the text in survey perspective describes places one at a time, it can give an overview of all places, and then go into detail; it does not have the requirement of following a certain "route" and therefore does not present the passage of time implicitly. Thus, the descriptions in route form may introduce another element of narrative, temporality, and further reduce expected differences the differences between description and narrative. This characteristic of route descriptions may explain why route instructions have been called narratives by earlier researchers.

Because readers of route instructions, or descriptions written in route perspective, have a tendency to project themselves as protagonists into these text passages, a greater distinction between narratives and descriptions was required for this study to exert great experimental control. Therefore, the current study incorporated both narratives and descriptions, written in both route and survey perspective.

The Current Study

The hypotheses of this experiment synthesize the two large bodies of research presented thus far. Based on the narrative comprehension research, readers of narratives construct a situation model which allows them a greater degree of success at updating their cognitive map from reading the text. In contrast, a lack of difference between the update of cognitive maps of readers of the two text forms would not support the advantage of the situation model, or may imply that readers of the description have another type of mental process functionally equivalent to the situation model. Based on spatial cognitive research, the survey perspective should allow readers to incorporate a greater degree of change into their cognitive map because the information they read is more complete. In contrast, the lack of difference between the cognitive maps of readers of the two spatial perspectives would not support the advantage of survey perspective.

In order to test these hypotheses, the following 3-phase experimental approach was employed: (a) developing a baseline cognitive map for all groups, (b) acquiring the changed spatial information in text form, and (c) measuring the degree to which the readers were able to incorporate this change. The first phase, developing a baseline, met one of the requirements for incorporating new information into a situation model, which is complete prior knowledge. All participants were shown a floor plan with objects located in all rooms; they were given as much time as they required to study this map. Then, they were asked to reproduce the map from memory. This procedure was used originally by Morrow et al. (1987; 1989), and reproduced by Wilson et al. (1993) and Blanc and Tapiero (2001). Because the main motivation behind the research was to assess the degree to which the cognitive map is changed, prior knowledge also provided a baseline measure on which to compare the final results and determine which group was better able to incorporate the information about changes to the environment.

To further assess the participants' baseline maps, the first phase also included spatial inference questions. Inference questions force participants to use their cognitive map more explicitly than recognition questions, and can provide effective measures of the participants' knowledge of spatial relations (Taylor & Tverksy, 1992b). The questions in this study were similar to the 'Judgement of Relative Direction' questions used by Shelton and McNamara (2004), although they looked slightly different. The particular form of inference questions used in the current study was tested by Parush and Treen (2006), and similar measures have been used by many spatial cognition researchers (Blanc & Tapiero, 2001; Morrow et al., 1987; Taylor & Tverksy, 1992b, 1996; Tversky, et al., 1994). The spatial inference questions concluded phase one of the experiment.

The second phase involved the reader incorporating change in their cognitive maps. Changes to the environment were described in text passages, and these passages reflected either route or spatial perspective, and either narrative or description text form.

The third and final phase of the experiment was the assessment of the resulting cognitive map, and the degree of successful incorporation of new information. In this phase, participants saw the same spatial inference questions as in the first phase. However, they were asked to judge the relative spatial position of the objects according to the new information they received in the text passage. The repetition of questions provided a direct comparison of baseline results to post-text results. Finally, the third phase of the experiment concluded with a final map drawing task, where the participants attempted to draw their updated cognitive map. Each map was subjectively scored according to the Map Goodness Scale. This assessment procedure was created by Billinghurst and Weghorst (1995), and it was originally used to assess the validity of using sketch maps when examining their participants' cognitive maps of virtual worlds. This method has been successfully used since (Darken & Sibert, 1996; Zanbaka, Lok, Babu, Xiao, Ulinski, & Hodges, 2004; Zanbaka, Lok, Babu, Ulinski, & Hodges, 2005).

During the second phase, the participants who received the narrative should have developed a situation model. The development of the model supports the incorporation of different information because the situation model contains causality. The causal element includes the protagonist, and cause and effect relations in the narrative. Changes that involve the protagonist, or illustrate cause and effect relations in the narrative, were more likely to be incorporated into the reader's situation model than changes that did not contain these narrative elements. If readers of the narrative demonstrate that interaction objects are more accessible than non-interaction ones, it would support the hypothesis that these readers developed a situation model. Since the descriptive text did not include the causal element, the reader should not have distinguished between types of change to the environment (involving the protagonist or not), and should not show preferences between what types of changes to incorporate. If readers of the description show similar accessibility as readers of the narrative for both types of objects, this would imply that there may be other factors influencing the mental processes of readers of descriptions. Because there is no basis to predict what these factors may be, it is important to measure the situation model of the readers of the narrative as it develops.

Measuring the situation model of the narrative group both could have verified that the narrative group created a situation model, and demonstrated that the situation model supported the incorporation of changed information. The development of the situation models was measured using the procedure of Morrow, Greenspan and Bower (1987). Within Phase Two of this experiment, the participants' responses to probe questions were the primary measure of the development of their situation model. In the narrative texts, the character in the narrative physically interacted with some objects in the environment, and not with others. Because the elements of a narrative are lacking in the description, there was no character present to interact with objects. Therefore, if the reader was developing a mental model from reading the narrative, when the character interacted with an object, it would have been more accessible in their mental model than an object that remains untouched (de Vega, 1994; Morrow et al., 1987; Morrow et al., 1989; Wilson et al., 1993). Objects that are more accessible in a participant's mental model would allow the participant to respond faster and more accurately when asked about its location (de Vega, 1994; Morrow et al., 1989; Morrow et al., 1987). Since there is no character in the description to interact with objects, the participants would be expected to maintain a similar degree of accessibility of the objects in their cognitive map, and therefore show no preference from some objects over others.

To control for differences between the text passages, the experiment incorporated all possible combinations of the text (narrative and descriptive) and perspective (route and survey) variables. The text passages used were: a narrative written in route perspective, a narrative written in survey perspective, a description written in route perspective, and a description written in survey perspective. These experimental manipulations helped to reveal the variables that are responsible for the greatest successes when participants updated their cognitive map.

Because it contains the element of causality, it was expected that the narrative structure would show an overall main effect by supporting the incorporation of changed spatial information into the reader's situation model. The changed situation model should, by definition, contain the element of a changed cognitive map. Since there is no reported evidence that description readers develop a situation model as narrative readers do, it was expected that they may incorporate less changes into their cognitive map. Lack of such differences would indicate either the impact of other factors on the narrative readers or the possibility that description readers develop a mental model of functional equivalence to the situation model. In terms of measurement, readers who received the narrative should have responded faster and more accurately when assessing the locations of objects related to the causal element (i.e., that the characters interacted with) than when assessing the locations of objects with which the character has no interaction. In contrast, the readers of the descriptive text should not show this distinction when assessing the locations of objects in the environment. Narrative readers should have responded faster and more accurately to spatial inference questions than descriptive readers. Narrative readers should have also shown a greater degree of change incorporated into their map than the description readers, upon free recall of the object locations. In summary, there is a main effect hypothesized for the text form manipulation.

The spatial perspective manipulation was predicted to create an interaction in the results. Survey information has proven to support the development of a more complete cognitive map, thus readers in the survey perspective were predicted to incorporate more changes into their cognitive map than the route perspective. However, the difference between these two groups was predicted to be smaller than the difference between the text form groups, due to the ease and practice at which readers readily project themselves into route directions. Therefore, the complete hypothesis predicted an interaction between the text form and spatial perspective variables. Due to their situation model, narrative readers were expected to perform better than description readers; a lack of differences may indicate that the situation model does not provide the narrative group with an advantage when updating a cognitive map. In terms of spatial perspective, readers of survey perspective will likely perform better than readers of route perspective, although the difference between these two factors may not be as significant.

Method

Participants

Eighty-three participants were randomly assigned to four conditions: description in route perspective ($n_1 = 21$; 9 males and 12 females), description in survey perspective ($n_2 = 21$; 10 males and 11 females), narrative in route perspective ($n_3 = 20$; 11 males and 9 females), and narrative in survey description ($n_4 = 21$; 13 males and 8 females). There were forty-three males, and forty females ($N = 83$). The median age of participants was 21 years (Range = 37). Participants were recruited from the general student population at Carleton University, by printed posters advertising the study and researcher's email address (Appendix 1) or when the participants logged on to the web-based experiment database system (www.carleton.sona-systems.com) to sign up (details provided in Appendix 2). As compensation, participants were given the choice of receiving either ten dollars ($10) or one experimental credit to be used towards the introductory psychology course. Because this experiment involved deriving information from a text passage, all participants were required to have English as their first language.

The participants each completed an introductory questionnaire (Appendix 4). Along with collecting demographic information, the introductory questionnaire was used to collect information on individual differences in spatial ability. The first area of individual difference recorded was "area of study". To note any extensive map-reading experiences, the participants indicated their major area of study (where Geography, or a similar area of study, could be noted), as well as any orienteering experience. One participant had experience as an Assistant Geographer, and another had flight training. However, no covariate for map-reading experience was used because the results from these two participants were not outliers. The second area of individual differences recorded was self-ratings of spatial ability (Appendix 4). The questions for this questionnaire are similar to the Santa Barbara Sense of Direction Scale (Hegarty, Richardson, Montello, Lovelace & Subbiah, 2002), although the items in the current study were suggested in previous meetings with committee members. Participants gave themselves a score in response to questions such as: "I easily learn a new route to a familiar location," and "I am usually able to provide direction to someone else to get to a familiar location." The response scale ranged from 1 (strongly disagree) to 7 (strongly agree). The results from this questionnaire were used to account for individual differences in spatial ability, and are summarized in the Results section, 'Individual Differences in Spatial Ability'.

Design

This study was a between-participants, 2 (text form) x 2 (spatial perspective) design. Crossing these two independent variables resulted in four text passages: narrative in route perspective, narrative in survey perspective, description in route perspective, and description in survey perspective. There were three phases of the experiment: establishing a baseline cognitive map, acquiring the changed spatial information, and measuring the degree to which the changed information was incorporated.

Phase One: Baseline cognitive map. To effectively measure change to the cognitive map as a function of the different text types, the first phase of the experiment was to establish a baseline cognitive map. Participants were also asked spatial inference questions about the spatial relations of objects within the changed environment. The spatial inference questions are explained in detail in the 'Apparatus' section.

The first phase in this procedure ensured that all participants acquired a similar degree of knowledge about the fictional environment, and that the original basis of knowledge could be assumed to be the same across all participants. This assumption was verified empirically, as explained in the first paragraph of the results section.

Phase Two: Acquiring the changed spatial information. The participants were then given the relevant text passage according to their experimental condition. Each text passage described the floorplan from the first phase of the experiment, except that the text passages reflected that some objects had changed rooms (n = 7), some objects had changed locations but stayed in the same room (n = 8), and some objects (n = 5) had not changed positions at all. Pilot testing revealed ceiling effects for environments that had only changed by 50%, so the number of objects that changed locations was increased to make the task slightly more difficult. Each text passage described the same changes in the fictional environment. During this phase, probe pairs of words were inserted throughout the passage to measure the situation model as it was being constructed. The probe questions, and pairs of words, are described in more detail in the 'Apparatus' section.

Phase Three: Assessing degree of change incorporated in cognitive map. Participants were given the same spatial inference questions they had answered in Phase One. In Phase Three, they were asked to answer according to the new information they had read. These inference questions forced participants to use their cognitive map more explicitly than simply recognizing sentences from the text passage, and provided measures of the participants' knowledge of spatial relations. To further examine the degree to which the participants updated their cognitive map, they were asked to draw the floorplan, according to the changes described in the text passages in Phase Two.

Apparatus and Materials

The experiment was run using E-Prime 2.0, and executed on PC computers in the HOTLab, Carleton University.

Map. The first stimulus presented to the participants was a floorplan of a fictional house (Figure 1.). The map is arranged to reflect a plausible floorplan, and the objects were consistent with what one might normally find in a house. Each room contained a minimum of one and a maximum of four objects; all objects were semantically related to the room name (i.e., the sofa in the living room, the television in the rec room, etc).

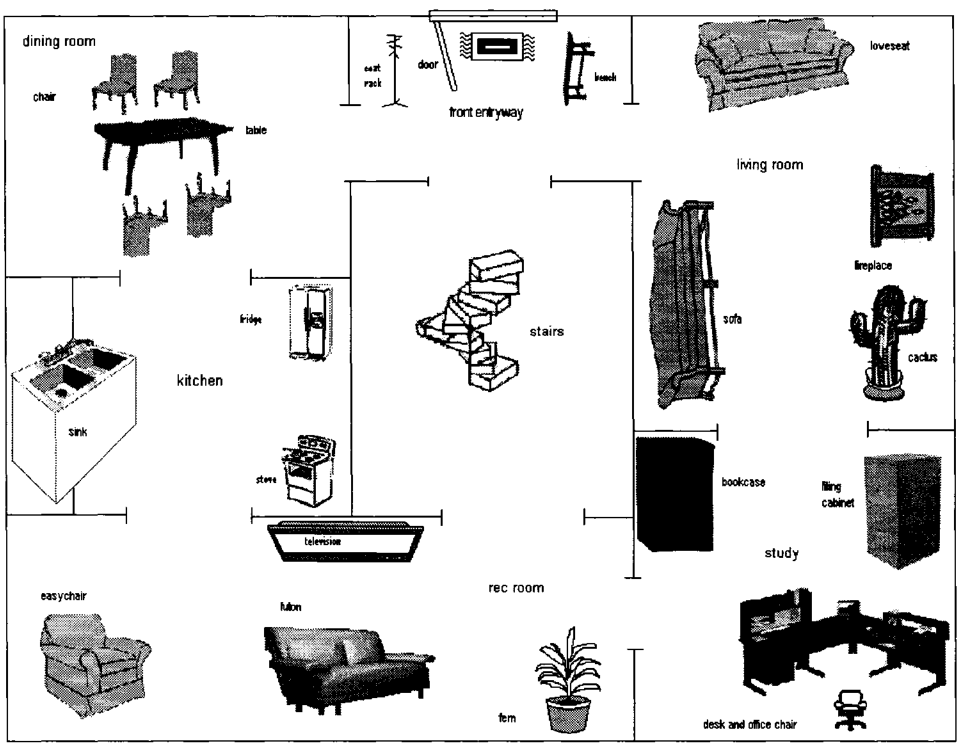

Figure 1. Map used to develop initial baseline for all participants.

Inference questions. In both Phase One and Phase Three, twenty-four (24) spatial inference questions were used to assess the participants' cognitive maps of the floorplan. Two words representing objects were placed in position on the screen, and there was an arrow connecting the two words, as shown in Figure 2. The participant was asked to judge if the spatial relation depicted by this arrow was true or false[2]. For each set of 12 questions, six were true and six were false. Participants used the keys labelled "true" or "false" (which were the keys *v* and *n* on the keyboard, respectively, chosen for their proximity to the space bar and for their distance from each other) to respond. There was an inter-trial interval of 50 ms, to ensure a brief period of time between questions. Before each inference question, there was a screen with a "+" sign in the centre; this served to prepare participants for the next inference question. This preparation screen appeared for 500 ms, to allow participants to focus their attention for the next question.

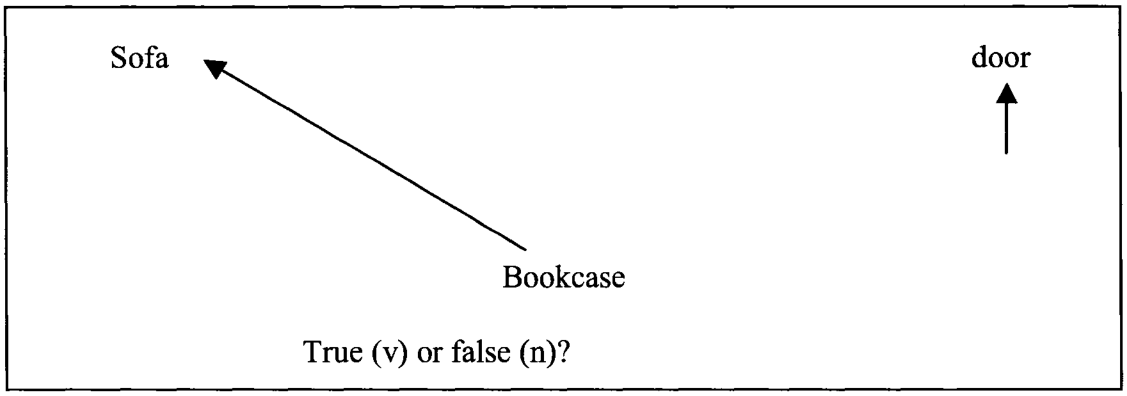

Figure 2. Example of a spatial inference question.

Text passages. There were four text stimuli, presented to each participant according to their random assignment to one of the experimental groups. The texts were narrative with a route perspective, narrative with a survey perspective,

[2] For all inference questions, there will be the word 'door', and an arrow pointing up; this is to give the participant an absolute reference point, without using cardinal points (since the route condition does not use cardinal directions).

descriptive with a route perspective and descriptive with survey perspective (Appendices 5-8, respectively).

Each text passage described the same house as portrayed by the original map, however the locations of most of the objects (n=15) had changed. Figure 3 illustrates the "changed" floor plan as it was reflected in the text passages.

