Talking about Space versus Sketching Space: An Investigation of the Differences in Conveying Spatial Information.

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Talking about Space versus Sketching
Space: An Investigation of the Differences in Conveying Spatial Information.

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Abstract

Conveying spatial information is one of the earliest uses of human language and has evolved over time. Today spatial information can be conveyed mainly via two modalities: the textual modality, which includes spoken and written language, and the graphical modality, which includes sketching. This thesis distinguishes between three dimensions of spatial descriptions: (1) place descriptions, (2) route descriptions, and (3) region descriptions. It investigates if there are differences in the spatial descriptions within the three dimensions of spatial descriptions between the textual and the graphical modality. For the investigation of the differences an experiment was conducted to collect six spatial description, one for every dimension and modality, from a total of 30 participants, respectively.

The results show that there are differences that are likely to be due to the different structure of the modalities: the textual descriptions have a linear structure whereas the graphical descriptions have a two-dimensional extend. Within each dimension of spatial descriptions there are significantly more description errors in the graphical descriptions, which were counted on a defined error scoring scheme. Reasons are discussed to be due to a higher number of explicitly mentioned and sketched spatial relations within the graphical descriptions which is again due to the difference in the underlying structure of the two modalities: textual descriptions predominantly contain qualitative information whereas graphical descriptions contain more quantitative information. Moreover, the results show that people predominantly use the route perspective in textual descriptions and even switch from other perspectives towards the route perspective. The reason for this is again discussed to be due to the linear structure of the textual descriptions.
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1 Introduction

Talking about space is one of the earliest uses of language which people used to convey information about where to find food and where not to go to avoid danger (Taylor & Tversky, 1996). The next step in human evolution of conveying spatial information were pictures such as cave drawings, petroglyphs and maps, followed by written language (Taylor & Tversky, 1992a; Gelb, 1963).

Spoken or written language as well as sketches are used to convey spatial information and are externalizations of the humans mental spatial representation and spatial knowledge (Richter & Winter, 2014). The knowledge is gathered through many senses, primarily sight, sound, and touch (Taylor & Tversky, 1996). Mental spatial representations are the result of properties of experiences that are stored in the brain in relation to their location. Relating several experiences this can cover not only locations but trajectories and whole environments (Richter & Winter, 2014). This knowledge allows individuals to navigate through their immediate or larger environment and to make inferences about both. It is therefore critical to the interactions with the physical world and the interaction between individuals (Taylor & Tversky, 1996). Externalizations of mental spatial representations into communication modes today covers spoken language, written language, drawings and gesturing (Richter & Winter, 2014).

More recently, with the advent of the information technologies and the development of computational systems that are capable of sensing the environment through several integrated sensors and interacting with humans via various modes, another layer of conveying spatial information has evolved. Smartphones got affordable for almost everyone and evolved to people’s daily companions. They can be used as navigation devices that assist humans in daily navigation and wayfinding tasks and besides sound output and visually displaying spatial information, these devices are able to give haptic feedback during navigation tasks.

Human computer interaction (HCI) is a research field that, among others, investigates how humans naturally behave and interact with each other in order to improve the usability and interaction between humans and computers (Dix, 2009). In computer assisted wayfinding and navigation tasks an interaction takes place that involves the conveyance of spatial information from the computer as a transmitter towards the human receiver. The question which types of information are transmitted via which type of modality is an important question that motivates this research. It is supposed that the design of computer devices can benefit from the understanding of how humans naturally think about and communicate about space.

Montello and Sas (2006) asked a number of questions that motivate the research of verbal route descriptions: “Which types of features should be included in verbal directions and how should these features be described? Should the verbal directions focus exclusively on landmarks and turn instructions, or should distance be included, too? Which objects in the environment should serve as landmarks?” (Montello & Sas, 2006, p.2006). Similar questions motivating the research of graphical descriptions could be asked: Which features should be included in graphical descriptions and how should
these features be sketched? Should features be labeled? Should distance information be included in graphical descriptions? How many objects should be included into graphical descriptions of space in order to preserve readability and overview?

Not all of these questions will be answered in the scope of this thesis, but they clearly motivate the research of spatial descriptions for both textual and graphical descriptions.

1.1 Hypothesis and Research Questions

The two modalities textual descriptions and graphical descriptions are very different in their underlying structure. Textual descriptions have by default a sequential structure whereas graphical descriptions have a two-dimensional extend. These differences permit the assertion that there are also differences in terms of the spatial information that is conveyed within these modalities. Psychology structures space with respect to its scale (e.g. Freundschuh & Egenhofer, 1997; Montello, 1993). This will be reviewed in detail in Section 2. Based on that distinction, this thesis distinguishes three dimensions of spatial descriptions: (1) place descriptions, (2) route descriptions, and (3) region descriptions. This will be reviewed and constituted in Section 3.

For the scope of this thesis, it is hypothesized that within the three dimensions of spatial descriptions - place descriptions, route descriptions, and region descriptions - there are differences in the externalizations of mental spatial representations between the two modalities - spoken or written language and sketching - for conveying spatial information.

The aim of this thesis is to answer the following questions:

- **What are the differences with respect to landmarks?**
  Landmarks are a central concept of spatial information and present in textual as well as graphical information. The proportion and the position of landmarks will play a central role in the investigation of this question.

- **What are the differences in terms of the correctness of the information?**
  For both textual and graphical descriptions a method for rating errors will be suggested, which considers for the first part landmark information and spatial relations.

- **What are the differences in terms of the richness of the information?**
  Solely the number of landmarks is not an indicator for the richness of the information content but a combination of landmarks and spatial relations.

1.2 Approach

As a central part of the thesis an experiment will be conducted that collects both textual and graphical descriptions of predefined places, routes and regions from the same
group of users. Collecting both descriptions from the same users allows the comparison between the modalities and a counterbalanced order of tasks will reduce the possible influence of the order onto the statistical results (see Taylor & Tversky, 1996). Collecting place, route and region descriptions from the same users does not allow a direct comparison between the three dimensions of spatial descriptions, however, it might reveal general differences about how spatial information is externalized within the three dimensions of spatial descriptions. Criteria for the investigation of the differences will include the investigation of landmarks, their spatial relation and their distances, as well as the correctness and the richness of the information given in the spatial descriptions (see Anacta, Schwering, & Li, 2014). Moreover, the spatial strategies will be tested subsequently to the former parts of the experiment by applying the Münzer Questionnaire on Spatial Strategies (Münzer & Hölscher, 2011).

1.3 Expected Results

It is expected that the results of the experiment will reveal differences within all three dimensions of spatial descriptions between the textual and the graphical modality. As the two modalities, the spoken or written language and the sketching, are very different in their underlying structure, it is assumed that this differences induce differences in the spatial descriptions that will be revealed through the statistical evaluation of the experiment. From this initial point, it seems to be possible that there will be differences with respect to the landmarks, e.g. more global landmarks in the graphical descriptions because the graphical descriptions allow an easier and unambiguous way of integrating the global landmarks, or possibly a higher average distance of the landmarks in the graphical descriptions. Moreover, knowing about the differences between textual and graphical descriptions with respect to spatial information will have practical consequences for the modern interface design of navigation devices. Although the focus of the thesis will be the investigation of the differences between the two modalities, and not a usability study on navigation devices, a final discussion about possible consequences of the differences with respect to the design of navigation devices will be held. Referring to the previous suggestion, it may be better to support the global orientation of navigation system users by displaying global landmarks better than mentioning them verbally.

1.4 Outline

The thesis is subdivided as follows: Section 2 introduces the related work that forms the scientific base of the thesis. Section 3 presents the methods and describes in detail how the research is planned to be performed. It presents the parameters that are relevant for the statistical analysis of the data, which will be collected in the experiment. Following this, the results of the experiment and the analysis will be presented in Section 4 and discussed in Section 5. Finally, Section 6 will conclude the thesis, summarize the findings and point to future work.
2 Related Work

A lot of research has been done in the past that forms a strong scientific base which this thesis relies on. The main research fields this thesis alludes to are spatial science and cognitive science. Key questions that arise from an initial point of view are how spatial information is structured, how it is stored in humans brains, and how it is communicated. This section will review the scientific background that underlies this thesis and is crucial for the investigation of the hypothesis and the research questions.

2.1 Space

Space and time are fundamental variables of the world and fundamental to any human behavior and reasoning (Freksa, 1997). Yet, a universal definition of space is (almost) impossible because different scientific disciplines (e.g. geography, mathematics, physics, psychology) have a different understanding of the term (Kray, 2003). The physical experienced space may be very different or even contrary to the mathematical and geographical representation within a Cartesian coordinate system. In psychology, moreover, space is often structured with respect to different scales. Freundschuh and Egenhofer (1997), for example, distinguish between small- and large-scale spaces and Montello (1993) distinguishes four different categories of space:

- **Figural space** is defined as the space that is projectively smaller than the human body and can be directly perceived from one place without appreciable locomotion (e.g. small objects or pictures).

- **Vista space** is defined as the space that is larger than the human body but can be visually apprehended from one place without appreciable locomotion (e.g. a single room).

- **Environmental space** is defined as the space that is larger than the human body but cannot be visually apprehended without considerable locomotion (e.g. a building or a city district).

- **Geographical space** is defined as the space that is larger than the human body but cannot be apprehended directly through locomotion and has to be learned from representation such as maps (e.g. a country).

Two of the most meaningful concepts of space that are relevant for this thesis are spatial relations and landmarks. These concepts will be reviewed in the following subsections.

2.1.1 Spatial Relations

Topological relations between spatial objects are the most important kind of qualitative spatial information (Li & Liu, 2010). The region connection calculus (RCC) (Randell et al., 1992) and the intersection model (IM) (Egenhofer & Franzosa, 1991) constitute
two main models for describing spatial relations. The RCC aims to classify the topological relationship between regions and supports the definition of two spatial relation algebras, i.e. the RCC5 and the RCC8, which make a small number of topological distinctions (Cohn et al., 1997; Li & Liu, 2010). The IM describes the topological spatial relations between two subsets of a topological space based on the consideration of the intersection of the boundaries and interiors of two sets (Egenhofer & Franzosa, 1991).

These models are limited to the intersection of regions and do not further classify the relation of disconnected regions. This, however, is required for the analysis of the spatial relations between objects in graphical descriptions. A calculus for describing spatial relations that considers the relation of three points that are not necessarily connected is presented by Freksa (1992). The single cross calculus (SCC) describes the direction of a point C with respect to a point B as it is seen from point A. This results, according to Freksa, in the planar relations (0) straight-front, (1) left-front, (2) left-neutral, (3) left-back, (4) straight-back, (5) right-back, (6) right-neutral, and (7) right-front. The double cross calculus (DCC) can be seen as an extension of the SCC considering in addition the location of the point C with respect to point A as it is seen from point B. This results in an overall distinction of 13 relations (7 linear and 6 planar) and four special cases where two or three points are overlapping (see Figure 2.1) (Dylla, 2008; Freksa, 1992; Wallgrün et al., 2006).

![Double Cross Reference Frames](image)

**Figure 2.1:** The Single and Double Cross Calculus Reference Frames (Wallgrün et al., 2006).

A last calculus that will be presented here is the so called Oriented Point Relation Algebra ($OPRA_m$). It considers oriented points as the basic entities and identifies atomic relations between oriented points at different granularity levels. Mathematically the $OPRA_m$ with $m \in \mathbb{N}$ has an angular resolution of $\frac{2\pi}{2m}$ (see Figure 2.2). Lücke et al. used the $OPRA_m$ calculus to map the eight turn directions of Klippel and Montello (2007) into the $OPRA_{16}$ reference frame (see Figure 2.3) (Lücke et al., 2011; Schwering et al., 2014).

These models and calculus constitute the basis for the analysis of spatial relations in spatial descriptions which will be presented later in this thesis.
2.1.2 Landmarks

The second concept that provides an important kind of qualitative spatial information is about landmarks. There are also many different definitions, yet, contradictory definitions of the term landmark. Richter and Winter (2014) outline a summary of different definitions and conceptualizations of the term. They state that an extensional approach of forming a taxonomy or generating a database that lists all entities that belong to the category landmark is unsatisfying, can not guarantee completeness, and does not explain what a landmark is. Moreover, they state that being a landmark is not a global characteristic of an object, but a function of parameters such as the individual that perceives and memorizes an environment. They present the following intentional definition:

Landmarks are geographic objects that structure human mental representations of space. (Richter & Winter, 2014, p.7)

Moreover, landmarks stand out in the environment and form cognitive anchors, markers or reference points for orientation, wayfinding, and communication. Richter and Winter (2014) argue that landmarks emerge in the process of perceiving, learning, and memorizing an environment in a particular context and that these landmarks will be picked up in communication processes.