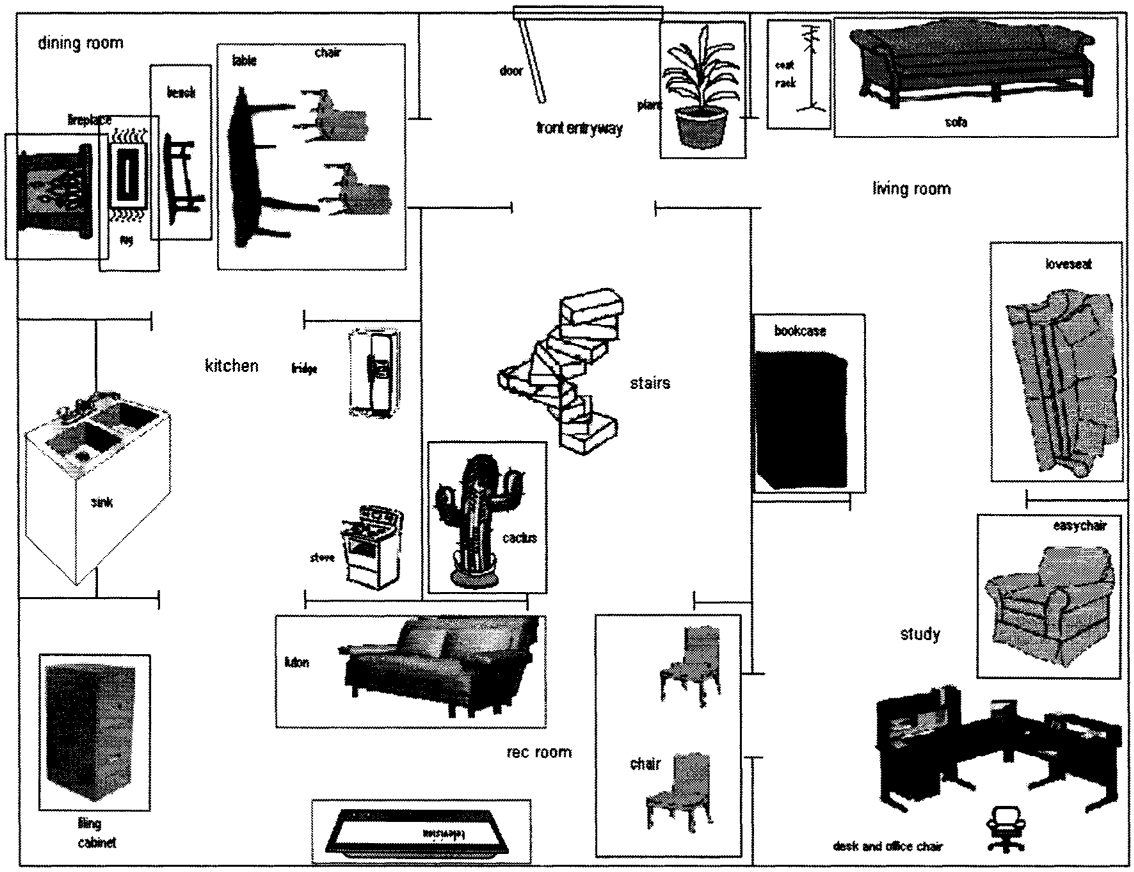

Figure 3. The changed map that is described in all four text passages. The red frames denote objects that changed places in the same room, and blue frames denote objects that moved into a new room.

All elements of a typical narrative were present in both narrative passages: events arranged along a timeline and organized according to a plot. The narrative with route perspective (Appendix 5) described a protagonist who is searching for a lost object (i.e., student ID card). This character was motivated to find the object, and her motivations were described in the context of the situation (i.e., she is on her way to write an exam, and must find the card before leaving). Her search also denoted the passing of time. Her search took her throughout the house, and she inspected all the objects in the house while searching. All objects were mentioned at least once in the narrative. This revealed whether the object had changed or not from the original floor plan.

The narrative in survey perspective (Appendix 6) also described a protagonist searching for a lost object. However, this character in this narrative mentally searched her house from a survey perspective. This allowed the text to convey the survey perspective while remaining in a narrative context, and also avoided the use of route perspective.

The descriptive texts were static descriptions of the changed floor plan of the house. There was no character described, and no context or passage of time given. The description mentioned all objects in the house and referred to each location in the same order as they were addressed in the narrative. The route perspective description followed the same route as the character in the narrative (Appendix 7). The survey description described each room in the same order as the character mentally examined them in her narrative (Appendix 8). This manipulation was done to make as many aspects of all texts equivalent, except for the elements of a narrative versus descriptive text and the length of the text passages.

The length of the narrative was longer than the descriptions. The narratives contained a mean of 941 words, and the descriptions contained a mean of 451 words.

Based on the development of the situation model, and the natural ease at which readers comprehend the narrative structure, the differences in length of text passages was not expected to create any issues with comprehension or ease of updating one's cognitive map. This difference may have affected the results by simply increasing the amount of time required for reading: the participant had to read more text in the narrative than in the description before seeing a probe question. (The probe questions are explained in detail in the following subsection). The length of time between when the participant studied the map and when they were asked a probe question may have been a factor for differences between groups, and this factor is examined the results section.

In order to present information in either spatial perspective, the language used in each text passage reflected this manipulation. The text passages in route perspective described locations of objects using words such as: *left*, *right*, *in front*, or *behind*. These words described locations of objects relative to the character (in the narrative), or "you" (the subject in the description). The text passage in survey perspective described the locations of objects using the cardinal direction points (north, south, east, west, etc.). These words gave the locations of objects according to absolute directions.

Probe pairs. To assess the construction of a situation model, twelve (12) probes were developed, each with a pair of words denoting objects. The participant was asked to determine if these two objects were in the same room as each other, or two different rooms from each other, according to the new information they received in the text passage. When the participant was presented with a probe, the first screen they saw was a cueing screen. This screen read “same room or different room?” to remind the participant of the task. The next screen showed two words describing probe objects. The participant used the keys labelled “same” or “different” (which were the keys *f* and *j*, respectively, chosen for their proximity to the space bar and for their distance from each other). The probe questions are presented in Appendix 9, and they type of objects in the questions (interaction or non-interaction objects), and the order in which they were presented.

All conditions saw the same probes, but the order changed depending on the spatial perspective (route or survey). This was due to the nature of how each perspective was organized. The route perspective reflected a route through the environment, thus presenting the details of the map in a specific order. The survey perspective avoided following a route and therefore presented the details of the map in a different order. Since each text passage revealed the changes in the map at different times, the probes only queried details that had already been revealed. To ensure experimental equivalency, both text forms in the same spatial perspective (i.e., the narrative and the description in the route perspective) presented the probes in the same order.

The probes were also classified as either interaction or non-interaction objects. Interaction objects were objects the protagonist in the narrative text physically interacted with as part of the plot. Non-interaction objects were objects that were mentioned in the narrative, but the protagonist did not interact with these objects. As a natural by-product of this manipulation, sometimes interaction objects were mentioned more often in the narrative. In order to control the number of times each object was mentioned, efforts were made to ensure that these interaction objects were mentioned the same number of times in the description. Because these efforts were not exact, the frequency with which an object was mentioned was examined as part of the results.

Procedure

Before beginning the experiment, each participant read and signed the informed consent. The researcher witnessed the informed consent (Appendix 3) and then explained that the data collected would be assigned a number only and no characteristics that tied an individual to their data. The participants were also told the experiment would last a minimum of 45 minutes, and a maximum of 60 minutes.

Each participant then completed the introductory questionnaire (Appendix 4). Upon completion of the questionnaire, the participant was seated in front of the testing computer, in the experiment rooms of the HOTLab. The remainder of the experiment was completed on the computer, or with the pencil and paper provided beside the computer. The participants were shown an instruction screen before each task. They were also given verbal instructions for all at the beginning of the experiment (Appendix 10).

Task 1: Map study and reproduction. The participant was shown the floorplan of the house. They were permitted to study the image for as long as they wanted, having received instructions that they would have to reproduce the map on a blank piece of paper. When the participant was ready to attempt reproduction, they pressed the space bar, and the image of the map was replaced by the instructions to draw the map, including all walls and objects. Upon completion of their drawing, the researcher returned into the experiment room and gave the participant feedback on the correct object placement, room labels, and wall placements in their map. If the rooms and all the objects were in the correct locations, the participant was given feedback and continued with the experiments. If there were mistakes (either missing objects or incorrect placement of objects or rooms) the participant repeated Task 1 until they reproduced a correct map. No participant exceeded two trials to successfully complete this task.

Task 2: Pre-text spatial inference questions. After the instruction screen, the inference questions appeared on the screen in random order. In Task 2, the participant assessed the spatial relations of the objects according to the map they just studied by answering "true" or "false" to the spatial inference questions.

Task 3: Reading the text passage with probes. The participant was given practice trials to become familiar with the reading procedure, and the procedure used to answer the probe questions. The text in the practice trials was unrelated to the map. The transcripts of the practice trials are provided in Appendix 11. The participant received feedback on their response to the probe during practice trials; a correct answer in the first trial allowed the participant to continue with the experimental trial, while an incorrect answer in the first trial brought them to a second practice trial.

Once finishing the practice trials, an instruction screen appeared (Appendix 10) and then the participant was presented with the text passage. The passage was presented in a sentence by sentence paradigm; when they finished reading the sentence on the screen, they pressed the space bar and the next sentence appeared. Occasionally, instead of the next sentence appearing, the cueing screen for the probe questions appeared, and it read “Same room or different room?”. The participant pressed the space bar, and the probe question appeared on the screen. After responding to the probe question, the participant was presented with the next sentence in the text passage. This continued until the participant had been presented with the entire text passage, and had answered all twelve probe questions.

Task 4: Post-text spatial Inference questions. After the instruction screen, the same inference questions in Task 2 were presented in random order. The procedure was identical to that of Task 2, except that the participant was asked to judge the spatial relations of the objects according to their updated locations.

Task 5: Map drawing. The participant was asked to draw the floorplan (i.e., the map) of the house, according to the changes they read in the text passage. They were given a blank paper and asked to reproduce the map according to the text passage. They were given one attempt at this task with no feedback on their accuracy. They were given as much time as they required; the mean time required to draw the map was 7 min, 14.39 seconds (*SD* = 125.40s). After they completed their map, they pressed space bar again where upon they read the “thank you” screen. The participant then brought the final map to the researcher.

Finally, the participant was thanked for their participation, and given the debriefing form (Appendix 11). If they chose to receive the ten ($10) dollars for their compensation, they signed a form confirming that they received this money for accounting purposes.

Measures

Measure 1: Time to reproduce map successfully. The first measure collected was the length of time required to memorize the map. This was measured in milliseconds and recorded in E-Prime. The number of attempts and re-trials required to complete the task successfully were also recorded. These measures were to be used as a covariate to control for individual differences in spatial memory, and the results of the data are summarized in the first section of the results section, 'Individual Differences in Spatial Ability'.

Measure 2: Response time to inference questions. The experimental software, E-Prime, recorded the time (ms) required for the participant to answer each spatial inference question individually. This was done for both pre-text and post-text inference questions.

Measure 3: Accuracy of responses to inference questions. Accuracy was measured by comparing the correct answer to the participant's response. A correct answer was given a "1", an incorrect answer was given a "0". The mean of this data gave a percentage of correct responses. This was for pre-text and post-text inference questions.

Measure 4: Response time to probes. Response time (ms) was recorded for the participant's response to each probe question individually. The response time measured here indicated the degree of availability of the reader's cognitive map they developed from reading the text passage.

Measure 5: Accuracy of responses to probe questions. Accuracy was coded using the same process as Measure 3.

Measure 6: Map goodness ratings. The maps drawn in Task 5 were scored according to the *map goodness scale*, where three raters assigned each map a score according to overall "goodness of fit" to the true map. By using the 'map goodness scale', raters used the question: "how well could I use this map to navigate if this were a real, physical environment?" as a metric for this score. The rating scale was: 3 for no errors, 2 for objects in incorrect locations, and 1 for incorrect room locations or walls.

Results

Individual Differences in Spatial Ability

Two measures were taken to assess individual differences in spatial ability: self-ratings of spatial ability and length of time required to study the original map in Phase One. Because either of these two measures could have been used as a covariate of individual differences in later analyses, their correlation to the participants' performance was assessed.

The first set of data used to assess individual differences in spatial ability was the self-ratings of spatial ability, collected from the introductory questionnaire (Appendix 4). Participants ranked their perception of their own spatial ability according to six questions. They used a Likert scale to score their responses, where "1" represented "strongly disagree", "7" represented "strongly agree", and "4" represented "neither agree nor disagree". Each question was given equal weight because as each question targeted a different aspect of spatial ability and all were considered important elements of individual differences.

The means of self-rated spatial ability for all participants are presented in Appendix 13, as well as a scatterplot of the means. The even distribution of means indicates an even number of higher or lower ranked participants in each condition. To empirically verify there were no differences between the groups on self-rated spatial ability, a two-way ANOVA (text form x spatial perspective) was conducted using the means of self-ratings as the dependent variable. There were no significant differences between groups in ratings of their own spatial ability; the ANOVA summary table is presented in Appendix 14.

Using the self-rated spatial abilities as a covariate in future analyses would help to control for individual differences. In order to assess the appropriateness of using this covariate, it was first necessary to determine if these self-rated scores were significantly related to the other measures in the experiment. For the probe questions, self-ratings of spatial ability were not significantly related to either response times or accuracy ratings (Pearson's *rs* = -.061, .070, respectively). For the spatial inference questions, self-ratings of spatial ability were not significantly correlated with response times (pre-text inference questions: Pearson's r = -.068, and post-text inference questions: Pearson's r = -.061), nor were they significantly correlated with accuracy scores (pre-text inference questions: Pearson's r = .025, and post-text inference questions: Pearson's r = .110). Because the spatial ability scores were uncorrelated with the participants' performance on the subsequent measures, these scores were not used as covariates in further analysis.

The second measure of individual differences in spatial ability was the length of time required to study the original map in Phase One. Participants who required relatively shorter times to study the map may have also shown better performance in the rest of the experiment, since these participants may generally be faster at encoding spatial information. Since all participants were required to reproduce the map perfectly, it can be assumed that the speed-accuracy trade-off does not apply in this instance (i.e., participants who took less time than others were not compromising their accuracy). The mean times required by all participants to study the original map are presented in Appendix 15. Some participants required more than one attempt to draw the map, and the cumulative time required for them to study the map is reflected by the means.

To assess whether the time required for map study could be used as a covariate to control for individual differences in spatial ability, it was necessary to assess whether map study time was correlated with performance on other measures. Time required for map study was not significantly correlated with either the response time for the probe questions (Pearson's $r = .093$), nor with accuracy for the probe questions (Pearson's $r = .126$). Time required for map study was also not correlated with response times for spatial inference questions (pre-text inference questions: Pearson's $r = .171$; post-text inference questions: Pearson's $r = .030$), nor was it correlated with accuracy for spatial inference questions (pre-text inference questions: Pearson's $r = .186$; post-text inference questions: Pearson's $r = .156$). Because neither measure of individual differences of spatial ability was significantly correlated to the participants' performance on subsequent measures in the current experiment, no covariate was used in the subsequent analyses.

Spatial Inference Questions

Spatial inference questions were used to measure participants' cognitive map of the floor plan. Participants responded to the same spatial inference questions twice: once before they read the text passage that introduces changes to the floorplan (pre-text inference questions) and once after (post-text inference questions). The pre-text inference questions simply assessed the extent to which participants have memorized the original map, by asking "true" or "false" questions about the spatial relations between objects in the map. The post-text inference questions assessed the degree to which the participant has incorporated the changed locations of objects into their cognitive map. Both response time (ms) and accuracy data were collected for the inference questions.

Response times. In general, participants required slightly less time to respond to the post-text inference questions than time required to respond to the pre-text questions. All participants required a mean of 7.64 seconds to answer the pre-text spatial inference questions ($SD = 2.16$), and a mean of 7.31 seconds to answer the post-text questions ($SD = 2.31$). The mean response times and standard deviations for all conditions are presented in Appendix 16. As reflected by the means, it appears that the readers of the narrative in survey perspective took more time to respond to the post-text inference questions than they took to respond to the pre-text inference questions, while the reverse was true for the three other groups.

To assess the significance of the above-mentioned differences, and confirm that a baseline was achieved for all groups, an ANOVA was performed. Text form and spatial perspective were between-subjects factors, and the within-subjects factor was labelled "time". The two levels of the "time" factor were (a) pre-text and (b) post-text. "Time" was treated as a within-subjects factor to address two issues: first, to assess the relative difference in response time from the pre-text to the post-text inference questions, and second, by using post-hoc analyses to reveal whether there were differences between all four groups in response times to pre-text inference questions. This second analysis helped to verify whether there was a common baseline established in Phase One. For these analyses, an alpha level of .05 was used to determine significance.

The resulting test was a 3-way ANOVA of 2x2 (between) x2 (within) mixed design. In this ANOVA, the assumptions of normality were met; the Box statistic showed an equality of the covariance matrix, $F(9,71943) = 1.01$, $p > .05$, and Levene's test demonstrated an equality of error variance for both levels of the within factor: $Fs(3,80) = .07, 1.31$, $ps > .05$. The ANOVA summary table is presented in Appendix 17.

There was no significant main effect of time, $F(1, 80) = 1.53$, $MSE =$ 3,068,120. The lack of main effect reveals there were no differences within each group between their pre-text and post-text response times to the inference questions. There was a significant 3-way interaction between spatial perspective, text form, and time, $F(1,80) = 3.83$, $MSE = 3{,}068{,}120$ (Appendix 17). For ease of presentation, the following graphs are separated according to spatial perspective; Figure 4 displays the results for the participants in the route perspective, and Figure 5 displays the results for those in the survey perspective.

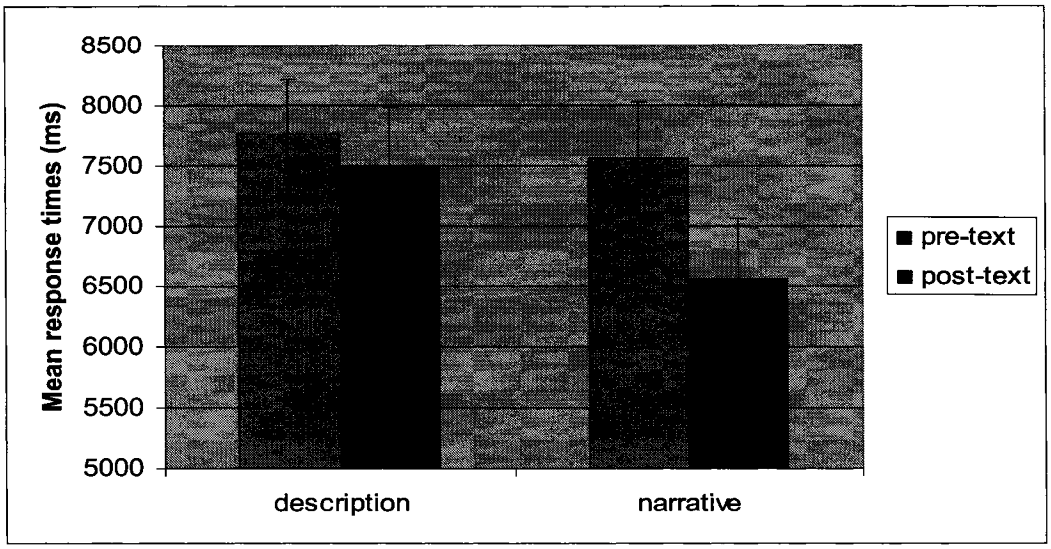

Figure 4. The mean response times, and their respective standard errors, for spatial inference questions in the route condition. The mean response time for the narrative route condition was significantly reduced for post-text inference questions.