Landmarks can be classified by their location in spatial descriptions. Following the literature, Anacta et al. distinguish three main classes of landmarks in route descriptions (see Figure 2.4): (1) landmarks along the route (AR), (2) landmarks at decision points (DP), and (3) global landmarks (GL), which are visible or non-visible distant landmarks (Anacta, Schwering, & Li, 2014; Anacta et al., 2016). Apart from the usage in route descriptions, as described by Anacta et al., global landmarks are in general defined as landmarks that stand out in a larger environment with a function of supporting global orientation and wayfinding (Richter & Winter, 2014). Accordingly, local landmarks stand out only locally.
2.2 Cognition

2.2.1 Spatial Cognition and Spatial Knowledge

Through the perceptions of the environment people build up a mental spatial representation of the environment. These mental spatial representations are based on spatial reference frames that facilitate an unambiguous way to locate objects in space (Richter & Winter, 2014; Tversky, 1993). A reference frame is established by a datum, which is the information that is required to fix a coordinate system to an object, and defines the origin of the reference frame (Iliffe & Lott, 2008; Richter & Winter, 2014). For individuals the own body (egocentric perspective) and oriented object in the environment (allocentric perspective) can serve as origin of their mental spatial representations (Burgess, 2006; Klatzky, 1998; Richter & Winter, 2014). In contrast to absolute reference frames like the geographic reference system that uses longitude and latitude, a relative reference system requires updates when the location or direction of the origin changes. An egocentric perspective therefore requires a constant update with the movement of the individual and causes considerable cognitive costs (Richter & Winter, 2014).

Through the perception of the environment people acquire knowledge about the environment. This knowledge includes places, landmarks, path connections between places, distances, and directions between places (Ishikawa & Montello, 2006). In general, three classes of spatial knowledge are distinguished: landmark knowledge, route knowledge and survey knowledge (Werner et al., 1997). Landmark knowledge links specific landmarks to other knowledge like turn instructions at a decision points. Route knowledge consists of a series of spatial actions, which form a route from an origin to a destination, and is most frequently gained from actively exploring an environment. Survey knowledge consists of information about the topology and/or spatial constellation of an environment and enables to establish multiple relationships between various locations within an area (Kray, 2003; Werner et al., 1997).
2.2.2 Spatial Abilities and Spatial Strategies

People orient themselves in known and unknown environments and there are large differences in orientation abilities between individuals (e.g. Just & Carpenter, 1985; Kozlowski & Bryant, 1977; Malinowski & Gillespie, 2001). Moreover, people are able to rate their own orientation abilities and experiments showed that this predicts their orientation abilities surprisingly good (e.g. Münzer & Hölscher, 2011; Bryant, 1982, 1991; Kozlowski & Bryant, 1977; Montello & Pick, 1993).

Münzer and Hölscher (2011) reviewed two instruments to test the orientation ability, however, could not reproduce consistent results with respect to the dimensionality. The Sense of Direction (SOD) reflects the ability of individuals to orient themselves and navigate successfully and is rated on the Santa Barbara Sense of Direction Scale (SBSOD) (Hegarty et al., 2002). The Questionnaire spatial representation measures the preferences individuals have for specific spatial representations and is based on the distinction of Siegel and White (1975) between landmark-based, route-based and survey-based spatial representation (Münzer & Hölscher, 2011).

However, because of the inconsistent results with respect to the dimensionality, Münzer and Hölscher developed the so called “Questionnaire on Spatial Strategies” (Münzer & Hölscher, 2011). This Questionnaire considers the three strategies of Siegel and White, landmark, route, and survey strategy and, moreover, the egocentric direction strategy and the ability to use cardinal directions. It classifies the three scales “global self-confidence, related to egocentric strategies”, “survey strategy”, and “knowledge of cardinal directions”, which were evaluated as valid and reliable predictors for spatial orientation and learning (Münzer & Hölscher, 2011).

2.3 Communication Modalities

People communicate about space by externalizing mental spatial representations. Communication covers spoken and written language, as well as sketching and gesturing. All modes include the central concepts landmarks and spatial relations that were presented above (Richter & Winter, 2014). However, the process of externalizing mental spatial representations into the communication modalities involves cognitive processes which lay a filter between the mental spatial representation and the result of the externalization. This cognitive processes consist mainly of (1) invoking portions of the mental spatial representation from long-term memory into working memory and (2) mapping selected elements of the working memory into the particular communication mode (Richter & Winter, 2014). Moreover, there is no one-to-one correspondence of the working memory and the expression, but there are many possible expressions so that they do not give a direct clue on the mental spatial representations (Richter & Winter, 2014).

Throughout this thesis the two modalities, sketching and spoken or written language, are considered and referred to as the graphical (sketching) and the textual (spoken or written language) modalities. Sketches are two-dimensional pictorial representa-
tions and descriptions of spatial locations, spatial configurations, and routes. They convey a filtered, abstracted and schematized subset of a mental spatial representation and reflect cognitive distortions of mental spatial representations. In contrast to sketches, textual descriptions are linear descriptions of locations, configurations or routes (Richter & Winter, 2014). Richter and Winter state that textual descriptions will have less impact on route descriptions, as they have a linear structure as well, but a stronger impact on location and configuration descriptions because they require cognitive linearization strategies.

2.3.1 Comparing Textual and Graphical Descriptions of Space

In the 1990s Taylor and Tversky did a lot of research in the area of textual and graphical descriptions of space. In 1992 they conducted an experiment comparing descriptions and depictions of the environment. The participants studied maps and were told subsequently to draw or describe the map from memory. In fact they had to do both drawing and describing the map from memory. Taylor and Tversky investigated the influence of the expectation to draw or to describe on the recalled information. They did neither find an effect of the expectation on the overall memory, nor did the order of describing and drawing influence the memory of the map. Moreover, Taylor and Tversky recorded the recall order of the landmarks in the descriptions and depictions and found a considerable order of the landmarks in the maps within and across subjects and within and across tasks (Taylor & Tversky, 1992a). Richter and Winter (2014) state that the first process in the externalization of mental spatial representations is the selection, aggregation, and abstraction of mental spatial representations. The second process is the transformation of the information into the communication modes. This suggests reasons for the results of Taylor and Tversky, as the second process of transformation into communication modes is based on the selection, aggregation, and abstraction of mental spatial representations and therefore results in a considerable order.