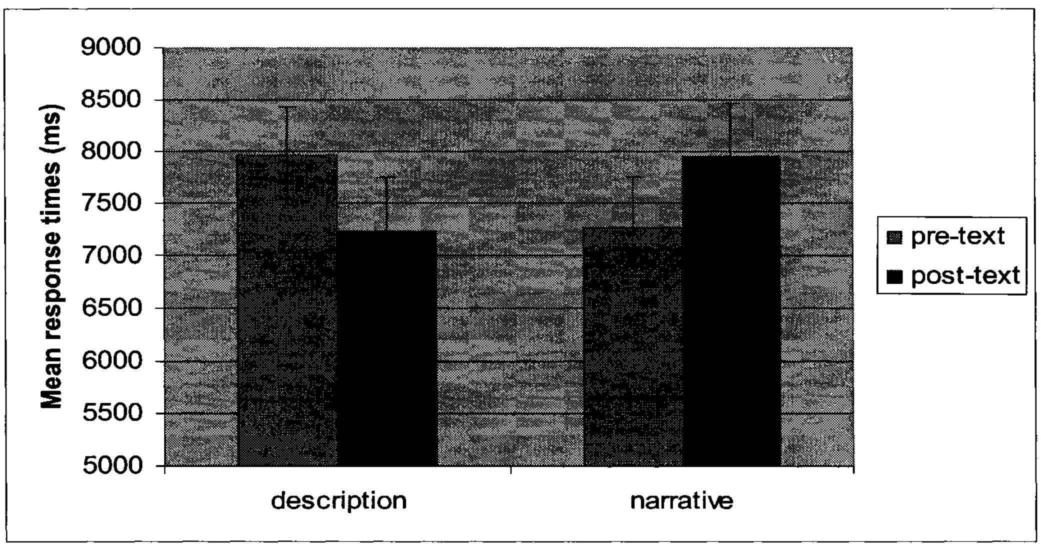

Figure 5. The mean response times and their respective standard errors for spatial inference questions in the survey condition.

Two possible sources of the interaction are implied by the data. Two post-hoc tests were performed to assess the significance of both sources, and an adjusted alpha level of .025 (.05 divided across two tests) was used.

The first possible source of the interaction was that participants who read the narrative text in the route perspective exhibited the largest difference between their pre-text and post-text response time. A post-hoc Bonferroni t-test revealed this difference was approaching significance (under the adjusted alpha level of .025). The participants in the narrative route group answered the post-text inference questions ($M = 6566.62$, $SD = 2619.55$) significantly faster than the pre-text inference questions ($M = 7565.71$, $SD = 2050.68$), $t(19) = 2.18$, $p = .04$.

The second possible source of the interaction was the differences between the two perspectives of the narrative; that is, participants seem to have responded faster to the inference questions after reading the narrative with route perspective, in contrast to participants who responded slower after reading the narrative with a survey perspective. A Bonferroni t-test revealed that this difference was approaching significance, $t\,(39) = -1.791$, $p = .08$. The main conclusion from these two possible sources of interaction is that there appears to have been an advantage to the route perspective in the narrative text. These results also support the general conclusion that readers who received the route perspective seemed to have an advantage over readers who received the survey perspective. The latter conclusion will be addressed throughout this section.

Finally, a Scheffe post-hoc analysis of the pre-text response times for all four groups revealed no significant differences. This result partly confirmed that a baseline was established during Phase One for all participants. This baseline was further confirmed by the accuracy results for the pre-text inference questions. These results are presented in the next sub-section.

Accuracy. All participants were successful when responding to both pre- and post-text sets of inference questions. The mean accuracy scores and standard deviations for all conditions are presented in Appendix 18. In general, participants were less accurate when responding to the post-text questions than to the pre-text questions. Across all groups, participants were 83.5% successful when responding to the pre-text inference questions, and 72.5% successful for the post-text inference questions. However, the differences in accuracies for pre-text and post-text questions are not consistent across groups, and further analyses were done to examine these differences.

Because the accuracy data was collected from both the pre-text and post-text inference questions, the same 2x2 (between) x2 (within) mixed design was employed for this analysis as in the previous section with response times. "Time" was used as a within-subjects factor; the two levels of the "time" factor were (a) pre-text and (b) post-text spatial inference questions. This analysis was aimed to reveal the degree of change in the post-text accuracy rates, relative to the pre-text accuracy rates. In addition, the post-hoc analyses were aimed to test whether there were *a priori* differences among groups in their accuracy rates for the pre-text questions only and confirm that a baseline was established for all groups.

A 3-way ANOVA was performed on the accuracy results of the spatial inference questions. The assumptions of normality were also met in this ANOVA; the

Box statistic revealed an equality of the covariance matrix, $F(9,71943) = 1.374, p > .05$, and Levene's test revealed the equality of error variances for both levels of the "time" factor, $Fs(3,80) = 1.46, 2.59, p > .05$. The summary table of the ANOVA is presented in Appendix 19. Unless otherwise noted, the results are significant at an alpha level of .05.

The results of the 3-way ANOVA revealed a significant main effect of the within-subjects factor, "time". All participants in all groups were less accurate in the post-text inference questions, when compared to their performance in the pre-text inference questions, $F(1,80) = 29.16$, $MSE = .016$. Figures 6 and 7 illustrate the differences in the groups across time; Figure 6 shows the results according to the spatial perspective condition, and Figure 7 shows the results according to the text form condition.

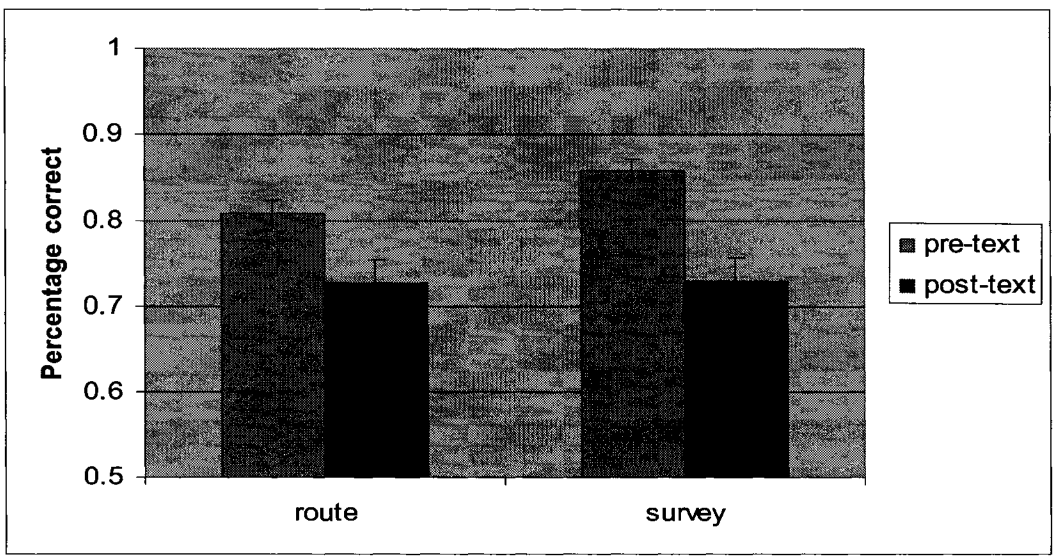

Figure 6. The mean percentage correct responses, and their respective standard errors, to the spatial inference questions; grouped by spatial perspective. Both conditions showed a reduction in accuracy for their responses to post-text inference questions.

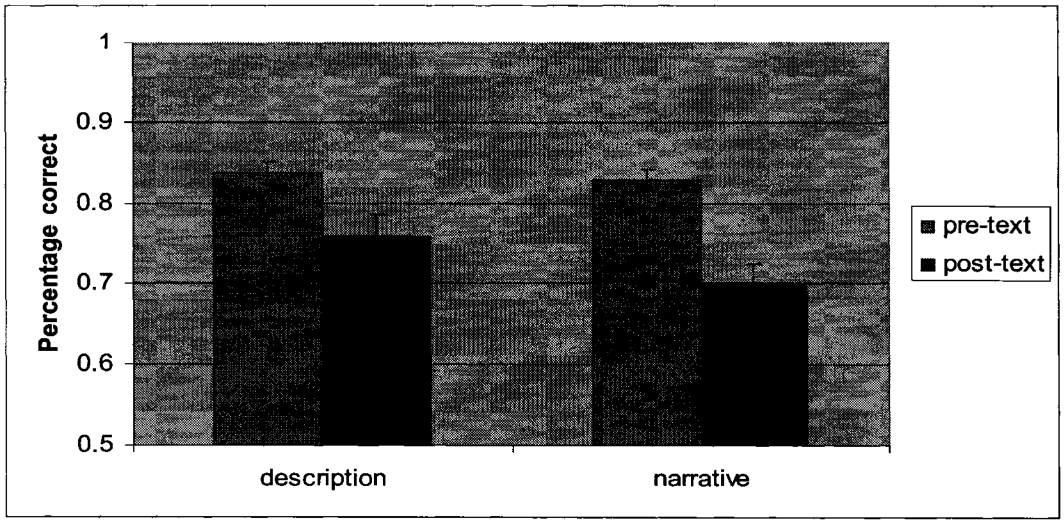

Figure 7. The mean percentage correct responses, and their respective standard errors, to the spatial inference questions; grouped by text form condition. Both conditions showed a reduction in accuracy for their responses to post-text inference questions.

The figures suggest there may be a difference between the accuracy of the readers in route and survey perspective on the pre-text inference questions, as is implied by Figure 6, or possibly between the accuracy of the narrative and the description readers on the post-text inference questions, as is implied from Figure 7. A Scheffe post-hoc analysis showed there were no significant differences in accuracy between the groups in their responses to the pre-text inference questions (see means in Appendix 18). The lack of differences between the accuracy rates for the pre-text questions confirmed a baseline was established for all participants in Phase One (as was shown in the previous section on response times). A second Scheffe post-hoc analysis revealed that there were no differences between groups in their accuracy rates on the post-text questions; all participants responded to these questions with roughly the same level of accuracy.

Analyses of position and type. Performance with post-text spatial inference questions was also examined as a function of the objects in the questions. There may have been differences that existed between readers of the narratives and those of descriptions depending on whether the objects in the inference questions were interaction or non-interaction objects. Differences may have also existed between readers that reflected whether the objects in the question had changed locations or stayed in the same place. These differences between groups of readers may not have been apparent by using response times to all questions pooled together, thus the inference questions were categorized according to object "type" and "position".

The first categorization within the post-text inference questions was done according to object "type": whether the object was an interaction object or not. Assuming a development of a situation model, it was predicted that narrative readers would respond faster and more accurately to interaction objects in the probe questions than readers of a description. The second categorization was according to "position"; if both objects had moved, it was categorized as "changed", and if one object had not moved, it was categorized as "consistent". In the "consistent" category, although there was still one object in the pair that had moved, this coding scheme was chosen for two reasons: the object in the pair that remained in the same place was considered to give the participant a reference point to judge the direction of the other object, and second, because there were no questions which asked about two objects that stayed in the same position. Both the "type" and the "position" factors were considered within-subjects factors because all participants answered the same inference questions.

Crossing the "type" and "position" factors formed four categories. Each category comprised more than one spatial inference question (see Table 1 for the break-down of questions as a function of this categorization scheme). Twelve questions that included both interaction and non-interaction objects in the same question were excluded from this analysis. The uneven number of questions in each cell contributed to the inability to meet the statistical assumptions of parametric statistics. Non-parametric tests were employed for the following analyses. Unless otherwise noted, the results are significant at an alpha level of .05.

Table 1. Categorization of spatial inference questions, according to position and type (interaction or non-interaction).

Position of object	**Interaction objects**	**Non-interaction objects**
Changed	Questions 5, 13, 14, 18, 21, 22	Questions 12, 23
Consistent	Questions 7, 11	Questions 17, 24

The first set of analyses was performed on the response times to the post-text inference questions. The mean response times and standard deviations are presented in Appendix 20, grouped according to the four categories of objects in spatial inference questions. The differences in response times between groups were assessed using the Kruskal-Wallis *H* test for independent groups. Because of the one-way nature of this test, the four experimental groups (i.e., narrative in route perspective, narrative in survey perspective, description in route perspective, and description in survey perspective) were treated as four separate levels of a single grouping variable. Four Kruskal-Wallis *H* tests, one for each of the four categories of objects in the spatial inference questions, were done to determine any differences between the four experimental groups. The results of the four *H* tests are summarized in Appendix 21. The only significant difference appeared to be between the four experimental groups in their response times to the questions with interaction objects that had not moved, $\chi^2(3) = 7.85$. To determine which of the four experimental groups differed from another, subsequent tests were done to compare the response times in this category.

To identify the differences between the groups in their response time to the interaction objects that had not moved, a series of Mann-Whitney *U* tests were performed. The Mann-Whitney *U* tests were chosen to compare the differences between two independent groups, rather than the Kruskal-Wallis *H* test that is more appropriate for more than 2 independent groups. This series of comparisons revealed that the difference between the readers from the two narrative groups (one in route perspective, the other in survey) was significant, $\chi^2(2) = 7.36$. The readers of the narrative in route perspective responded faster to questions with interaction objects that had not moved ($M = 5079.39$, $SD = 938.54$) than the readers of the narrative in survey perspective ($M = 6423.48$, $SD = 892.73$). This result reinforced the previously reported differences between the narrative groups as a function of spatial perspective; the first was the difference in response times to all post-text questions. This result also supports the general finding that there appeared to be an advantage for readers who read route perspective over those who read with a survey perspective.

The second set of non-parametric analyses was done on the accuracies in responses to the post-text inference questions, categorized by "type" and "position". The mean accuracies and standard deviations for all conditions are presented in

Appendix 22. Because of the dichotomous nature of the accuracy scores (i.e., “1” represents a correct answer, and “0” represents an incorrect answer), a chi-squared test was preferred for this analysis. The chi-squared analysis revealed no differences between the groups in their accuracy as categorized according to “position” and “type”. The results are presented in Appendix 23.

Summary for results of spatial inference question. In regards to establishing a baseline, the results of the spatial inference questions revealed that a baseline was indeed established for all participants. There were no a-priori differences between groups in their response times or accuracies to the pre-text inference questions. After Phase One, all participants acquired cognitive maps that were similar enough to each other to safely assume a common level of spatial knowledge.

In terms of response times for the post-text inference questions, all groups responded slightly faster to the post-text inference questions than to the pre-text inference questions. The only exception to this was the readers of the narrative in survey condition; they took longer to respond to the post-text inference questions than to pre-text ones. There was also a difference between the two groups of narrative readers: those who read in route perspective responded faster to the post-text inference questions than those who read in survey perspective. This same pattern emerged when the post-text inference questions were grouped according to object “type” and “position”; for the narrative readers, those who read in route perspective responded faster to interaction objects that had not moved than those who read in survey perspective.

In terms of accuracy, all groups were less accurate in their responses to the post-text inference questions than to the pre-text inference questions. There were no significant differences between the groups.

Probe Questions

The probe questions were used as a measure of whether the narrative readers constructed a situation model. Because narrative readers were expected to form a situation model facilitating their cognitive map change, it was expected that they would respond quickly and accurately to interaction objects, as compared to non-interaction objects. Readers of the description were expected to show equal performance for all questions since there was no interaction described in their text passage. To examine differences between the performance of all groups on the probe questions as a function of object "type", all twelve probe questions were categorized as "interaction" probes, where both objects were interaction objects, or non-interaction probes, where both objects were non-interaction. Analyses were also done to address the "position" category of objects; these results are presented in the subsequent section entitled: 'Analyses of position and type'.

Response time. There appeared to be little differences in mean response times between participants in the four experimental groups (the means and standard deviations are presented in Appendix 24). However, the mean response times for the non-interaction objects appear to be approximately 1000 ms longer than the mean response times for the interaction objects, and this difference appears in all groups. A repeated measures ANOVA of 2x2 between (text form and spatial perspective) x2 within (type) was performed to investigate these differences, with response time as the dependent variable. Unless otherwise noted, an alpha level of .05 was used to determine significance.

As indicated by Levene's test, the assumptions of normality were met for the distribution of response times at both levels of the within-subjects factor, type: F (3, 81) = .22, .55, $p > .05$, for interaction and non-interaction objects, respectively. The ANOVA summary table is presented in Appendix 25.

There was a significant interaction between object type and spatial perspective, $F(1,81) = 10.541$, $MSE = 799$ (Figure 8). There was also a main effect of type (interaction or non-interaction), but in light of the significant interaction with the spatial perspective factor it will not be discussed. It can be seen from Figure 10 that non-interaction objects required longer response times for all groups in the survey perspective. Two Bonferroni post-hoc tests (with an adjusted alpha level of .025) helped to interrogate the source of the interaction between object type and spatial perspective. For the readers in survey perspective, the difference in response times to the two types of objects was significantly larger than the difference for the readers in the route perspective, $t(81) = -8.012$. Also, readers in the survey perspective required significantly more time to respond to non-interaction objects ($M = 3769$, $SD = 1335$) than to interaction objects ($M = 5180$, $SD = 1782$), $t(42) = -6.205$. There was no effect of the text form manipulation.

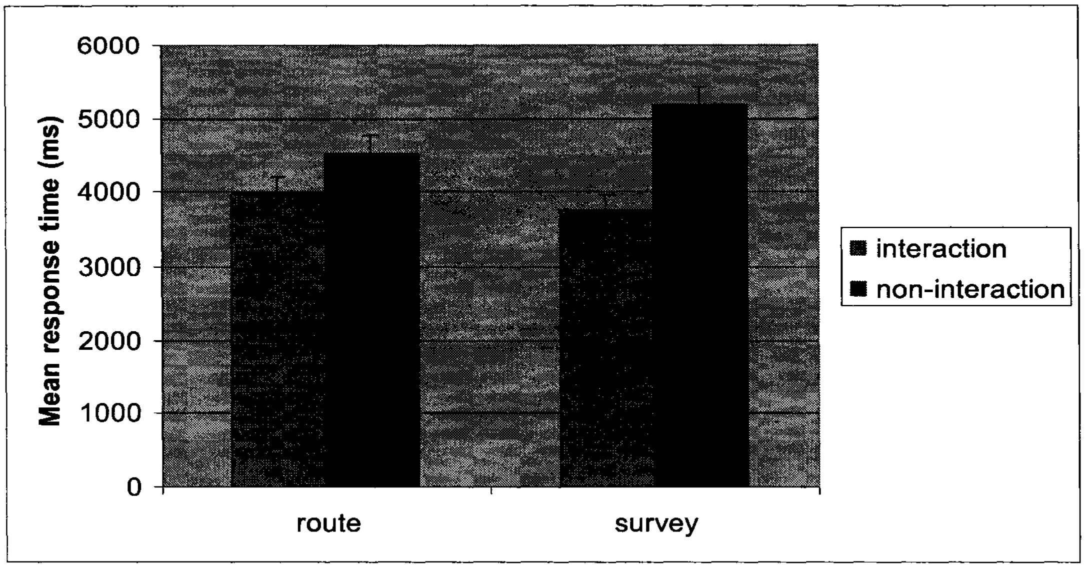

Figure 8. The mean response times, and their respective standard errors, for the probe questions, grouped according to spatial perspective. Participants in the survey condition required significantly longer response times when responding to probe questions about non-interaction objects than to questions with interaction objects.

Accuracy. Accuracy of responses to probe questions was also relatively high for all groups, similar to the accuracy of responses to the spatial inference questions. Means and standard deviations for this data are presented in Appendix 26. Although the participants who read the narrative in survey perspective showed the lowest mean accuracy scores for non-interaction objects, their average of 77% correct responses demonstrated that they answered over three-quarters of the questions correctly.

There were some differences among the four experimental groups, and an ANOVA was performed to investigate them. A repeated measures ANOVA of 2x2 between (text form and spatial perspective) x2 within (type) was performed to investigate this difference, with accuracy as the dependent variable. Unless otherwise noted, an alpha level of .05 was used to determine significance.

The assumptions of normality were met for the distribution of accuracies at both levels of the within-subjects factor, type: $F\,(3, 81) = 1.93, .187, p>.05$, for both interaction and non-interaction objects, respectively. The ANOVA summary table is presented in Appendix 27.

The results of this ANOVA show there was a significant main effect of text form, $F(1, 81) = 11.189$, MSE = .30; description readers ($M = .91$, $SE = .019$) answered the probes significantly more accurately than narrative readers ($M = .82$, $SE = .019$). There was also a significant interaction between object type and spatial perspective, $F(1, 81) = 8.30$, $MSE = .017$ (Figure 9). The source of the interaction was examined with a post-hoc Bonferroni test. In the survey perspective, participants were significantly more accurate for interaction probes ($M = .91$, $SD = .16$) than for non-interaction probes ($M = .84$, $SD = .17$), $t(42) = 2.120$.

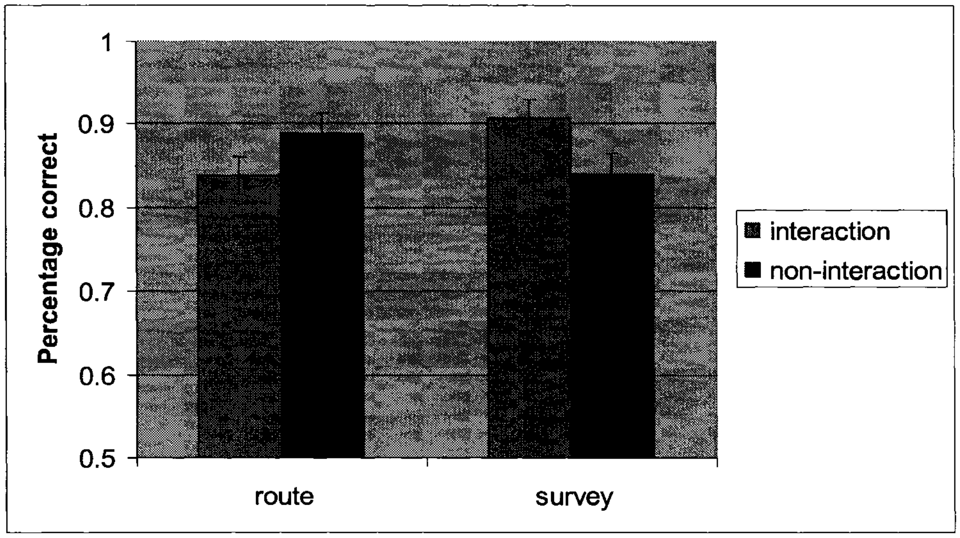

Figure 9. Mean percentage of correct responses, and their respective standard errors, to probe questions; grouped according to spatial perspective. Participants in the survey condition were less accurate when responding to probe questions with non-interaction objects than to those with interaction objects.

Analyses of position and type. To get more information about possible differences between all four experimental groups, the data from the probe responses was also categorized according to whether the object had moved locations, as described by the text passage. For this analysis, objects in the probe questions were categorized using the same within-subjects factor of "position" that was done in the analysis of the inference questions. Table 2 reflects the grouping of the probe questions. As was the case with the categorization of spatial inference questions, the uneven distribution of questions in each category made non-parametric tests the more appropriate choice for these analyses. For this section of analyses, an alpha level of .05 was used to determine significance unless otherwise noted.

Table 2. Categorization of probe questions, according to position and type of object (interaction or non-interaction).

Position of objects	**Interaction objects**	**Non-interaction objects**
Changed	Probes 1, 3, 6, 8, 10, 12	Probes 2, 7, 9, 11
Consistent	Probe 4	Probe 5

While any differences revealed in the following analyses may be statistically significant, they may also be a reflection of the distribution of probe questions in each category. For example, the category of probe questions for interaction objects that changed locations had six questions, while the one for interaction objects that had not moved had four questions, and each category of the non-interaction objects had one question. The small distribution of response times, particularly for the categories of non-interaction objects, increases the likelihood of finding significant differences when compared to the likelihood of finding differences between groups in a more normal distribution of scores, as is with the larger category of interaction objects that changed locations. This was taken into consideration when interpreting the following results.

The first set of analyses was done to examine the differences in response time to probe questions, organized by the two within-subjects variables: position and type. The mean response times for all four categories of objects in probe question are presented in Appendix 28. The mean response times reflected a general trend of participants requiring longer response times for non-interaction objects that changed positions, while the differences between the other three categories of probe questions appeared smaller. To confirm this observed trend, and to rule out other possible differences between experimental groups, further analyses were warranted.

Differences in response times between the four experimental groups were assessed using the Kruskal-Wallis *H* test for independent groups. As with the analysis done for the inference questions, each of the four experimental groups (i.e., narrative in route perspective, narrative in survey perspective, description in route perspective, and description in survey perspective) was treated as a separate level in a single grouping variable. Four Kruskal-Wallis *H* tests, one for each of the four categories of probe questions, were done to determine any differences between the four experimental groups. The results revealed significant differences between the experimental groups for all four categories of the objects in the probe questions; the results of the four tests are summarized in Table 3.

Table 3. Summary of four Kruskal-Wallis *H* tests for differences between groups in response times for probe questions, grouped according to object "type" and "move".

	Interaction objects		Non-interaction objects	
	Changed	**Consistent**	**Changed**	**Consistent**
Chi-squared	7.40	15.04	24.39	19.02
df	3	3	3	3
Asymptotic significance	.050	.002	.000	.000

Because there were differences between the experimental groups in all four categories of objects in probe questions, further analyses were done to determine which groups differed and on what category. A series of sixteen pair-wise Kruskal-Wallis *H* tests were performed to assess differences in response time among the four experimental groups in each of the four object categories. The four tables in Appendix 29 present the results. Two sets of four pair-wise comparisons examined differences between response times for readers of both text forms, as a function of spatial perspective (i.e., Table A summarizes the tests between the narrative readers in route and survey perspectives; Table B summarizes the tests between description readers in route and survey perspectives). The second two sets of four pair-wise comparisons examined differences between readers of texts in both spatial perspectives, as a function of text form (i.e., Table C summarizes the tests between readers of narrative and descriptions in route perspective, and Table D summarizes the tests between readers of narratives and descriptions in survey perspective). For each set of four tests, there were significant differences in response time for three of the four categories. Because most of the differences between groups were significant, it is simpler to discuss the category that showed the least differences: interaction objects that changed positions. For this category, there were no differences in response time between narrative and description readers in survey perspective, narrative and description readers in route perspective, and readers of the description in either route or survey perspective. There were significant differences in response times between all other groups on all other categories.

The second analysis examined the possible impact of object types and position changes on the accuracy of responses to the probe questions. The means and standard deviations for all groups are presented in Appendix 30. In general, participants showed high accuracy scores for all categories of objects in the probe question. The percentage correct ranged from 71% (in the responses of narrative readers with a survey perspective to non-interaction objects that had changed location), to 100% (all participants were correct in their responses to non-interaction objects that had not moved). This latter ceiling effect may be partly due to the fact that there was only one question in this category; consequently it was difficult to say whether this was a result of a good cognitive map or simply an easy question, and no other comparisons were done for data in that particular category. As for the differences between groups on the other categories, the small standard deviations made it difficult to assess potential differences so further analyses were performed.

Because of the dichotomous nature of the accuracy scores (i.e., "1" represents a correct answer, and "0" represents an incorrect answer), a chi-squared test was preferred for the analysis of accuracies. There were significant differences between narrative and description readers in their accuracy scores: the description group was more accurate than the narrative group for both interaction objects (*M*s = .93, .82, *SD*s = .14, .14, respectively), $\chi^2(3) = 16.08$, and for non-interaction objects (*M*s = .89, .76, *SD*s = .19, .21, respectively), $\chi^2(3) = 8.92$. There were no differences between the route and survey perspectives.

Summary of results for probe questions. In general, results from the probe questions seem to show an effect of the text form manipulation. Although readers of the description had the same response times as those who read the narrative, they were more accurate in their responses. Once the probe questions were categorized into groups reflecting the within-subjects factors position and type, participants in the description group were again more accurate in their responses to interaction objects than the participants in the narrative group.

It should be noted that the spatial perspective manipulation also had an effect. The readers of the route perspective showed a faster response time than those who read in survey perspective, although they were equally accurate in their responses.

Object Placement in Maps and Map Goodness Scores

In Phase Three, participants were required to draw the floor plan according to the changes described in the text passage. These maps were another measure of the degree to which participants were able to update their cognitive map. The maps were assessed with two types of analyses: object placement, and map goodness scores.

For the object placement analyses, the maps were objectively examined for the number of objects they contained, and the placement of those objects. Three categories of object placement were created: correct placement of objects, incorrect placement of objects, and missing objects. These three categories were further separated into interaction and non-interaction objects, however the results of this separation were not significant so this factor is not reported further. The results of object placement are presented as a mean proportion (Appendix 31); these scores represent the mean accuracy (i.e., the mean percentage correct or incorrect for each category of objects). Overall, the mean proportions for each group reflect that participants placed more objects correctly than incorrectly. In addition, the mean proportions of missing objects are generally small. However, the mean proportions of correct objects placed by the narrative readers appeared smaller than correct objects placed by the description readers. It also appeared that the reverse trend was occurring for objects incorrectly placed. To assess the significance of these differences, further analyses were performed.

Because the mean proportions for object placement were ordinal data, a non-parametric test for independent groups was used to assess the significance of differences between the text form groups. An alpha level of .05 was used to determine significance. The Mann-Whitney U tests revealed significant differences between the text form conditions for: correctly placed objects, $Z=-2.525$, and incorrectly placed objects, $Z=-3.332$. In each of these instances, readers of the description placed more objects correctly, and misplaced fewer objects, than readers of the narrative group. Figure 10 shows the mean proportions of participants for all maps.

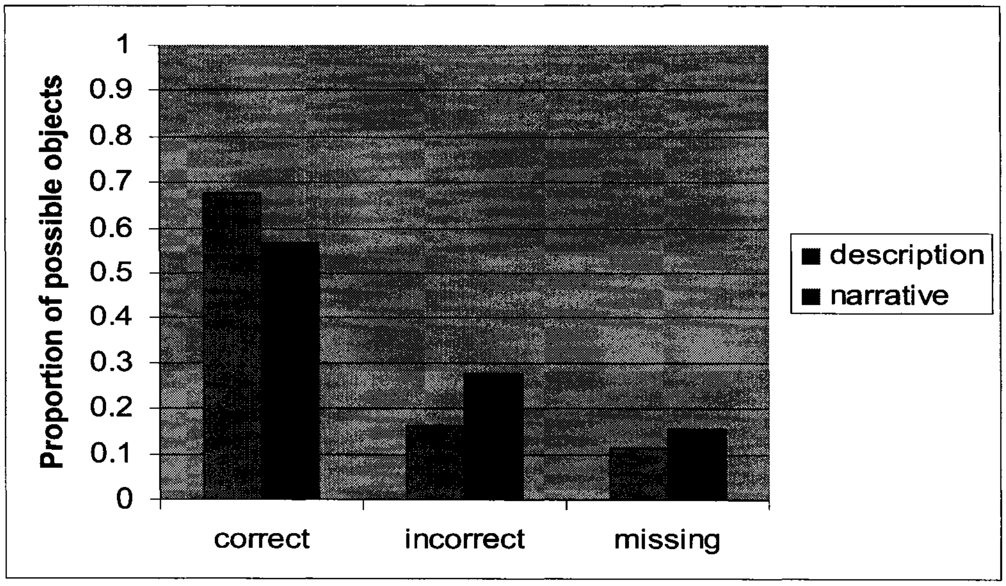

Figure 10. The mean proportions for objects placed correctly, objects placed incorrectly, and missing objects, grouped by text form conditions.

For the map goodness analyses, all maps were coded by three independent raters. The raters were instructed to evaluate the maps according to the question: "How well could I use this map to navigate the true world?" The map was given a "3" if the answer was "very well"; a "2" if the answer was "somewhat well"; and a "1" if the answer was "not well at all". These raters showed moderate agreement in their inter-rater reliability; the value for Cohen's Kappa was .540, .494, and .501 for raters one and two, two and three, and one and three, respectively. The intra-class correlation (ICC) was .593, which shows moderate concordance among raters.

The mean scores for all maps, grouped according to rater, are presented in Appendix 32. The means appear to show larger differences between groups than within groups, so a further statistical analysis was done. The scores given to each map were of ordinal value, so the Kruskal-Wallis H test was used for a non-parametric test of three independent samples. An alpha level of .05 was used to determine significance. This was performed twice: once for the spatial perspective variable, and once for the text form condition. For the spatial perspective condition, two of the three raters ranked the maps drawn by the participants in the route perspective condition higher than those drawn by the participants in the survey perspective condition (χ^2 (41) = 5.82, for rater one; χ^2 (41) = 5.16 for rater two) For the text form condition, all three raters ranked the maps drawn by those in the description condition as higher than those in the narrative condition (χ^2(41) = 7.12, 6.381, and 8.30, for all three raters, respectively).

Summary of map drawing results. For both sets of results based the map drawing task, object placement and map goodness scores, readers of the description outperformed readers of the narrative group. Readers of the description drew more correct maps than readers of the narrative; this was confirmed by the results of the object placement analysis and the map goodness scores. The map goodness scores also reflect that readers in the route perspective drew more correct maps than the readers in survey perspective.

These results were not predicted by the hypotheses. To ensure there were no confounding variables that affected the results of the experiment, an analysis on the questions (item analysis) was done.

Item Analysis

Objects from the map were the subjects of both kinds of questions, probe and inference, presented the participant. These objects were mentioned throughout the text passage as well. Two issues that may have influenced the results of the current experiment are the frequency with which some objects are mentioned in the text passages, and the amount of text the participant must read before responding to probe questions. The following sections examine these issues in turn.

The first issue of object frequency refers to the number of times an object was mentioned in the text passage. An object that was mentioned frequently may have become more accessible for readers than an object that was mentioned once. A more frequently mentioned object may have led to better performance on questions (either probe or inference questions) containing those objects.

The second issue refers to the fact that readers of the narrative were required to read more text than readers of the description. For example, the readers of the narrative in route perspective read 10 sentences, and readers of the narrative in survey perspective read 17 sentences, before the first probe question. In the description, readers in route perspective read 3 sentences, and readers in survey perspective read 8 sentences, before the first probe. If the larger amount of text had a negative impact on the performance of the narrative readers, it would manifest in the order in which the probes were presented. Because narrative readers had more text to read before their first probe question, they would show a relatively weaker performance in the first probe when compared to the description readers. And because narrative readers had more sentences to read between each probe question, this difference between the two groups would steadily grow. Therefore, the order in which the probes were presented would indicate whether the amount of text had a negative impact on performance for the narrative groups. Both of these issues are addressed in turn; the first is referred to as "object frequency" and the second is referred to as "probe order".

Object frequency. Every object was mentioned at least once in each text passage but some more than others. A summary table of the number of times each object was mentioned is presented in Appendix 33. Any object that was mentioned more than once was classified as a "high" frequency object, and anything mentioned once was classified as a "low" frequency object.

To determine the degree of impact of object frequency on performance for probe and inference questions, objects in the probe and inference questions were categorized as "high" frequency if the question contained at least one high frequency object. Because the high frequency objects were slightly different for each text passage (i.e., the coat rack was mentioned twice in the narrative in route perspective, and the description in route perspective, but only once in each of the other two passages), the categories of frequency contained different questions for each text passage. The probe and spatial inference questions are categorized according to object frequency, and the questions in each these categories are presented in Appendix 34. The descriptive statistics are presented in Appendix 35; Table A summarizes the mean response times, accuracies, and their respective standard deviations for inference questions, and these are organized according to their experimental groups and object frequencies. Table B summarizes the same statistics for the probe questions, and is organized in the same manner.