Richter and Winter, furthermore, affirm the distinction between place descriptions and route descriptions. Place descriptions answer the where questions for objects or a configuration of objects (Richter & Winter, 2014; Shanon, 1979). Route descriptions are guiding through an environment or to a particular destination (Klein, 1979). Emmorey et al. (2000) add a third type, which is the description of a whole environment and Richter and Winter (2014) distinguish between complex place descriptions and basic place descriptions. This will be called region description. Richter and Winter refer to this as more complex place descriptions.

Schwering et al. (2013) collected textual and graphical route descriptions from participants and found that people include local landmarks at decision points and along the route as most common type of landmarks, which is also mentioned by others (e.g. Denis et al., 1999; Michon & Denis, 2001; Tversky & Lee, 1998). Moreover, participants include global landmarks along a route in both graphical and textual descriptions (Schwering et al., 2013).
2.3.2 Reference Frames and Perspectives of Spatial Descriptions

In order to describe a spatial environment, people must take a perspective on it. In the literature three kinds of reference frames as well as three kinds of perspectives are distinguished for textual spatial descriptions. Referencing previous research (e.g. Levinson, 1996; Buhler, 1982; Carlson-Radvansky & Irwin, 1994; Levelt, 1984, 1989) Taylor and Tversky (1996) summarize the three reference frames as follows:

1. The relative reference uses one of the participants as the origin of the coordinate system and describes the locations of an object in relation to that individual’s front, back, left and right, with respect to some other object in the scene.
2. The intrinsic reference frame uses a specific object as origin of the coordinate system and describes the location of the other objects in relation to the objects intrinsic front, back, left, right, top and bottom. In this case, the origin could also be a person, which will later be seen in route descriptions.
3. The extrinsic or absolute reference frame uses an origin of the coordinate system that is external to the scene and most commonly describes the location of objects in relation to the cardinal directions north, south, east and west (Levinson, 1996; Taylor & Tversky, 1996).

<table>
<thead>
<tr>
<th>Properties</th>
<th>Gaze</th>
<th>Route</th>
<th>Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewpoint</td>
<td>fixed, external</td>
<td>changing, internal</td>
<td>fixed, external</td>
</tr>
<tr>
<td>Verbs</td>
<td>stative</td>
<td>active</td>
<td>stative</td>
</tr>
<tr>
<td>Referent</td>
<td>object (or person)</td>
<td>person</td>
<td>object</td>
</tr>
<tr>
<td>Terms of reference</td>
<td>LRFB</td>
<td>LRFB</td>
<td>NSEW</td>
</tr>
<tr>
<td>Frame of reference</td>
<td>relative</td>
<td>intrinsic</td>
<td>intrinsic</td>
</tr>
<tr>
<td>World analog</td>
<td>View entire scene from fixed point, horizontally displaced</td>
<td>View while exploring</td>
<td>View entire scene from fixed point, vertically displaced (map)</td>
</tr>
</tbody>
</table>

**Table 2.1:** Properties of Types of Description Perspectives (Taylor & Tversky, 1996).

Based on their findings Taylor and Tversky suggest the distinction of three perspectives of describing environments that are related to the three reference frames and reflect a natural way of experiencing and describing an environment (see Table 2.1):

1. The gaze perspective takes a stationary viewpoint outside the environment from which the entire scene can be viewed and applies the relative reference frame for the description.
2. The description in the route perspective corresponds to the intrinsic frame of reference and describes the scene from a changing viewpoint within the environment analogous to viewing an environment by exploration.
3. The survey perspective describes an environment from a fixed external viewpoint and corresponds to the extrinsic reference frame. It is analogous to the descriptions from the birds-eye-view (Ehrich & Koster, 1983; Levelt, 1982; Taylor & Tversky, 1996).

Studying different environments, Taylor and Tversky discuss that different characteristics of the environment affect the selection of perspectives. Two of these characteristics are the number of paths through the environment and the sizes of the environment.
(Taylor & Tversky, 1996). Moreover, Taylor and Tversky showed that people mix perspectives and in a later study they investigated why people mix perspectives in textual descriptions of the environment about half the time (Taylor & Tversky, 1996; Tversky et al., 1999). They outline that there are cognitive costs related to the descriptions for both retaining a perspective and switching perspective. Parameters of the descriptions that are related to the cognitive costs and may change when the perspective changes are the referent object, the viewpoint and the terms of reference. Possible reasons for mixing perspective might be that at some point the costs for retaining perspective might not be higher than changing perspective and switching perspective may be more effective in communication than not switching perspective (Tversky et al., 1999). Another reason for switching perspective is that people perceive and represent the environment from multiple perspectives simultaneously. However, when environments are well-learned and presumable abstracted into a perspective-free representation, cognitive costs of switching perspectives disappear (Tversky et al., 1999; Vasardani et al., 2013).

2.4 Analysis

2.4.1 Analyzing Textual Descriptions

Zlatev (2007) provides a core overview of cognitive linguistics research in spatial semantics. He mentions seven spatial concepts that are present in almost all descriptions of spatial semantics: Trajector, Landmark, Frame of Reference, Region, Path, Direction, and Motion. Vasardani et al. (2013) uses a natural language parser to label natural language sentences to a spatial role set that consists of a subset of Zlatev’s semantic concepts. This approach can be used in combination with the annotation scheme of Kordjamshidi et al. (2011) to extract the two major components of spatial descriptions, landmarks and spatial relations, out of textual descriptions of an environment.

Another approach for analyzing textual descriptions is given by Denis (1997). He presented a general framework for analyzing textual descriptions of routes. According to Denis the two major components of textual route descriptions are referring to landmarks and prescribing actions. The framework, Denis suggests, consists of three main steps:

1. **Generating propositional expressions**: The propositions are minimal information units combining a predicate and one or two arguments. This step transforms the data of textual descriptions into a standardized representation.