The goal of the first set of analyses was to assess the effect of frequency on participants' responses within the same condition. For example, the first set of analyses was done to determine if participants who read the narrative in survey perspective responded faster or more accurately to high frequency objects than to low frequency objects. The same analyses were done for the three other experimental groups. Because of the uneven number of high frequency objects within each text (eg., in the narrative written in survey perspective, seven objects were high frequency objects and fourteen objects were low frequency objects), non-parametric tests were chosen for this analysis. The Wilcoxon Rank for two related samples was chosen for this set of analyses. For the results of the spatial inference questions, the *Z* values revealed that the frequency with which some objects were mentioned in the text had no effect on either the participants' response times or accuracies. Similarly for the probe questions, the *Z* values revealed no effect of frequency on the participants' response times or accuracies.

The goal of the second set of analyses was to assess the effect of frequency on participants' responses between groups. For example, the "table" was mentioned four times in the narrative in route perspective, three times in the description in route perspective, twice in the description in survey perspective, and once in the narrative in survey perspective. Using the particular example of the object "table", all questions containing "table" were assessed for differences in response times and accuracy between groups. In the spatial inference questions, the ones that contained "table" were questions 1, 15, and 20. In the probes, questions 7 and 9 contained "table".

As in the previous analysis, the unequal number of questions in each category made non-parametric tests the most appropriate choice for the second set of frequency analyses. Because the goal of this analysis was to determine the effect of object frequency between groups, the Kruskal-Wallis *H* test for independent groups was used. The *H* test revealed no differences between groups on either the response times or accuracies for the spatial inference questions. In a similar result for the response times and accuracies to the probe questions, the *H* test revealed no difference between groups.

Probe order. The goal of this set of analyses was to examine the participants' performance as a function of the order in which probes were presented, (i.e., to determine if the length of text passage had an effect). Because the order of probes was the same for within each spatial perspective, this variable was not included in the subsequent analysis.

To assess the differences between the mean response times of the readers of the two text forms, the data for the probes was arranged by order of presentation in the text passage. The mean response times and standard deviations for each text form are presented in Appendix 36. The means for the first probe appear different for participants in each text form condition, but the means for the second probe show a smaller difference. An ANOVA was required to determine if there was an effect of probe order.

There were an equal number of response times for each probe question, and because response time was a continuous variable, parametric tests were appropriate here. Each probe was entered as a separate level of the within-subjects factor: "probe order". A 2 (text form) x12 (probe order) mixed ANOVA was performed. After a square root transformation, the data met the assumptions of normality, as evidenced by the Levene's test of normality of error variances (for probes 1-12: $Fs(3,82) = 1.34$, .84, .18, 1.09, ..45, .50, 2.81, 2.06, 1.20, .84, 1.48, 2.03, all $ps > .05$, respectively). The ANOVA summary table is in presented in Appendix 37.

There was no main effect of text form on the response times (F (1, 83) = .62, MSE = 764.20). There was a significant interaction between probe order and text form (F (11, 73) = 6.92, MSE =180.98); however upon examination of the mean response times, no consistent pattern appeared. For clarity of the results, an illustration of the mean response times in presented in Appendix 38. For example, the narrative readers responded faster than the description readers to the first probe question, and slower to the second probe question. On probes 3 and 9, the readers of the description were faster than the readers of the narrative, but the remainder of the response times appear to show no differences. Because these mean response times do not represent a clear and consistent effect of the amount of text the readers were presented with before answering probe questions, no further analyses were done on these results.

The second set of analyses was done to assess the effect of the amount of text read (as a function of probe order) on the accuracies to the probe questions. The mean accuracies and standard deviations for the probe questions are presented in Appendix 39, organized according to probe order and text form. Because the distribution of the data did not meet the assumptions of normality, a non-parametric test was more appropriate for this set of analyses. A chi-squared table (Appendix 40) demonstrated that there were significant differences between narrative and description readers in their accuracies to the probe questions, and an illustration of the accuracy results is presented in Appendix 41.

Similarly to the response times, no consistent pattern was evident in the results of the accuracy analysis as a function of probe order. In general, the description group was more accurate than the narrative group where there were differences between the text form conditions. However, participants in the two text form groups were equally accurate for probes 2-8, and again for probes 11 and 12. Therefore, these accuracy results do not reflect a clear and consistent effect of the amount of text each participant was required to read, and no further analyses were done on this data.

Summary of All Results

Overall, readers of both the description and narrative showed similar response times and were similarly accurate in their responses to the spatial inference questions. While the readers of the narrative in survey position took longer to answer the post-text questions than the pre-text questions, they did not take longer than any other group when responding to the post-text questions.

The text form manipulation showed a stronger effect on performance with the probe questions and the map drawings than it did with the inference questions. In terms of the results for the probe questions, the participants who read the description were more accurate than those who read the narrative. In terms of the results for map drawing, participants in the description group also drew maps with a higher proportion of correctly placed objects than participants in the narrative group. Description readers also received higher map goodness scores than the narrative readers.

There was an impact of spatial perspective in the text passage on performance. Participants who read the narrative in route perspective showed the only significant decrease in response time from the pre-text to the post-text inference questions.

Participants who read text in route perspective generally showed faster response times and more accurate responses to probe questions than those who read in survey perspective. Finally, those who read in route perspective also received higher map goodness scores than those who read the survey perspective.

Discussion

Most participants were successful in updating their existing cognitive map, based on changes introduced in the text they read, be it a description or a narrative in either route or survey perspective. Success rates in responses to the probe and spatial inference questions were at least 69% correct and higher and, despite differences between groups, the final drawn maps were coded as showing the majority of objects in the correct location. Therefore, this study demonstrated that participants were able to update their cognitive map from reading a text passage.

However, the results of this study did not follow the pattern that would be expected from existing literature. The readers of the narrative did not perform better than the readers of the description. In fact, readers of the description outperformed readers of the narrative in their accuracy rates to probe questions, and in their object placement scores and map goodness scores. In a similarly unexpected result, the readers of text in route perspective were required significantly less time than the readers of text in the survey perspective when responding to the spatial inference questions. The readers of the route condition also drew more accurate maps, as rated by their map goodness scores. Thus, the results of this study do not show support for predictions based on existing literature.

The results from this experiment highlight two key findings. First, readers of descriptions are better at updating their cognitive maps than readers of narratives. This could reflect that the situation model did not provide its hypothesized advantage to the readers of the narrative, or it could also reflect that readers of a description create mental models that are functionally equivalent to the situation model. There are several factors that influence the reader's ability to update their cognitive map from text passages and these are presented in terms of dual-tasks requiring dual-coding, the issue of goal management for readers, the overdeterminacy of text, and the retrieval of spatial information in a situation model. The second key finding was that the readers of the route perspective performed better than the readers of the survey perspective. The possible advantage of the route perspective when updating a cognitive map from text is discussed. The possible influences on how readers update their cognitive map from text are discussed in the following section.

Factors that Influence Updating Cognitive Maps from Text

The following is a discussion of additional factors that may have posed difficulties in retrieving spatial information from the text, and the means by which these factors may have had a greater negative impact for the readers of the narrative.

Issue of dual-tasks that require dual-coding. The dual-tasks in the present experiment, where the participants mentally update a map as they read a text passage, may have interfered with complete situation model construction or may have simply made it more difficult to retrieve spatial information from the text. The dual-coding nature of these types of dual-tasks (interpreting spatial information and language simultaneously) can create this difficulty (Baddeley, 1992; Fincher-Kiefer, 2001;

Hermer-Vazquez, Spelke, & Katsnelson, 1999). In a particularly relevant example, Fincher-Kiefer (2001) showed that a visuospatial task executed throughout narrative reading impaired the participants' ability to construct a situation model. Her experiment showed that a task with high verbal complexity did not show the same degree of interference that the complex visuospatial task did because there was no cross-modality processing required. As in the present study, all readers were still successful at comprehending the narrative, but some were more successful than others. The experimental tasks in the current study may have caused similar interferences as those suggested by Fincher-Kiefer (2001).

The current study was similar to the previously cited study since both experiments had dual-tasks requiring dual-coding. The tasks in the current study required the participant to encode the original map in the non-verbal processor (Paivio, 1986); then, while the participant was reading the text passage and encoding the text in their verbal processor, they were also retrieving their cognitive map in their visuospatial processor for manipulation (Baddeley, 1992; Fincher-Kiefer, 2001). This cross-modal task was likely more difficult for narrative readers than for description readers because narrative readers had greater demands on their verbal processor than the description group. Although the readers did not seem to be affected by the volume of text (as evidenced by the "probe order" section in the item analysis), it may have been the uniquely narrative elements, such as protagonist and plot, that increased the demands on the verbal processors of these readers. Therefore, the different demands on the verbal and non-verbal processors may have interfered with the narrative readers' abilities to update their cognitive map to a greater extent than it interfered with the ability of description readers to do the same.

Managing reader goals. A second factor that may have promoted the ability of readers of the description to extract more spatial information from the text than narrative readers is the factor of goal coordination (Magliano & Radvanksy, 2001). Readers of descriptions had one main goal: to attend to spatial information. Readers of narratives had the goal of maintaining spatial information, but they were introduced to a secondary goal when reading: the goal of the protagonist. For narrative readers, Magliano and Radvansky (2001) showed that the protagonist's current goal is the most immediately accessible to the reader, and that previous goals (semantically related or unrelated) are more difficult to retrieve. In an analogous way, the results may suggest that the participants prioritized the protagonist's goal (i.e., Sarah looking for her ID card or resume) in order to comprehend the narrative and their personal goal of attending to the spatial information became secondary. This prioritizing of goals is a natural by-product of narrative comprehension, and was likely not a conscious decision by the readers to give less attention to the spatial information. Since the description readers did not have a protagonist with a goal, they were free to attend solely to the spatial information in the text. Because the narrative readers may have had difficulty balancing the goals of the protagonist with their personal goal of updating the locations of objects, this confusion in goal management may have interfered with their ability to retrieve spatial information from the text.

Overdeterminacy of text. Because the description provided only spatial information, and the narrative provided extra information as well as spatial details, the simplicity of the description may have supported the readers' abilities to update their cognitive map. Schneider and Taylor (1999) defined "overdeterminate" as giving extra information that was not necessary for the person to navigate. These researchers found that the degree of spatial information given (indeterminate, determinate, and overdeterminate) in a textual description of a place, influenced the cognitive maps people were able to make. In particular, an overdeterminate description overloaded on the participants' working memory, and impaired their ability to construct a cognitive map[3]. In this study, the overdeterminacy of the narrative condition (such as the information about the protagonist and their goals) may have contributed to the weaker performance of these participants. For example, in the narrative, the rec room was described this way:

> She went past the two dining room chairs that were on either side of the doorway on the rec room, and went straight over to the futon. It was on her right, and faced the large television on the wall to her left. Her roommate Melissa had left the television on with no volume, so Sarah quickly turned it off, annoyed but refusing to be distracted. She was getting more anxious, and lifted the smaller cushions off the top of the futon.

In the description, the rec room was depicted this way:

> On either side of the doorway between the rec room and the study are two dining room chairs. In the centre of the wall on your left is the television set. The futon sits facing it, on the opposite wall.

---

[3] This research did not explicitly measure a situation model, although because the cognitive map is an element of the situation model, the situation model would be affected in a similar way.

The effect of overdeterminacy addresses the effects of receiving more information than spatial details, and how the extra information detracts from updating one's cognitive map.

Retrieval of spatial information. The ability of narrative readers to retrieve spatial information from the narrative may have been influenced by changes in the protagonist's location that occurred in the story. Such influences were not present for the participants who read a description. Levine and Klin (2001) demonstrated that readers of narrative were easily able to access, or remember, the current location of the protagonist in the story. However, once the protagonist changed locations, the accessibility for the previous location quickly became more difficult. The same result was found for changes in time (Speer & Zacks, 2005), when the readers had more difficulty recalling location and contextual information from earlier in the story, before a change in the narrative's timeline. In the current study, the difficulty of retrieving spatial information should have been reduced by the task demands (i.e., the instructions to attend to the spatial details). However, the reader's tendency to discard spatial information when updating of their situation model is a natural process of allocating memory resources during narrative reading. It is then reasonable to suggest this may have occurred in the present experiment.

Anecdotal evidence from participants suggests that those who were in the narrative condition felt the tasks were more demanding than the participants in the description condition. Often, participants in the narrative condition would leave the experiment room with comments referring to the difficulty of the tasks and how they felt confused, particularly in the narrative condition with a survey perspective. Such anecdotal evidence was rare in the description condition, and in fact there were a few participants in the description condition who found the task easy. This evidence supports the findings that, not only were the description readers more successful at updating their cognitive maps, the narrative readers subjectively reported the task as harder.

Synthesis. This discussion presented four factors that may influence the updating of a cognitive map from text, and all four of these factors seemed to point to a cost associated with retrieving spatial information from a narrative. The likely source of this cost is the extra information included in the narrative, but the results could be interpreted in different ways. For example, the extra information in the narrative could be described as overloading the verbal processor (in the context of dual-coding in a dual-task). Or, it could be described a conflict of readers managing their personal goals with the protagonist's goal. Finally, it could be described in terms of the overdeterminacy of the text. Without running further experiments, it is difficult to say that one explanation is more correct than another. The fourth factor presented was the natural tendency of narrative readers to not maintain previous spatial information as the location of the protagonist changes. Regardless of the factor attributed to the cost of updating one's cognitive map from a narrative, the results from the current study clearly show that the description is a more effective means of updating one's cognitive map. The results also show that route perspective may have provided an advantage to participants in that condition, and this advantage is discussed in the following section.

The Effect of Route Perspective on Updating a Cognitive Map From Text

Spatial cognition research suggests that those who receive survey information will create a more complete, more accurate cognitive map than those who receive survey information (Taylor & Tversky, 1992b, 1996; Thorndyke & Hays-Roth, 1982). However, in the present experiment, participants in the route condition generally exhibited better performance than those in the survey condition, both in their responses to the probe questions, and their map goodness scores. Therefore, the process of updating the cognitive map was not necessarily better for the survey condition. Theoretical explanations regarding ways in which people acquire spatial information, and how readers use ecological frames of reference are provided to explore the potential advantage to updating cognitive maps in route perspective rather than survey.

The readers acquired changed spatial information from the text passages, and then incorporated the new information into their cognitive map. To explain the processes of the spatial knowledge acquisition, Siegel and White (1975) developed a sequential model: landmark knowledge was acquired first (information about objects in the environment which aid navigation), then route knowledge, and finally survey knowledge. Survey knowledge is considered to be the final step in the sequence since it can be created through combining information about routes and landmarks. In the present experiment, because readers had to acquire new spatial information, a prediction of the sequential model is that there would be a regression to the route knowledge phase in the development of spatial knowledge. This possible regression would result in more difficulty for the readers in the survey perspective as they attempt to update their cognitive map, and as a result, there would a more pronounced effect of spatial knowledge updating for the route perspective condition.

The frame of reference used by readers of the route perspective may have also aided them at updating their cognitive map. There is a natural ease with which people are able to update their cognitive maps in relation to their *ecological frame of reference*, or the planes of space around their own bodies (Shelton & McNamara, 2001; Franklin & Tversky, 1990); this is also called "relative" frame of reference (Levinson, 1996). Franklin and Tversky (1990) identified three planes of space around the body that participants used to identify the locations of objects in space: either above or below them, then in front or behind them, and then to their left or right. In all cases, participants used their body, and the space around it, to easily judge the location of objects. Shelton and McNamara (2001) found that participants had difficulty updating their cognitive map when rotating in an imagined direction, and showed a tendency to rely on their egocentric view; the researchers suggested this preference for the egocentric view showed that participants learned their cognitive map from an egocentric perspective. Therefore, since participant from previous studies have shown a tendency to determine the locations of an object relative to themselves, an egocentric frame of reference would to have a strong effect on participants updating their cognitive maps. The egocentric text used in the route perspective (i.e., "You enter the house through the front door, and you stand in the front entryway. There is a plant on your left side.") may therefore have contributed to these readers updating their cognitive map more easily than was possible for readers receiving the survey perspective.

The egocentric frame of reference may have been particularly pronounced for the readers who received a description in route perspective. It is likely that Avraamides (2003) concept of *imagined ecological frame of reference* played an important role in the route perspective; this concept refers to the tendency of readers to project themselves into route descriptions. Although it is likely that the readers of narratives also projected themselves into the narratives, the readers of the description in route perspective had two advantages: they were able to project themselves into the route descriptions, and they were able to attend only to the spatial information. They were not presented with the extra information presented in the narrative, and this left the readers free to focus on updating their cognitive map. These two factors likely accounted for the better performance of participants in the route condition, and participants in the description condition. While all participants were successful at updating spatial information from texts, there are some issues with this process that may have been exaggerated for the readers of the narrative, and therefore had a negative impact on their performance when compared to the readers of descriptions.

In summary, narratives can be useful ways of presenting information in a compelling way or allowing readers to discover other characters, but they are not the most effective ways to present new spatial information to be updated into the reader's cognitive map. If the goal of the text passage is to convey new spatial information, a description should be chosen as the most appropriate text form. Also, to make updating the cognitive map most effective, route perspective should be used. The results from this study show that survey perspective was not as effective as route perspective when participants were updating their cognitive map. The current study also highlighted some methodological issues that should be taken into consideration to better isolate and study the potential positive impacts of the narrative.

Methodological Implications

Experience with extracting spatial information from narratives. One characteristic of the readers that was not considered in this experiment was the practice which readers had at extracting spatial information from narratives. The Inuit use stories to communicate spatial information to each other (Aporta, 2004), and they have been using this tradition for generations. The listeners of these stories are quite practiced at developing cognitive maps from narratives, whereas most readers of narratives do not need to attend to spatial information to understand a narrative. For most readers, for example, their comprehension of the plot does not hinge on whether the bookcase was along the west or the east wall. Based on the issues outlined in the previous section, it is clear that extracting spatial information, particularly from the narrative, is not a straightforward process for most readers. Therefore, the readers of the narratives may have had more difficulty than the readers of the description when extracting spatial information because they are simply not practiced at doing this task.

The operational definitions of interaction and non-interaction objects. The readers of the narrative did not consistently distinguish interaction objects from non-interaction objects in their responses to either the inference or the probe questions. This could reflect the fact that all participants were generally successful at their task, but it could also indicate that there needed to be a more clear distinction between interaction objects and non-interaction objects. In the current study, the protagonist physically interacted with the objects; future studies may require that the protagonist does not enter the same room as the non-interaction objects, or a similar type of manipulation.

Simply because interaction objects were mentioned more often (both in the narrative and in the description, for the sake of consistency), the frequency with which objects were mentioned did not have an effect of the participants' performance. However, to test the strength of the situation model, efforts should be made to mention each object only once in both text forms. While this manipulation of word count may lead to an unnatural flow for a narrative, it will provide a stronger manipulation of the text forms. Stronger controls for the exact number of times objects are mentioned should be in place for future experiments.

The measurement of a situation model. When comparing the mental representations of participants who read descriptions and narratives, the method selected for measuring the situation model is critical. Although previous researchers have shown significant results in measuring a situation model with manipulations such as inconsistencies in global and local coherence (Albrecht & O'Brien, 1995), or protagonist movement and object location (Morrow, Greenspan & Bower, 1982), these measures have not been used to compare the differences between in mental representations from descriptions and narratives. In the current experiment, readers of the narrative did not distinguish between interaction and non-interaction objects. Because no participants reported that they did not understand the narrative, previous researchers suggest that the narrative readers formed a situation model (van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998) and yet the measures employed for this situation model do not consistently support this conclusion. Because there is no previous research that compares the mental representations of description readers with those of narrative readers, a measure for this type of comparison should be developed. This new measure should account for the possibility that description readers may create a model that is functionally equivalent to the situation model, and be able to compare the differences between these models.

The issue of encoding specificity. Finally, readers of the narrative may have had difficulty with retrieval because of the effect of encoding specificity (Thompson & Tulving, 1973; Wiseman & Tulving, 1976). Because the spatial inference questions were not framed using context from the narrative, the context in which the information was encoded was missing for the narrative readers. For example, the spatial inference questions did not ask what direction Sarah should walk in order to get from the futon to the TV. The question was shown as a diagram: two words with an arrow pointing between them, and the task asked "is this true or false?" (See Figure 2). Petersen and Jacob (1978) demonstrated that one cue word could elicit recall of three other associated words in the participant's memory. Therefore, if the spatial inference question did not have a particular "cue" word for the participant (i.e., the protagonist), recall for that spatial information could have been more difficult. Further, if the narrative context was particularly salient, the *context deletion effect* (Burt, Connors, & Grant-Taylor, 2003; Tulving & Thompson, 1971; Underwood & Humphreys, 1979;) – where removing the context in which the word was studied negatively impacts the recall of that word – may have also had a negative impact on the performance by the readers of the narrative. Although both the narrative and the description provide textual context, the situation model provided stronger textual context than the description, which is why the context deletion effect would be more pronounced for the readers of the narrative. Although it may compromise consistency between groups, there may be an improved performance by the narrative group if the questions were framed in a similar context to which they appeared in the narrative. Further research that measures the context-dependency of narrative encoding may be fruitful in assessing the impact of the situation model.

A Concluding Reflection

In sum, the present study highlights some key findings and contributions. All readers were successful at their tasks. Readers of both narratives and descriptive texts successfully updated their cognitive map, based solely on information they received in text form. Although the description group showed a higher degree of success, the narrative group still performed well. Also, readers of texts in both route and survey spatial perspectives successfully updated their cognitive maps. Based on the present data there did seem to be an advantage for the participants who read the route perspective, but the survey perspective was generally successful as well. Another major contribution of the current research is the direct comparison the results of cognitive mapping derived from narratives to those of descriptions. Based on a review of existing research, this direct comparison is a unique examination of how readers interpret the spatial information in these two types of text forms. Finally, the present research has methodological implications for future research. First, future researchers should develop a rigorous operational definition of interaction and non-interaction objects. Second, researchers should examine their choice of measures for the development of the situation model when comparing narrative and descriptive texts. Finally, researchers should consider the issue of encoding specificity and incorporate context into the measures.

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Appendix 1.

Recruitment notice.

Appendix 2.

Recruitment announcement

Study Name: The Impact of Narrative on the Update and Change of an Existing Cognitive Map

Abstract: Participants have the option of receiving ten dollars ($10) OR one (1) credit.

Description: PARTICIPANTS HAVE THE OPTION OF RECEIVING TEN DOLLARS ($10) FOR THEIR PARTICIPATION, OR ONE (1) PERCENTAGE TOWARDS PSYC 1001/1002. People are able to construct a representation of an environment based on verbal information; this has been shown for straightforward textual description (eg. Taylor & Tversky, 1992, 1996) and for narrative text (eg., Morrow, Greenspan, & Bower, 1992). Are there differences in the relative impact of these two types of verbal information on the construction and update of cognitive maps? We have developed a framework that postulates the mediation of a situation model developed by narrative readers (Zwaan, Magliano & Grasser, 1995) in facilitating and enhancing changes to a previously acquired cognitive map more than a simple textual description does. An empirical study in progress involves presenting participants with a map, followed by texts (either narrative or descriptive) which describe changes to the environment in the map. We predict the situation model, developed from reading the narrative, will facilitate the incorporation of the changes into the readers' cognitive maps.

Eligibility requirements: Native English speakers only

Duration: 45 minutes

Percentage/Pay: 1%

Preparation: None

Researchers: Meaghan Beirne; Avi Parush

IRB Approval Code: 05-184

IRB Approval Expiration: September 17, 2006

Visible to participants? Yes

Active study? Yes

Pre-requisites: none

Disqualifiers: none

Course restrictions: none

Sign-up password: <blank>

Is this a web-based study? No

Participant sign-up deadline: 24h

Participant cancellation deadline: 24h

Should the researcher receive an email notification? Yes

Researchers at Timeslot Level: No

Can a participant sign up for this study more than once? No

Appendix 3.

Informed Consent

The Impact of Narratives on the Update and Change of an Existing Mental Map

The purpose of this consent form is to inform you, the participant, what you will be required to do for this study. It will provide you with adequate information to decide whether or not you wish to participate in this study.

Research Personnel. The following people are involved in this research project and may be contacted at any time. The principle investigator is Meaghan Beirne (520-2600, ext. 6628; mbeirne@connect.carleton.ca) and the faculty sponsor is Dr. Avi Parush (520-2600, ext. 6026; avi_parush@carleton.ca). Should you have any ethical concerns about this study, please contact Dr. Janet Mantler (Chair, Carleton University Ethics Committee for Psychological Research; 520-2600, ext. 4173; janet_mantler@carleton.ca) or Dr. M Gick (Chair, Dept. of Psychology; 520-2600, 2648).

Purpose. This study will examine the unique contribution of the narrative context as participants attempt to integrate new information into their existing cognitive map.

Task requirements. This experiment is composed of three sections: baseline, text reading, and assessment of the final cognitive map. During baseline, you will be asked to study and remember a map. You will also be asked true or false questions about the map. Then, you will be given a text passage which describes the same map, but with changes to the environment. Throughout the reading, you will be asked to assess the spatial locations of objects in the environment. Finally, you will be assessed on the degree to which you were able to incorporate these changes. This assessment will consist of true or false questions, and a map-drawing task. Most of these tasks will be done on a PC computer, using the monitor and the keyboard. The map-drawing tasks will be done with pencil and paper. This experiment will last about 45 minutes.

Duration and locale. The experiment will last approximately 45 minutes, and will be conducted in the experiment rooms of room 210, in the HOTLab, SSRB.

Potential risk/discomfort. There are no potential physical or psychological risks in this experiment.

Anonymity/Confidentiality. The data collected in this experiment are confidential and anonymous. All data are coded such that you name is not associated with the data. In addition, the coded data are made available only to the researchers associated with the project.

Right to withdraw. You have the right to withdraw from the experiment at any time. You also have the right to refuse to answer specific questions, should you choose. In return for your participation in this study, you have the choice to receive experimental credit towards PSYC 1001 or 1002, or ten ($10) dollars.

I have read the above description of the Narrative and Cognitive Map Study and understand the conditions of my participation. My signature indicates that I agree to participate in the experiment.

Participant name:__________________ Researcher name:______________________
Signature:__________________________ Signature:______________________________
Date: _____________________________

Appendix 4.

Introductory questionnaire.

Please answer these brief questions before beginning the experiment.

Gender: M F Age:___________________________

Level of degree program (please circle): undergraduate Master's PhD

What is your major? ____

Languages spoken (please circle):

English:	native	fluent	spoken only
French:	native	fluent	spoken only

Do you speak any other languages?

____

Languages read (please circle):

English:	easily	moderate difficulty	great difficulty
French:	easily	moderate difficulty	great difficulty

Can you read any other languages?

____

Do you have any experience with orienteering? Yes No

If yes, please elaborate

____

____

____

Using the scale provided, please circle the degree to which you agree or disagree with the statements below. Here is an example:

		✖				
1	2	3	4	5	6	7
Strongly disagree			Neither agree or disagree			Strongly agree

1 – I am usually successful when following a map to an unfamiliar destination.

1	2	3	4	5	6	7
Strongly disagree			Neither agree or disagree			Strongly agree

2 – I am usually able to provide direction to someone else to get to a familiar location.

1	2	3	4	5	6	7
Strongly disagree			Neither agree or disagree			Strongly agree

3 – I easily learn a new route to a familiar location.

1	2	3	4	5	6	7
Strongly disagree			Neither agree or disagree			Strongly agree

4 – I find it easy to learn my way around a new city or neighbourhood.

1	2	3	4	5	6	7
Strongly disagree			Neither agree or disagree			Strongly agree

5 – When I travel with friends or family, I am usually the person who reads the map and provides the navigation.

1	2	3	4	5	6	7
Strongly disagree			Neither agree or disagree			Strongly agree

6 – When I receive verbal directions, I can usually follow them with little difficulty.

1	2	3	4	5	6	7
Strongly disagree			Neither agree or disagree			Strongly agree

Appendix 5.
Narrative form in route perspective

Sarah was feeling very anxious. Her calculus exam was in an hour, and she really didn't feel prepared for it. She had studied a lot, but maybe she should have cancelled the movie date with Steve last night. 'Too late now,' she thought, as she stuffed her notes into her binder, 'I will just have to rely on what I remember so far.' She stood in the front entryway facing the front door as she did a once-over of all her stuff for the exam. Pencil, check; extra pencil, check; big eraser, check; calculator, check; student ID...... 'Oh man, where is that stupid thing?' she yelled to the plant sitting to the right of the door. 'They don't let you write the exam without it!' She cursed herself for not putting it back in the same place she always does, and then set off to find it.

She first ran to her left and into the living room. She almost tripped on the coat rack on her left as she ran by; she had to hop over one of its legs. She went over to the sofa in the left corner of the room and ran her hands between the cushions. She thought that the ID card might have fallen out of her pocket when she was sitting here. 'No luck yet,' she muttered to herself. She looked to her right at the loveseat which was against the back wall. She didn't look there, however, since that's the cat's couch and she never sits there anyways.

She turned around to look at the bookshelf in the opposite corner of the room, and although she couldn't really think of any reason it would be there, she walked over and lifted up a couple of books. 'OK, focus Sarah – it wouldn't be here,' she told herself. She turned left and continued into the study.

On her left was the easychair, but she ran by that to go straight to the computer desk on the far wall. She ran around to the office chair, and sat down for a second so she could get a better look at the desk. 'I may have left my ID card here when I was logging in to the library site last night,' she thought. She lifted various papers and notes, but there was no ID card anywhere. She stood up, took a deep breath, and went left into the rec room. 'Maybe it fell out of my pocket while I was watching 'Lost' last night?' she asked aloud to the room.

She went past the two dining room chairs that were on either side of the doorway on the rec room, and went straight over to the futon. It was on her right, and faced the large television on the wall to her left. Her roommate Melissa had left the television on with no volume, so Sarah quickly turned it off, annoyed but refusing to be distracted. She was getting more anxious, and lifted the smaller cushions off the top of the futon. To her dismay, no little ID card fluttered down to the ground. She turned left and briefly glanced on the top of the filing cabinet along the far wall. She didn't really look hard there; she would have to stand on her toes to look on the top. Still no ID card, and the bus to school would be coming pretty soon....

She stood in the centre of the kitchen and look around sternly. The sink was to her left, the stove in the bottom right corner and the fridge in the top right. She shook her head, 'There is absolutely no way that my ID card could be in a major appliance or down the drain – moving on!' Her father's thriftiness engrained on her brain, she couldn't leave the kitchen without turning off the dripping tap in the sink, and then she ran into the dining room.

With her hands on her hips, she stood on the small rectangular rug between the fireplace and the table. The fireplace was along the left wall, and the table sat parallel to it. To get a good look under the dining room table, she got down and knelt on the rug. She looked under the bench, which served as seating along one side of the table. Melissa had put the bench on the side of the table closest to the fireplace because she liked to sit by the fire while she ate. She knelt on the rug, and scanned the floor under the table for the ID card, even looked as far as under the chairs on the far side of the table. She was even getting so anxious about her search, she opened the grill to the fireplace! She rolled her eyes in exasperation and jumped up to keep looking.

She stood up from the bench and walked back into the front entryway. She was thinking about how she would explain the disappearance of her ID card to her proctor, when something caught her eye on the right side of her field of view.

She turned towards the staircase, and noticed there was a large pink note with her name on it, stuck to one of the big needles on the cactus. 'Why didn't I notice that before?' she thought as she walked past the stairs on her left, and over to the cactus in the far right corner of the room to detach the note from the cactus needle. The note read: 'Sarah: you left your ID card on the computer desk. Don't forget it for your exam. Melissa.' Attached to the punctured note from her roommate was her ID card!!

Hurriedly, she shoved the ID card in her pocket and ran out the front door, grabbing her bag as she went by. She could hear the bus coming but knew she would make it to the stop before it did. Now all she had to do was survive calculus….

Appendix 6.

Narrative form in survey perspective

Jen was driving faster now. 'I can't believe I left my resume at home! What was I thinking?' as she cursed her forgetfulness aloud. Her big interview was in an hour, and she had left the house with plenty of time. She needed the extra time to find the office, then find a place to park, then find a washroom for a place to check her teeth before going in to the interview. But when she stopped at the red light downtown, she reached for her resume to make sure it was lying flat, and it wasn't there. She had forgotten to bring it, and was racing home to grab it, and turn around again to make the interview.

She noticed she was driving much faster now, and started to worry about getting a ticket. 'Calm down,' she told herself. 'Go through the house in your mind and see if you can figure out where it might be. Then, when you get home, you'll be able to just run in and get it.'

She went through the rooms in her head: the front entryway, then the living room, the study, the rec room, the kitchen, the dining room, and finally the staircase in the centre. This was also a good way of calming her a bit, and she noticed her speed dropping. She still a distance to go, though, so she kept up her mental walkthrough of the house.

'Could it be in the dining room?' She thought about the room in the north west corner of the house. She had been in there shortly before leaving for the interview. She has closed the grill to the fireplace, along the west wall of the room, so that the cat wouldn't walk through the ashes. She remembered crouching down on the small rectangular rug between the bench and the fireplace to close it.

As she was doing that, she turned behind her to look under the table. The cat was sitting on one of the chairs on the other side of the table, and she could see him because the bench was short enough to let her see through. The length of the table went north-south, and she remembered telling the cat that he was out of luck if he wanted in the fireplace. Of course, he simply yawned and looked at her, but she knew he wasn't going anywhere. But she didn't remember having anything else in her hands.

So she didn't have her resume there… was it in the kitchen? She had walked through the kitchen fairly quickly, stopping only to turn off the dripping faucet. She was walking north, because she had come from the rec room. And of course, she wouldn't have left it in the fridge or in the stove, both along the east wall of the kitchen. She was in a rush, but she wasn't THAT forgetful.

'It probably wouldn't be in the rec room either,' she thought. The tv, which sits along the south wall of the room and faces north towards the futon, was broken. She been sitting on the futon last night, planning to watch 'Lost' last night, and couldn't turn the dumb thing to turn on. There were very few other reasons to spend much time in that room. The filing cabinet, along the west wall of the room, was hardly ever used. There were two dining room chairs which sat on either side of the doorway to the study, but they collected more papers than actually being used for seats.

She thought about the room with the staircase, in the centre of the house. There was a cactus plant in the south west corner of that room, and she had watered it a few days ago. Since she hardly ever had to water that thing, it was pretty unlikely that she had been hanging around it with her resume this morning.

The study was a likely place for her to have left it. After all, that was where the computer and printer were; on the desk along the south wall of the room. She remembered sitting in the office chair while waiting for the resume to print, and staring across the desk and the easychair in the northeast corner of the room.

She took the resume off the printer, and then what?

'A-ha!' she exclaimed aloud. She remembered where she left it! She had been in the living room, in the northeast corner of the house. She had put her resume down on the sofa, which was beside the coat rack. Both were along the north wall of the room. She was getting her coat down from the coat rack, when realized she needed her keys. She went over to the bookcase in the southwest corner of the room to get her keys. She walked past the loveseat along the east wall, went north, and then turned northwest and walked straight out the front door. She noted that the plant in the front entryway needed watering; she started thinking about other things and had forgotten her resume on the futon!

She pulled into the driveway and left the car running as she sprinted into the house. 'Well, at least I know where it is – now all I need to do is find a parking spot!'

Appendix 7.

Descriptive form in route perspective

You enter the house through the front door, and you stand in the front entryway. There is a plant on your left side.

You turn to your left, and walk into the living room. You pass a coat rack on your left side, and there is a sofa just beyond the coat rack. You turn right, towards the majority of the room. There is a loveseat on your left, and a bookcase on your right.

You walk forwards and into the study. There is an easychair in the corner of the room on your left. There is a large desk in front of you. It is L-shaped, and the join of the L points towards you. There is an office chair in the centre of the desk. You turn right, and walk into the rec room.

On either side of the doorway between the rec room and the study are two dining room chairs. In the centre of the wall on your left is the television set. The futon sits facing it, on the opposite wall. On either side of the futon are doorways; the closest one leads to the room with the staircase, and the farther one leads to the kitchen. There is a filing cabinet on the farthest wall. You walk the length of the rec room, and turn right.