2. **Classifying items**: The propositional expressions are classified in a second step into five classes: (Class 1) prescription of actions without referring to any landmark, (Class 2) prescriptions of actions with reference to a landmark, (Class 3) reference to a landmark without referring to an associated action, (Class 4) description of landmarks, and (Class 5) commentaries.
3. **Building mega-descriptions:** In a last step of Denis’ framework, reduced versions of the descriptions are generated which are expected to contain only essential prescriptions and landmarks in order to follow the route.

Denis’ framework can be used for the deconstruction of spatial descriptions. Stopping at the second step, the two major components, landmarks and spatial relations can be extracted. Items classified as Class 2 and Class 3 contain all the landmarks in the textual description. Items classified as Class 1, Class 2, and Class 5 contain all explicitly mentioned spatial relations in the textual descriptions.

### 2.4.2 Analyzing Graphical Descriptions

Sketch maps are externalizations of mental spatial representations that conceptualize reality and omit, regularize, and exaggerate information and use inconsistent scale (e.g. Lloyd & Heivlyt, 1987; Tversky, 1999; Schwering et al., 2014). According to Schwering et al. (2014) this leads to different kinds of errors: distance estimation errors, direction estimation errors, errors that occur due to schematization, and other notable errors which might be errors of quantity, shape, size, angles and perspective.

As for the textual descriptions, the focus in the analysis of graphical descriptions will lie on the landmarks and the spatial relations. In contrast to textual descriptions the landmarks can be directly extracted from the sketches. Extracting the relevant spatial relations, however, is not obvious, as according to Tobler everything is related to everything else (Tobler, 1970), which means for graphical descriptions that all landmarks are related to one another. However, not all spatial relations between landmarks are equally relevant and closer landmarks will be stronger related than distant landmarks. This argument will have an impact on the analysis of the spatial relations in the graphical descriptions that will be presented in the next section.
3 Methods

This section presents the methodology that is proposed to test the hypothesis and answer the research questions. It provides the reasoning for the type of the experiment, the description of the testable parameters, and the description of the experiment.

As a central part of the methodology an experiment is designed that will collect spatial descriptions. This will be statistically analyzed in order to proof the hypothesis and answer the research questions. The hypothesis mentions on the one hand three dimensions of spatial descriptions, on the other hand two modalities. For each dimension of spatial descriptions, place, route and region description, two spatial descriptions, one textual and one graphical description, will be collected from the same group of participant. The collection of the descriptions from the same group of participants enables the direct comparison of the textual and the graphical descriptions within the selected dimensions. However, the order of the descriptions might have an effect on the results. Giving two descriptions for the same task might lead participants to describe what they previously sketched or sketch what they previously described. Within this setup, this effect can not be eliminated, however, the effect on the statistical results can be eliminated by randomizing the order of the descriptions.

Additionally there are two possible ways for collecting spatial descriptions within the different dimensions of spatial descriptions. On the one hand these descriptions can be collected from different participants, which would require a larger number of participants. On the other hand all descriptions can be collected from the same group of participant which would reduce the required number of participants but lead to a possible effect from the descriptions within one dimension on the descriptions of the other dimensions of spatial descriptions. However, in the same way as mentioned before, a randomization of the order will eliminate the effect on the statistical results. Moreover, there will be no direct statistical comparison between the descriptions of different spatial dimensions, but only a comparative discussion of the results from within the dimensions of spatial dimensions.

In contrast to the experiments of Taylor and Tversky (1992a), where participants studied maps and recalled the maps in spatial descriptions, this research will collect textual and graphical descriptions from participants by asking them to recall the information from memory only. Besides the investigation of the differences between the textual and the graphical modality an analysis of the description perspectives will be applied to the textual descriptions. This will investigate the perspectives the participants take within the different dimensions of spatial descriptions.

3.1 Dimensions of Spatial Descriptions

The distinction between the three dimensions of spatial descriptions - place, route, and region descriptions - is reasoned in the following. As shown in the previous section, there are different definitions and categorizations of space. A clear categorization is challenging because different disciplines have a different understanding of the term.
and there are often no clear boundaries between the classes (e.g. Montello, 1993). A categorization of different dimensions of spatial descriptions might therefore not be universal, but is defined for the scope of this thesis as follows:

1. A route descriptions is sequential and focusses on the guidance through the environment or to a particular destination (Shanon, 1979). In this sense, it can be clearly distinguished from the other two categories of descriptions. Within the textual modality the default perspective for route descriptions is the route perspective (see the properties of a route description in Table 2.1).

The difference between a place and a region descriptions is not that obvious and the first question that arises is if place and region descriptions differ only in their scale. It can be argued that a point is just a small region but it can be argued that a place is just a small region and therefore place descriptions and region descriptions differ only in their scale. But in the same sense as the distinction between places and regions is valid and there is not only a conceptual difference in the scale, the distinction between place descriptions and region descriptions is valid.

2. Place descriptions, in this sense, do not intend to describe the spatial configurations of an environment but support the localization of objects in the environment and identify locations. This might simply be the place where the keys have been left, the place where to meet in the evening, or the place where an emergency happened (Richter & Winter, 2014). Place descriptions are centered to one point which is the location of the particular object or a point of interest. In case of an emergency it might mean to describe the visual surroundings of the particular place or to describe the location in relation to nearby global landmarks. The intention of a place description is always the identification of a particular location.

3. Region descriptions, in contrast to place descriptions (and route descriptions), describe a larger environment by describing the location and configuration of several objects (Emmorey et al., 2000; Taylor & Tversky, 1992b). One way of describing a region is the description within the survey perspective (see Table 2.1). Another possible way of describing a region is by describing one or more routes through the environment or even a circuit. The intention of a region description is, in this sense, not to answer a single where question but to answer the where question for several objects and locations and to answer the how question - “how is the environment structured?”

3.2 Parameters of the Experiment and Analysis

As stated in the research questions the three main aspects in the analysis of the spatial descriptions will be the landmarks, the correctness of the information, and the richness of the information. The detailed parameters will be presented in the following, aiming to provide all necessary information for an external reproduction of the experiment and its statistical analysis.
3.2.1 Landmarks and Spatial Relations

In Section 2.4.1 two approaches that can be used to extract the explicitly mentioned landmarks and spatial relations out of textual descriptions were presented. Both approaches are reviewed in more detail by applying it to a few textual place, route and region descriptions. This is done in order to evaluate the usefulness of the two approaches for the scope of the thesis. As the approach of Denis (1997) is only suited for textual route descriptions, it is applied to the route descriptions. The approach presented by Vasardani et al. (2013) in combination with the annotation scheme of Kordjamshidi et al. (2011) is applied to the place and region descriptions.

Both methods deconstruct the spatial descriptions and result in a list of the explicitly mentioned landmarks and spatial relations, but are both found to be quite time demanding. Another approach, which is the direct extraction of the landmarks and the spatial relations from the spatial descriptions, is evaluated and the results are compared to the previous results. As there are no differences found in the results and the direct extraction is found to be more time-efficient, it is decided that the necessary information will be extracted directly from the spatial descriptions. Ambiguous and questionable parts, however, will be verified with the two previously presented methods.

Extracting the landmarks out of the graphical descriptions will be performed directly as well. It is noted at this point that streets and intersections are not treated as landmarks, but lights and crosswalks are. As already mentioned above, extracting the spatial relations out of graphical descriptions is challenging because by default every landmark will more or less be related to every other landmark. The parameter for the extraction of the spatial relations in the graphical description is set as follows:

1. For route descriptions the relevant spatial relations for the analysis will be the temporal order of the landmarks along the route, and the direction of the landmarks with respect to the route. The temporal order is the sequence of the landmarks along the route, starting from the origin. This information is directly comparable to the textual route descriptions, as they present a sequence of the landmarks along the route through the linearity of the description. The direction of the landmarks along the route will be evaluated by applying an abstraction of the \( OPR\mathcal{A}_{10} \) (Figure 2.3) (Lücke et al., 2011). The three planar categories half left, left, and sharp left are summarized to the direction left and the categories half right, right, and sharp right to the direction right. This is done because for example the direction of a landmark that is to the right of the route will be sequentially true for all three categories - half right, right, and sharp right. Therefore the shortest euclidean distance of the landmark towards the route is selected and evaluated to be front, back, left or right. The oriented points with respect to the \( OPR\mathcal{A} \) calculus is in the first part the imaginary route follower, who is oriented with respect to the route. The direction is as well directly comparable between textual and graphical descriptions because textual descriptions provide the same kind of direction information for the landmarks, although not necessarily for all landmarks.

2. For place and region descriptions the selection of spatial relations is different
because they are not sequential as the route descriptions are. There is, however, the possibility to describe a place or region sequentially in the textual descriptions, but this does not ensure the comparability between the textual and graphical descriptions. Therefore a different approach for the analysis of place and region descriptions will be utilized.

For regional landmarks that are closed and define an inside and an outside, which is for example true for the Promenade in the city of Münster, the RCC5 calculus is selected for the evaluation (see Figure 3.1) (Cohn et al., 1997; Li & Liu, 2010). For point landmarks that do not define an inside and an outside it is chosen to evaluate the relation of one landmark with respect to its two nearest landmarks by applying the Double Cross Calculus (Figure 2.1) (Wallgrün et al., 2006). Depending on the perspective of the descriptions, the spatial relations will additionally be evaluated with respect to the previously described abstraction of the OPRA calculus. The requirement for this is the reference in terms of LRFB (left, right, front, back) directions towards an oriented object with a defined intrinsic frame of reference (Figure 2.1).

For each landmark a distance information will be calculated. For the place descriptions the distance will be the euclidean distance from the landmarks to the location of the requested place. For the route descriptions the distance will be the shortest orthogonal distance of the landmarks towards the route. For the region descriptions the distance will be the euclidean distance of the landmarks towards the center of the requested region.

The parameter for the analysis will first be basically the number and the proportion of the landmarks per participant. It will be investigated how it differs within the three dimensions of spatial descriptions between the textual and the graphical modality. Secondly, the distance of landmarks will be analyzed. For route descriptions it will be distinguished between landmarks that are located at the route and landmarks that are distant to the route. The proportions of these landmarks will be analyzed between the textual and the graphical descriptions. For place and region descriptions a first step will group the closest 90% of the landmarks and the 10% of the landmarks that lie outside this distance. This step will account for the consideration of extreme values in the distances. A second step will compare the mean distances between the textual and the graphical descriptions of these groups and enable to answer the question if peo-
people make differences in the distances of landmarks they include in the descriptions of the different modalities. For place descriptions, moreover, each landmark will be categorized to lie within the vista space or outside the vista space (Montello, 1993). As Montello speaks of “without appreciable locomotion”, a radius of 20 meters in reality is choosen. A landmark is considered to lie within the vista space if in reality there is a line of sight from the particular place with a radius of 20 meters around it to the landmark. Based on this information it can additionally be investigated for place descriptions if there are differences not only in the radius of the landmarks but also with respect to Montellos categorization of vista space.

3.2.2 Correctness

The investigation of the correctness is a step that relies on the extracted landmarks and spatial relations. As for the previous parameters it will be investigated if there are differences within the three dimensions of spatial descriptions between the textual and the graphical modality. Investigating the correctness of spatial information, and in this case between two different modalities, requires an error scoring scheme that applies to the descriptions of both modalities. In the following an error scoring scheme is presented that will add up the errors of the spatial descriptions and will provide the basis of the statistical analysis of the correctness of the spatial descriptions. Each error is rated with a value of one.

The first type of error that possibly occurs in all three dimensions and two modes of spatial descriptions, is an error in the name of a landmark. This error might appear as non-existing landmark, where participants mention a landmark that does not exist, or wrong landmark, where participants refer to a landmark that exists somewhere else. This is the only error that considers solely the landmarks. All other errors will be related to the landmarks and its spatial relations.