You pass through the farther of the two doorways, into the kitchen. In the kitchen, there is a sink to your left. There is a fridge in the far corner on your right side, and there is a stove in the corner closest to you on your left hand side. The dining room is beyond the kitchen, and you must pass through the other doorway in the kitchen to get there.

You stand in the dining room. There is a fireplace in centre of the wall on your left. The head of the table is closest to you, since the length of the table is parallel to the fireplace. There are two chairs on the right side of the table, and there is a bench on the left side of the table. Between the table and the fireplace is a small rectangular rug.

You pass the table on your left as you walk back towards the front entryway. When you arrive at the front entryway, you turn right and walk into the room with the stairs. There is a cactus plant in the farthest right corner of the room. The staircase is in the centre of the room.

Appendix 8.

Descriptive form in survey perspective

The floorplan of the house begins with the front entryway, which is centered along the north wall. The living room occupies the northeast corner of the house, and the study occupies the southeast corner. Along the south wall and in the southwest corner of the house is the rec room. The kitchen is centered along the west wall, and the dining room is located in the northwest corner of the house. Finally, the stairs are located in a room in the centre of the house.

Beginning in the northwest corner, the dining room is almost a square room. The fireplace is tucked into the western wall, and faces out to the centre of the room. The table is positioned north-south, with two chairs on the east side, and a bench on the west side. There is also a small rectangular rug between the fireplace and the bench.

The kitchen is centered along the western wall of the house. The sink is on the west side of the room. The fridge is in the northeast corner of the room, and the stove is in the southeast corner.

In the southwest corner of the house is the rec room. The length of the room goes along the south wall of the house. On the west wall of the room is the filing cabinet. The television is on the south wall, and directly north of it is the futon. The futon is between two doorways which lead north; one into the kitchen and the other into the room with the staircase. Along the east wall of the rec room are two dining room chairs. One is in the northeast corner, and the other in the south east corner. They are on either side of the doorway which leads into the study.

The room in the centre of the house contains the staircase. The stairs are located in the centre of that room. There is a cactus plant in the southwest corner of the room.

The study occupies the south east corner of the house. There is a computer desk in the southeast corner of the room. It is L-shaped, and the join of the L-shape points north. There is an office chair in the centre of the desk. There is also an easychair in the room; it's in the northeast corner of the room.

The living room is located in the northeast corner of the house. There is also a loveseat which sits in the southeast corner of the room. The bookcase is in the southwest corner of the room. The sofa lies along most of the length of the north wall. There is a coat rack which stands just to the west of the sofa, in the north west corner of the room.

The front entryway is in the centre of the northern wall. There is a large plant just east of the front door.

Appendix 9.

Table of all probes, and the order in which they appear in the texts.

Probes #	Route	Order presented in route	Order presented in survey
1	coat rack sofa interaction probe	1	7
2	Loveseat plant Non-interaction probe	2	8
3	coat rack bookcase interaction probe	3	9
4	easychair desk interaction probe	4	5
5	Television futon interaction probe	5	12
6	Stove plant Non-interaction probe	6	4
7	table bench Non-interaction probe	7	10
8	television fireplace interaction probe	8	1
9	filing cabinet table Non-interaction probe	9	3
10	coat rack cactus interaction probe	10	2
11	easy chair loveseat Non-interaction probe	11	6
12	cactus rug interaction probe	12	11

Appendix 10.

Instructions for all tasks.

Participants were verbally given all instructions before beginning the experiment. They were allowed to ask questions, and seek clarity on explanations they found confusing. The instructions given on the screen were written exactly the same way they first listened to them from the experimenter.

i. Instructions for Step 1 of Task 1, Map Study.

You will see a map, depicting a floorplan of a house. Please study it carefully. You will be asked to reproduce this map on the blank paper provided.

Take as much time as you require, and when you are ready to draw the map, press the space bar.

Please press the space bar now to continue.

ii. Instructions for Step 2 of Task 1, Map Study.

Please draw the map on the blank paper provided. Include as many objects and room names as you can remember.

When you are finished, the researcher will look over your map and provide feedback.

iii. Instructions for Task 2, Inference Questions (pre-text).

You will be presented with two words, representing objects in the map. There will be an arrow connecting the two words.

Please indicate if the positions of the two objects are true or false, in relation to each other. The absolute distance between the objects is irrelevant. Please respond using the keys labeled 'true' and 'false'.

The door and the direction arrow in the upper right corner of the screen indicate the orientation of the floorplan in general, but not the true position of the door.

iv. Instructions for Task 3, Reading and Probes.

You will be shown a text passage, which describes the floor plan you have studied. However, many of the objects have changed locations. You will be presented with each sentence one at a time; when you are finished reading, press the space bar to receive the next sentence.

Occasionally, you will be presented with a pair of words representing objects in the floorplan. Your task will be to decide whether these objects are in the same room as each other, or in different rooms from one another. You may respond by using the keys labelled 'same' or 'different' on the keyboard. To remind you of your task, and to let you know what is coming next, the question 'same room or different room?' will appear before each pair of words.

Press the space bar to continue on to the practice trial. This text has nothing to do with the map; it is simply to allow you some practice with the reading and the task procedure.

v. Instructions for Task 4, Inference Questions (post-text).

This task will be similar to one you have already done. You will be presented with two words, representing objects in the map. There will be an arrow connecting the two words.

Please indicate if the positions of the two objects are true or false, in relation to each other. This time, please judge the relation based on the floorplan described in the text passage. Please respond using the keys labeled 'true' and 'false'.

The door and the direction arrow in the upper right corner of the screen indicate the orientation of the floorplan in general, but not the true position of the door.

vi. Instructions for Task 5, Map Drawing.

Using the blank paper provided, please draw the floorplan of the house according to the text passage you read. Take as much time as you like.
When you are finished, please press the space bar.

Finish screen:
Thank you for your participation in this study! Please bring your final map to the researcher.

Appendix 11.

Practice trials for Task 3.

<screen 1>
PRACTICE

<screen 2>
Benny was getting nervous about his presentation.

<screen 3>
He looked out over the empty board room table, and made sure that there were plenty of copies of his handouts.

<screen 4>
After trying the slide projector for the third time, he took a deep breath and tried to relax.

<screen 5>
He walked into the kitchen, over to the coffee machine and poured himself a small cup.

<screen 6>
Same room or different room?

<screen 7>
projector handouts

At this point the participant will receive feedback on their accuracy. If they were correct, they continue to Task 3. If not, they will try a second practice trial.

Practice trial 2.

<screen 1>
PRACTICE

<screen 2>
"Do I have the right room?", Daniel wondered.

<screen 3>
He expected that there would have been more students in the class by now.

<screen 4>
Thinking he was lucky to have arrived early, he had put his schoolbag down in a chair beside the window.

<screen 5>
"So much for luck," he muttered as he wandered out into the hall.

<screen 6>
He took his agenda with him, to verify the room number of the class.

<screen 7>
Same room or different room?

<screen 8>
agenda schoolbag

Appendix 12.

Debriefing

The Impact of Narrative on the Update and Change of an Existing Cognitive Map

Purpose of the research. This study attempts to isolate the unique contribution of the narrative context on readers' ability to integrate new spatial information into their existing mental representations of space. That is to say, we are attempting to address the question: does reading about new spatial information in the narrative context make it easier for readers to adopt into what they already know about the environment?

Brief review of the research issues. This is an area previously unexplored by either the narrative and discourse psychology field, or by the area of spatial cognition research. The results from this study may help to highlight the importance of using survivor stories of escape to aid emergency workers, structural engineers, and the review of safety standards. They will also help to provide theoretical underpinnings to current socio-cultural studies of the oral transmission of spatial information in story form.

Hypotheses and predictions. The Impact of Text Form: Because readers of a narrative develop a situation model (a mental representation of the narrative, its location in time and space, and its characters), this model will help readers create a more complete cognitive map of the changed space. A situation model has implicit spatial information contained within it, and will therefore support the readers' abilities to integrate new spatial information. They will be able to do this more easily than those who read a simple description, and who therefore do not create a situation model.

The Impact of Spatial Perspective: Readers who receive information from a survey perspective (or a birds-eye view) will be able to form a more complete cognitive map than those who receive information in route perspective, or from an egocentric point of view. This is because by receiving survey information, the reader is able to understand the environment in a way that resembles a map image, and they are better judge distances and create new routes, if necessary. Route information does not lend itself to these kinds of judgements as well.

An Interaction between Text Form and Spatial Perspective: Route directions are a common, everyday occurrence. They are a description from point A to point B, and they are given in route perspective. Those who receive route directions may have a tendency to project themselves into this description, as they imagine themselves following this route. This tendency introduces the reader as the 'protagonist' in the route descriptions, therefore bringing the route descriptions one element closer to the narrative. Because of this tendency, we predict that we will see less differences between the narrative and descriptive groups in the route perspective, and more differences in the survey perspective.

If you have any questions or concerns about this research, please contact the principle investigator: Meaghan Beirne (520-2600, ext. 6628; mbeirne@connect.carleton.ca) or the faculty sponsor: Dr. Avi Parush (520-2600, ext. 6026; avi_parush@carleton.ca). Should you have any ethical concerns about this study, please contact Dr. Janet Mantler (Chair, Carleton University Ethics Committee for Psychological Research; 520-2600, ext. 4173; janet_mantler@carleton.ca) or Dr. M Gick (Chair, Dept. of Psychology; 520-2600, 2648).

Appendix 13.

Table A. Means and standard deviations of self-rated spatial ability from a scale of 1 to 7, with 7 being "strongly agree" and 1 being "strongly disagree". These are organizes according to experimental groups.

	Survey perspective		Route perspective	
Summary	**Narrative**	**Description**	**Narrative**	**Description**
Mean	4.66	4.79	5.25	4.27
SD	1.14	1.37	.86	1.47

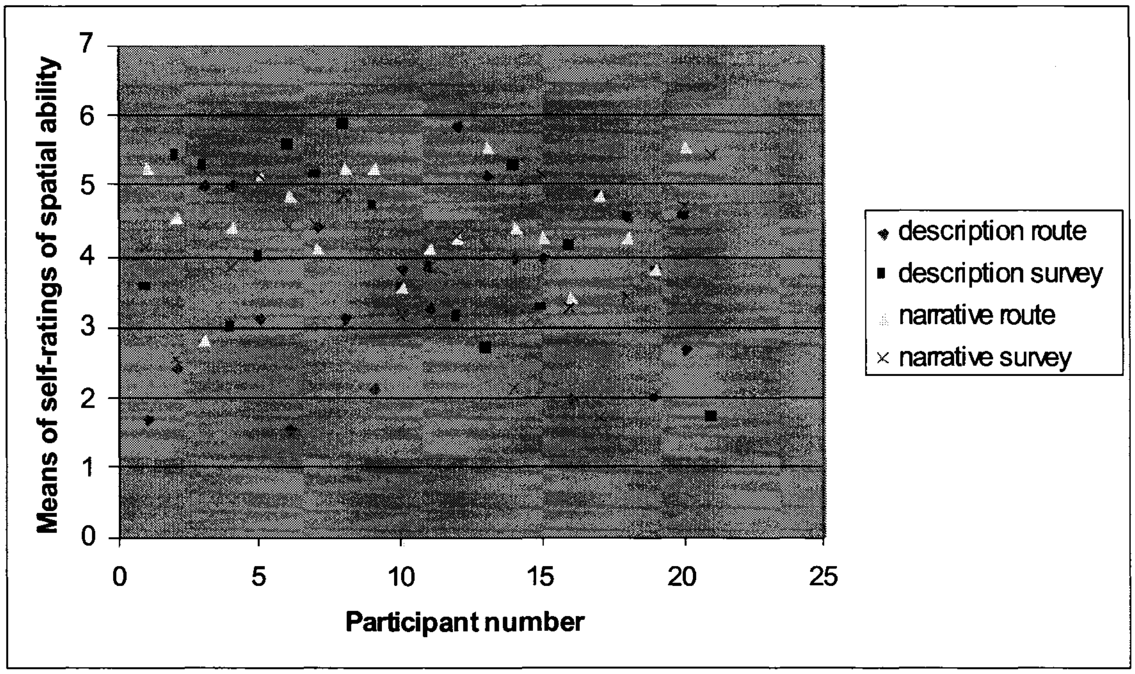

Figure A. Means for self-ratings of spatial abilities for all experimental groups.

Appendix 14.

Summary tables for 2-way ANOVA: text form and spatial perspective are between-subjects factors. Means of self-rated spatial ability is the dependent variable.

Factor	**df**	**Mean Square**	**F**	**Sig.**
Spatial perspective	1	.012	.008	.931
Text form	1	3.982	1.611	.310
Spatial perspective * Text form	1	6.792	2.454	.138
Error	78	1.525		

Appendix 15.

Mean response times (ms) required for participants to study the original map in Phase One before successfully reproducing the map by hand.

	Survey perspective		**Route perspective**	
Summary (ms)	**Narrative**	**Description**	**Narrative**	**Description**
Mean	190734.07	183435.33	203840.94	204732.38
SD	107701.58	101559.73	130996.03	94212.05

Appendix 16.

Mean response times (ms) for spatial inference questions, organized by text form and spatial perspective and presented for both the pre-text and post-text inference questions.

	Survey perspective		Route perspective	
Summary	**Narrative**	**Description**	**Narrative**	**Description**
		Pre-Text Inference Questions		
Mean	7274.50	7939.44	7565.71	7760.89
SD	2287.51	2314.42	2050.68	1993.66
		Post-Text Inference Questions		
Mean	7942.76	7237.56	6561.66	7482.46
SD	2313.91	1660.35	2619.54	2672.27

Appendix 17.

Summary tables for 3-way ANOVA: text form and spatial perspective as between-subjects factors, and time (pre-text and post-text) as within-subjects factor. Response time for pre- and post-text inference questions is the dependent variable.

Table A. Within-subjects effects.

Factor	df	Mean Square	F	Sig.
Time	1	4,688,449.30	1.53	.22
Time * Spatial perspective	1	3,952,303.47	1.29	.26
Time * Text form	1	1,161,764.85	.38	.54
Time * Spatial perspective * text form	1	117,498,868.36	3.83	.05
Error	80	3,068,120.39		

Table B. Between-subjects effects.

Factor	df	Mean Square	F	Sig.
Spatial perspective	1	2,861,413.58	.396	.53
Text form	1	3,154,375.01	.437	.51
Spatial perspective * Text form	1	3,378,545.21	.468	.496
Error	80	7,217,679.76		

Appendix 18.

Mean proportion of correct responses to spatial inference questions, organized by text form and spatial perspective and presented for both the pre-text and post-text inference questions.

	Survey perspective		Route perspective	
	Narrative	**Description**	**Narrative**	**Description**
	Pre-Text Inference Questions			
Mean	.87	.85	.79	.83
SD	.093	.074	.109	.075
	Post-Text Inference Questions			
Mean	.69	.76	.70	.75
SD	.140	.155	.161	.233

Appendix 19.

Summary tables for 3-way ANOVA: text form and spatial perspective as between-subjects factors, and time (pre-text and post-text) as within-subjects factor. Accuracy for pre- and post- text spatial inference questions is the dependent variable.

Table A. Within-subjects effects.

Factor	df	Mean Square	F	Sig.
Time	1	.455	29.161	.000
Time * Spatial perspective	1	.021	1.337	.251
Time * Text form	1	.031	1.989	.162
Time * Spatial perspective * text form	1	.024	1.533	.219
Error	80	.016		

Table B. Between-subjects effects.

Factor	df	Mean Square	F	Sig.
Spatial perspective	1	.027	1.138	.289
Text form	1	.050	2.112	.150
Spatial perspective * Text form	1	.008	.342	.560
Error	80	.024		

Appendix 20.

Mean response times (ms) to spatial inference questions for all experimental grouped, organized according to object position and type.

	Survey perspective		Route perspective	
Position	**Narrative**	**Description**	**Narrative**	**Description**
	Interaction objects			
Changed	Mean = 8503.01 SD = 750.36	Mean = 8354.19 SD = 750.356	Mean = 7681.56 SD = 788.86	Mean = 7628.21 SD = 733.10
Consistent	Mean = 6423.48[a] SD = 892.73	Mean = 7360.31 SD = 892.73	Mean = 5079.39[a] SD = 938.54	Mean = 8155.98 SD = 872.20
	Non-interaction objects			
Changed	Mean = 8926.86 SD = 1197.53	Mean = 8550.83 SD = 1197.53	Mean = 7559.58 SD = 1258.98	Mean = 10455.68 SD = 1169.99
Consistent	Mean = 8572.26 SD = 1484.64	Mean = 5886.93 SD = 1484.64	Mean = 5824.68 SD = 1560.82	Mean = 6196.89 SD= 1450.51

[a] The difference between response times is approaching significance at $p = .02$.

Appendix 21.

Summary of Kruskal-Wallis *H* tests for differences in response times to the spatial inference questions between all experimental groups in each of the four object categories (organized according to position and type).

	Interaction objects		**Non-interaction objects**	
	Changed	**Consistent**	**Changed**	**Consistent**
Chi-squared	3.379	7.849	2.977	.336
df	3	3	3	3
Asymptotic significance	.337	.049	.395	.953

Appendix 22.

Mean proportion of correct responses to spatial inference questions of all experimental groups, organized according to object position and type.

	Survey perspective		Route perspective	
Position	**Narrative**	**Description**	**Narrative**	**Description**
		Interaction objects		
Changed	Mean = .71 SD = .26	Mean = .83 SD = .19	Mean = .72 SD = .23	Mean = .75 SD = .20
Consistent	Mean = .93 SD = .24	Mean = .76 SD = .37	Mean = .78 SD = .30	Mean = .80 SD = .33
		Non-interaction objects		
Changed	Mean = .71 SD = .30	Mean = .69 SD = .37	Mean = .65 SD = .40	Mean = .61 SD = .41
Consistent	Mean = .69 SD = .33	Mean = .81 SD = .29	Mean = .70 SD = .34	Mean = .84 SD= .32

Appendix 23.

Summary of Chi-squared tests of the differences in response accuracy to the spatial inference questions between all experimental groups in each of the four object categories (organized according to position and type).