In the route descriptions two possible errors might occur which are errors with respect to the previously described parameters temporal order and direction. For the temporal order one error is scored for every misplaced landmark with respect to its previous landmark. The detailed procedure for scoring the spatial description in terms of the temporal order of the landmarks looks as follows:

```plaintext
1: procedure COUNTERRORS(Landmarks)
2:  e ← 0  ▷ Number of errors
3:  for i ← 1, length(Landmarks) do ▷ For every Landmark
4:      if before(Landmarks[i],Landmarks[i − 1]) then
5:         e ← e + 1
6:      moveLandmarkToCorrectPosition()
7:  return e
```

The `moveLandmarkToCorrectPosition()` is a function that can be imagined to toggle down the landmark to the correct position and, thereby, it does not influence the indexes of the for-loop.
For the direction of the landmarks with respect to the route one error is scored for every wrong direction compared to the real world direction. For every landmark the real world direction is determined by the abstraction of the $OPRA_{16}$, as described in the previous subsection, and compared to the particular textual or graphical description. If the direction is not given, for example because it is not explicitly mentioned in the textual description, it is marked as missing.

For place and region descriptions the scoring of errors is again different from the route descriptions, but still consistent within the particular category. In the previous subsection the extraction of the spatial relations from place and route descriptions was already outlined. This spatial relation will in general be compared with the real world relations and errors will be scored for deviations to the textual and graphical descriptions. The following procedures are implemented for the scoring:

1. For every regional landmark in the descriptions calculate the RCC5 relation to every point landmark. Compare the results of the descriptions to the reality. Score one error for every deviation.
2. For every point landmark in the descriptions select its two nearest landmarks and determine the relation within the DCC. Compare the results of the descriptions to the reality. Score one error for every deviation.

Table 3.1 summarizes the error scoring scheme for the three dimensions of spatial descriptions.

<table>
<thead>
<tr>
<th>Error Category</th>
<th>Error Description</th>
</tr>
</thead>
</table>
| Place Landmark | • Non-existing landmark  
|               | • Wrong landmark   |
| RCC5          | • Deviation in region connection between description and reality |
| DCC           | • Deviation in double cross direction between description and reality |
| Route Landmark| • Non-existing landmark  
|               | • Wrong landmark   |
| Temporal Order| • Wrong order of landmarks along the route |
| Abstraction of $OPRA_{16}$ Direction | • Wrong direction of landmarks with respect to route |
| Region Landmark| • Non-existing landmark  
|               | • Wrong landmark   |
| RCC5          | • Deviation in region connection between description and reality |
| DCC           | • Deviation in double cross direction between description and reality |

Table 3.1: Error Scoring Scheme for the Analysis of Spatial Descriptions.
3.2.3 Richness

Two concepts will be distinguished here: the richness of descriptions and the quality of a description. The richness of a description does not directly reveal something about the quality of the description (Richter & Winter, 2014). The richness, as it is defined and used here, is only a measure of the information content of the descriptions, whereas the quality would measure the quality of the information content. A less rich description, in this case, can be qualitatively better than a richer one because a very rich description might appear cluttered, whereas a less rich descriptions might lead to better navigation performance. Others have already investigated parameters that can be used to analyze the quality of spatial descriptions. Daniel et al. (2003) suggests that the effectiveness of route directions depend on their ability to connect actions to landmarks. However, for the scope of this thesis, the richness of the spatial descriptions will be investigated and it is chosen to measure the content by the number and proportion of landmarks in combination with the spatial relations.

The analysis of the richness of the spatial descriptions, as it is proposed here, will rely on the extracted landmarks and spatial relations from Section 3.2.1. (1) As already outlined, for route descriptions all landmarks will be noted and for each participant the proportion of landmarks in the text and in the sketch will be calculated, once with respect to all landmarks the participant mentioned itself and once with respect to all landmarks mentioned by all participants. Subsequently for every landmarks it will be noted if the temporal order and the direction is missing, correct or incorrect. First it will be distinguished if the temporal order and direction exists or is missing. Secondly for all existing spatial relations it will be evaluated if the relation is correct or incorrect. Again the proportions will be calculated. The proportion of landmarks alongside with the proportion of the existing or missing relations will be used to analyze the richness of the particular description and make a comparison between the textual and graphical descriptions.

(2) For place and region descriptions the number and proportions of the landmarks will be calculated as outlined for the route descriptions. However, an analysis of the spatial relations, as it will be performed for the route descriptions, is not possible because without further investigation of the textual descriptions only the explicitly mentioned relations can be analyzed. Therefore, there is no direct comparison of all spatial relations between the textual and graphical descriptions. The saying "a picture is worth a thousand words" only indicates the obvious fact that the graphical descriptions will by default provide information which textual descriptions will not or hardly provide and that in this sense the graphical descriptions will by default be richer than the textual descriptions. However, it was shown that textual descriptions contain spatial information and spatial relations which are not explicitly mentioned in the description, but can be inferred from the context or medium (Klein, 1979; Tversky & Lee, 1998). This information are not contained in the extracted spatial relations from Section 3.2.1. Tversky and Lee (1998) proposed two rules that can be used to recover the missing information (continuity and forward progression) which, however, only apply to route descriptions.
and not to place and region descriptions.

On the basis of this reasoning it is decided to concentrate on the explicitly mentioned spatial relation in the textual descriptions and evaluated in how far they exist in the graphical descriptions. This analysis allows no direct inferences about the richness of the information in the textual and the graphical place and region descriptions, however, allows a discussion about the spatial relations in the textual descriptions.

3.2.4 Perspective

The perspectives of the spatial descriptions are not mentioned in the hypothesis and research questions, but the Section 2.3.2 showed that it is an important parameter, especially of textual descriptions. Table 2.1 shows a summary and distinction of the description perspectives for textual descriptions. Although there might be different perspectives for graphical descriptions, there is no such distinction as for textual descriptions (Tversky et al., 1999). Considering the perspectives, graphical descriptions do not allow the same properties as textual descriptions, i.e. viewpoint, verbs, referent, frame of reference (see Table 2.1). Therefore a direct comparison of the perspectives between the textual and graphical modalities will not be possible.

However, it is worth analyzing the perspectives of the textual descriptions and compare them to the results of Tversky et al., who reported a mix of perspectives. Moreover, the perspectives parameter reveals structural differences between the two modalities that have an impact on the information that is conveyed within these modalities. This will be discussed in Section 5.