	Interaction objects		**Non-interaction objects**	
	Changed	**Consistent**	**Changed**	**Consistent**
Chi-squared	3.745	.617	4.305	4.148
df	3	3	3	3
Asymptotic significance	.290	.892	.230	.246

Appendix 24.

Mean response times (ms) to probe questions for all experimental groups, organized according to type.

	Survey perspective		Route perspective	
Type of object	**Narrative**	**Description**	**Narrative**	**Description**
		Interaction objects		
Mean	3742.159	3793.965	3650.908	4337.088
SD	283.369	276.854	290.367	276.854
		Non-interaction objects		
Mean	5301.934	5063.485	4435.749	4598.415
SD	364.636	356.253	373.641	356.253

Appendix 25.

Summary tables for 3-way ANOVA: text form and spatial perspective as between-subjects factors, and object type as a within-subjects factor. Response time for probe questions is the dependent variable.

Table A. Within-subjects effects.

Factor	df	Mean Square	F	Sig.
Type	1	39,832,812.33	49.79	.000
Type * Spatial perspective	1	8,432,542.34	10.54	.002
Type * Text form	1	1,756,285.10	2.19	.142
Type * Spatial perspective * text form	1	144,302.13	.18	.672
Error	81	799,959.91		

Table B. Between-subjects effects.

Factor	df	Mean Square	F	Sig.
Spatial perspective	1	2,050,929.16	.56	.457
Text form	1	1,162,988.09	.32	.575
Spatial perspective * Text form	1	2,843,701.92	.77	.382
Error	81	3,678,453.36		

Appendix 26.

Mean proportion of correct responses to probe questions for all experimental groups, organized according to type.

	Survey perspective		Route perspective	
Type of object	**Narrative**	**Description**	**Narrative**	**Description**
		Interaction objects		
Mean	.86	.95	.80	.88
SD	.03	.03	.03	.03
		Non-interaction objects		
Mean	.77	.91	.86	.92
SD	.04	.03	.04	.03

Appendix 27.

Summary tables for 3-way ANOVA: text form and spatial perspective as between-subjects factors, and object type as a within-subjects factor. Mean proportion of correct responses to probe questions is the dependent variable.

Table A. Within-subjects effects.

Factor	df	Mean Square	F	Sig.
Type	1	.002	.13	.71
Type * Spatial perspective	1	.144	8.30	.00
Type * Text form	1	.003	.19	.66
Type * Spatial perspective * text form	1	.014	.79	.37
Error	81	.017		

Table B. Between-subjects effects.

Factor	df	Mean Square	F	Sig.
Spatial perspective	1	.004	.125	.724
Text form	1	.337	11.189	.001
Spatial perspective * Text form	1	.020	.666	.417
Error	1	.004	.125	.724

Appendix 28.

Mean response times (ms) to probe questions for all experimental groups, organized according to object position and type.

	Survey perspective		**Route perspective**	
Position	**Narrative**	**Description**	**Narrative**	**Description**
		Interaction objects		
	Mean = 3892.19	Mean = 3999.24	Mean = 3533.77	Mean = 4072.31
Changed	SD = 276.37	SD = 270.02	SD = 290.55	SD = 276.37
	Mean = 2841.97	Mean = 2562.33	Mean = 3544.69	Mean = 4144.08
Consistent	SD = 228.82	SD = 223.56	SD = 240.56	SD = 228.82
		Non-interaction objects		
	Mean = 6097.19	Mean = 4953.26	Mean = 4210.19	Mean = 4462.72
Changed	SD = 351.56	SD = 343.47	SD = 369.59	SD = 351.56
	Mean = 3860.48	Mean = 4046.51	Mean = 3070.66	Mean = 2782.94
Consistent	SD = 317.92	SD = 310.61	SD = 334.24	SD= 317.92

Appendix 29.

Kruskal-Wallis *H* tables for pair-wise comparisons of response times between groups for each of the four categories of probe questions.

Table A. Narrative condition in route perspective compared to narrative condition in survey perspective.

	Interaction objects		**Non-interaction objects**	
	Changed	**Consistent**	**Changed**	**Consistent**
Chi-squared	3.825	4.050	9.026	11.568
df	1	1	1	1
Asymptotic significance	.051	.044	.003	.001

Table B. Description condition in route perspective compared to description condition in survey condition

	Interaction objects		**Non-interaction objects**	
	Changed	**Consistent**	**Changed**	**Consistent**
Chi-squared	2.243	19.024	4.418	6.362
df	1	1	1	1
Asymptotic significance	.134	.000	.036	.012

Table C. Narrative condition in route perspective compared to description condition in route perspective.

	Interaction objects		**Non-interaction objects**	
	Changed	**Consistent**	**Changed**	**Consistent**
Chi-squared	4.886	18.353	5.869	8.773
df	2	2	2	2
Asymptotic significance	.087	.000	.053	.012

Table D. Narrative condition in survey perspective compared to description condition in survey perspective.

	Interaction objects		**Non-interaction objects**	
	Changed	**Consistent**	**Changed**	**Consistent**
Chi-squared	5.592	7.723	10.978	11.547
df	2	2	2	2
Asymptotic significance	.061	.021	.004	.003

Appendix 30.

Mean proportion of correct responses to probe questions for all experimental groups, organized according to object position and type.

	Survey perspective		Route perspective	
Position	**Narrative**	**Description**	**Narrative**	**Description**
		Interaction objects		
	Mean = .87	Mean = .96	Mean = .78	Mean = .91
Changed	SD = .03	SD = .03	SD = .03	SD = .03
	Mean = .86	Mean = .91	Mean = .90	Mean = .76
Consistent	SD = .08	SD = .07	SD = .08	SD = .08
		Non-interaction objects		
	Mean = .71	Mean = .87	Mean = .83	Mean = .90
Changed	SD = .04	SD = .04	SD .046	SD = .04
	Mean = 1.00	Mean = 1.00	Mean = 1.00	Mean = 1.00
Consistent	SD = .00	SD = .00	SD = .00	SD= .00

Appendix 31.

Proportion of objects placed correctly, incorrectly or missing, in map drawings, for all experimental groups.

	Survey perspective		**Route perspective**	
Objects	**Narrative**	**Description**	**Narrative**	**Description**
	Mean = .523	Mean = .69	Mean = .61	Mean = .66
Correct	SD = .25	SD = .31	SD = .26	SD = .38
	Mean = .32	Mean = .19	Mean = .23	Mean = .14
Incorrect	SD = .20	SD = .20	SD = .19	SD = .17
	Mean = .15	Mean = .12	Mean = .16	Mean = .10
Missing	SD = .21	SD = .22	SD = .18	SD = .22

Appendix 32.

Mean scores and standard deviations of map goodness scores for all experimental groups; presented by rater.

	Survey perspective		Route perspective	
Rater	**Narrative**	**Description**	**Narrative**	**Description**
Rater One	Mean = 1.67 SD = .73	Mean = 2.27 SD = .70	Mean = 1.90 SD = .72	Mean = 2.00 SD = .85
Rater Two	Mean = 1.33 SD = .48	Mean = 2.18 SD = .85	Mean = 2.2 SD = .83	Mean = 2.27 SD = .86
Rater Three	Mean = 1.19 SD = .40	Mean = 1.82 SD = .80	Mean = 1.75 SD = .72	Mean = 1.95 SD = .70

Appendix 33.

Frequencies of objects mentioned in each text passage.

	Survey perspective		Route perspective	
Objects	**Narrative**	**Description**	**Narrative**	**Description**
Plant	1	1	1	1
Bench	2**	2**	3**	1
Rug	1	1	3**	1
Sofa	1	1	1	1
Loveseat	1	1	1	1
Fireplace	2**	2**	3**	2**
Coat rack	2**	1	1	2**
Desk	2**	2**	1	1
Filing cabinet	1	1	1	1
Bookshelf	1	1	1	1
Futon	1	2**	2**	1
TV	1	1	1	1
Easychair	1	1	1	1
Sink	1	1	2**	1
Stove	1	1	1	1
Fridge	1	1	1	1
Table	2**	1	4**	3**
Chairs (dining room)	2**	1	1	1
Chairs (rec room)	1	1	1	1
Stairs	2**	1	2**	3**
Cactus	1	1	2**	1

** Classified as 'high' items, as mentioned in the text passages.

Appendix 34.

Spatial inference and probe questions containing high frequency objects.

Type of Questions	Survey perspective: Narrative	Survey perspective: Description	Route perspective: Narrative	Route perspective: Description
Probe	1, 3, 6, 7, 8, 9	4, 6, 7	6, 7, 8, 9, 10, 12	1, 3, 6, 7, 8, 9, 10
Spatial Inference	1, 5, 8, 15, 18, 19, 20, 24	1, 2, 3, 8, 11, 14, 16, 19	1, 2, 6, 7, 8, 10, 14, 15, 16, 20, 22, 24	1, 8, 15, 18, 24

Appendix 35.

Table A. Mean response times and accuracies, and their respective standard deviations, for all experimental groups on spatial inference questions, organized according to high or low object frequency.

	Survey perspective		**Route perspective**	
	Narrative	**Description**	**Narrative**	**Description**
	High Object Frequency			
Response times	M = 7450.50 SD = 1547.95	M = 7878.25 SD = 888.52	M = 6049.53 SD = 909.50	M = 7035.53 SD = 1160.35
Accuracies	M = .73 SD = .42	M = .70 SD = .37	M = .71 SD = .42	M = .78 SD = .42
	Low Object Frequency			
Response times	M = 8240.19 SD = 1002.52	M = 7146.03 SD = 1984.61	M = 7259.03 SD = 1046.02	M = 7737.12 SD = 1581.31
Accuracies	M = .69 SD = .43	M = .78 SD = .39	M = .70 SD = .42	M = .75 SD = .39

Table B. Mean response times and accuracies, and their respective standard deviations, for all experimental groups on probe questions, organized according to high or low object frequency.

	Survey perspective		**Route perspective**	
	Narrative	**Description**	**Narrative**	**Description**
	High Object frequency			
Response times	M = 4119.42	M = 3905.67	M = 3178.94	M = 4208.74
	SD = 284.03	SD = 546.03	SD = 612.08	SD = 452.09
Accuracies	M = .79	M = .86	M = .93	M = .89
	SD = .07	SD = .08	SD = .13	SD = .06
	Low Object frequency			
Response times	M = 4157.67	M = 4961.04	M = 3798.82	M = 3905.62
	SD = 763.45	SD = 692.62	SD = 472.31	SD = 521.06
Accuracies	M = .86	M = .90	M = .73	M = .81
	SD = .09	SD = .04	SD = .15	SD = .08

Appendix 36.

Mean response times (ms) to probe questions, arranged according to the text form condition, and in the order presented in the text.

	Narrative		Description	
Probe Order	**Mean**	**SD**	**Mean**	**SD**
First	5754.13	356.62	3675.27	344.15
Second	3952.44	393.28	4892.93	379.52
Third	4318.98	414.15	5752.84	399.66
Fourth	3946.74	322.31	4329.29	311.04
Fifth	3045.56	220.41	2857.51	212.70
Sixth	2909.10	126.78	2980.78	122.35
Seventh	3459.47	378.23	3302.35	365.03
Eighth	3912.60	341.10	3435.46	329.17
Ninth	4822.99	671.76	6388.87	648.26
Tenth	3832.37	371.96	4526.41	358.95
Eleventh	4019.58	302.64	3631.75	292.05
Twelfth	5977.66	481.57	5443.04	464.72

Appendix 37.

Summary tables for 2-way mixed ANOVA: text form as the between-subjects factor and probe order as within-subjects factor. Response time is the dependent variable.

Table A. Within-subjects effects.

Factor	df	Mean Square	F	Sig.
Probe order	11	3792.201	20.954	.000
Probe order* Text form	1	872.161	6.923	.000
Error	73	180.976		

Table B. Between-subjects effects.

Factor	df	Mean Square	F	Sig.
Text form	1	194.516	.255	.615
Error	83	764.201		

Appendix 38.

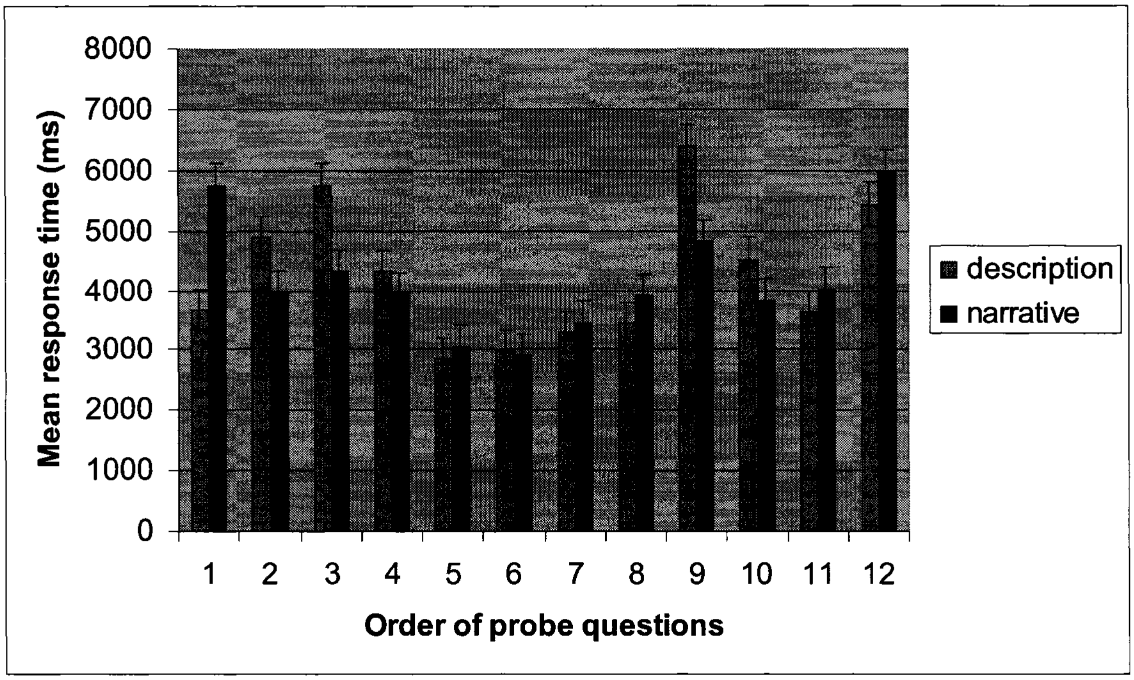

Figure A. Mean response times for all participants to the probe questions, presented according to the order in which the probes were presented and according to text form.

Appendix 39.

Mean proportion of correct responses to probe questions, arranged according to the order of presentation of the probes and according to text form.

	Narrative		Description	
Probe Order	**Mean**	**SD**	**Mean**	**SD**
First	.44	.07	.84	.07
Second	.90	.05	.89	.05
Third	.76	.06	.84	.06
Fourth	.95	.05	.86	.04
Fifth	.98	.02	.98	.02
Sixth	.93	.04	.95	.04
Seventh	.85	.05	.95	.04
Eighth	.88	.05	.89	.05
Ninth	.80	.05	.98	.05
Tenth	.71	.06	.93	.06
Eleventh	.83	.05	.93	.05
Twelfth	.88	.05	.91	.05

Appendix 40.

Chi-squared tests of mean proportion of correct responses to probe questions, organized by order presented in the text passages. Significant values represent differences between text form groups.

Probe order	Chi-Squared value	df	Significance
First	14.83	1	.000
Second	.06	1	.811
Third	.94	1	.332
Fourth	1.88	1	.170
Fifth	.003	1	.960
Sixth	.29	1	.590
Seventh	2.50	1	.114
Eighth	.01	1	.906
Ninth	6.58	1	.010
Tenth	7.27	1	.007
Eleventh	2.12	1	.145
Twelfth	.21	1	.644

Appendix 41.

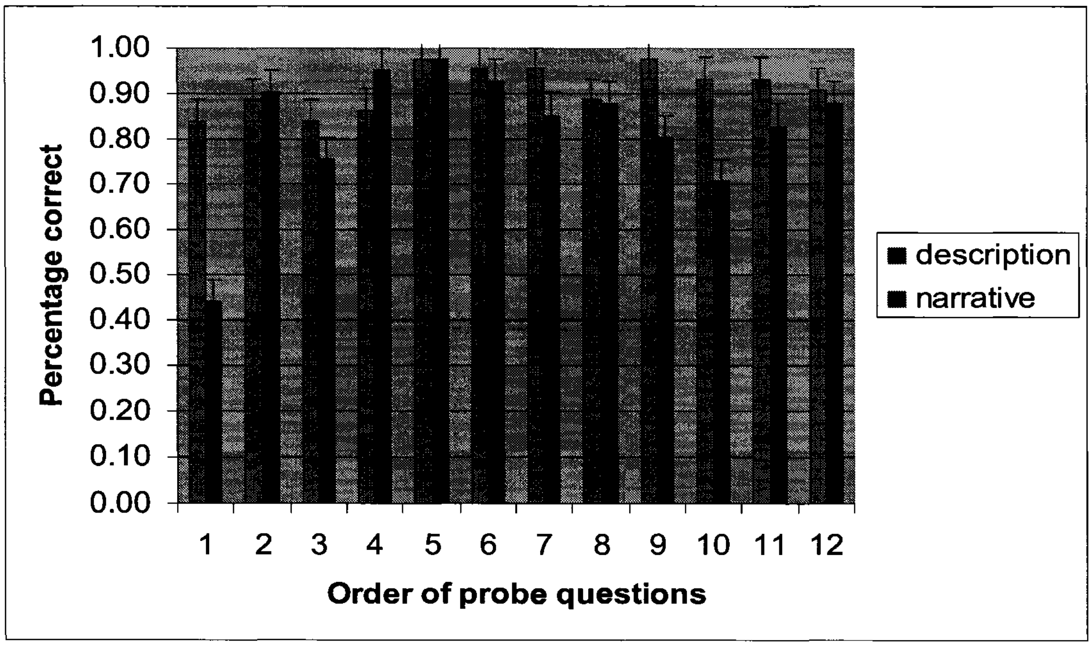

Figure A. Percentage correct responses to probe questions in the order the probes were presented in the text passage, and organized according to text form.