3.3 Experiment

3.3.1 Participants

A total of 30 people (13 male, 17 female) participated in the experiment. All participants were native German speakers between 20 and 30 years (M = 24.07, SD = 2.36). The participants were required to have lived in the city of Münster for at least six months. This was chosen in order to ensure the familiarity of the participants with the layout of the city. However, the self-assessed familiarity was queried in the experiment. All participants had lived for at least nine month in the city of Münster. One participant lived there for a year, and moved to a neighboring city, but was still studying in Münster. Most of the participants were students from various disciplines. They received 10 € allowance for their participation.

3.3.2 Design and Procedure

The experiment setup was a simple experiment room where only the participant and the experimenter were present. The experiment was designed to last for approximately one hour. After signing a consent form, participants were handed out the experiment material, consisting of three parts (see Appendix A). Part 1 asked the participants
some general questions, in part 2 participants gave in total six spatial descriptions, and in part 3 they answered the Questionnaire Spatial Strategies (see Münzer & Hölscher, 2011). During the experiment there was no further interaction between participants and experimenter, but the participants were provided with all necessary information and questions by the experiment material.

The aim in the first part of the experiment was to get some general information about the familiarity of the participants with the city and their predominant means of transport. The order of the questions for the spatial descriptions in the second part were randomized in two ways. At first the order of the dimensions place, route, and region was randomized and secondly within the three dimensions the order of the textual and the graphical description was randomized. Although participants were told to solve each task independently, the randomization avoids effects on the statistical results that are due to the order of tasks.

As it can be seen in the Appendix A, for each spatial description the participants were provided with a short explanation, some context, and the task. Additionally each task was restricted to a maximum of one page for the textual description, approximately one page for the graphical description and a time limit of five minutes per task. However, the actual time was not monitored, but the limit was provided as an orientation for the participant to estimate the required level of detail for the descriptions.

As already mentioned above, the study area was the medium-sized city Münster in the northwest of Germany (Anacta et al., 2016), which all participants were familiar with. For the place descriptions, textually as well as graphically, participants were asked to give a place description answering the where questions. Telling the participant to imagine standing at a certain location in the city, however, is a place description in itself. Thus the way of imaginary locating the participant at that particular location in the city had to be excluded from the possible answers of the participants. Therefore one of the most prominent points in the city, the Lambertikirche, was chosen, which could simply be referred to by its name. The participants then were asked to provide a description for a person that did not know this particular landmark but everything else. In this part it was expected that the participants would give spatial descriptions that are more or less restricted to the vista space and are centered to the particular location of the Lambertikirche and would not have a large two-dimensional extend.

For the route descriptions the participants were provided with the context of a bike as means of transport and were asked to provide a route descriptions between two prominent global landmarks in Münster which are the main train station (Hauptbahnhof) and the castle (Schloss). The bike is one of the main means of transport in Münster and the infrastructure is reasonably good developed. Geographically the Hauptbahnhof and the Schloss are on opposing sides of the inner city, which itself is surrounded by a promenade. The promenade represents the location of the former city wall and is a global landmark with a regional structure. For the route descriptions linear descriptions of the route from the Hauptbahnhof to the Schloss were expected. Because of the linear structure of both the route and the textual descriptions, it was expected that
the textual descriptions would be better suited for this type of description and therefore perform better in the analysis of correctness and richness. It was furthermore expected that the participants would not only include landmarks along the route but also include spatial information distant to the route that support the global orientation (Schwering et al., 2013).

For the *region descriptions* participants were provided with the context to imagine a friend visiting Münster and asking for a spatial descriptions of the city, once textually and once graphically. It was expected that participants would give descriptions with a larger two-dimensional extend and that graphical descriptions would be better suited for this kind of descriptions because of the two-dimensional layout, which is equivalent in graphical descriptions and space.
4 Results

The methodology, as described in the previous section, was divided into four main subsections: (1) the landmarks and the spatial relations, (2) the correctness of the spatial information, (3) the richness of the spatial information and (4) the perspective in the textual descriptions. This division was made in order to meet the hypothesis and the research questions, which are to analyze the differences between the textual and graphical descriptions in terms of the landmarks, the correctness and the richness of the spatial information. Another crucial part of the textual descriptions, which was not included in the research questions but was found to be relevant for the thesis, is the perspective of the descriptions. Although there is no direct comparison between the textual and the graphical descriptions in this part, it will be included in the analysis and discussion.

As a main part, an experiment was conducted to collect textual and graphical descriptions for the statistical analysis. This section presents the results of the experiment and of the evaluation. The statistical evaluation was performed to meet the hypothesis and research questions as well as the methodology. Therefore this section mostly preserves the structure of the previous section.

4.1 General Analysis

As already mentioned, 30 people, mostly students from different departments, participated in the experiment. All participants completed the experiment successfully and no data had to be excluded from the analysis. All participants were familiar with the area of interest, which was a requirement for the participation. In the first part of the experiment, where the participants answered general questions (see Appendix A), participants were explicitly asked to rate their familiarity with the area of interest, which was the inner city of Münster. Table 4.1 shows that almost three-fourths of the participants rated their familiarity as good and no participants as bad. Moreover, participants reported on the frequency of their means of transport, which shows that the participants most frequently used the bike or afoot as means of transport (Table 4.1).

<table>
<thead>
<tr>
<th>Familiarity</th>
<th>Car</th>
<th>Bike</th>
<th>Bus</th>
<th>Afoot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>daily</td>
<td></td>
<td></td>
</tr>
<tr>
<td>very good</td>
<td>16.67</td>
<td>0</td>
<td>66.67</td>
<td>6.67</td>
</tr>
<tr>
<td>good</td>
<td>73.33</td>
<td>0</td>
<td>23.33</td>
<td>10</td>
</tr>
<tr>
<td>not so good</td>
<td>10</td>
<td>6.67</td>
<td>10</td>
<td>33.33</td>
</tr>
<tr>
<td>bad</td>
<td>0</td>
<td>93.33</td>
<td>0</td>
<td>50</td>
</tr>
</tbody>
</table>

Table 4.1: Familiarity and Means of Transport.
4.2 Landmarks

The first part of the analysis considers the number and the proportions of the landmarks in the textual and graphical descriptions. Table 4.2 shows the average number of landmarks for the three dimensions of spatial descriptions and the two modalities. The first two columns show the number of landmarks for the particular modalities, whereas the third column shows the results for the aggregated number of landmarks for the textual and the graphical descriptions. The values in the third column are obviously higher than the values in the first two columns. The results are visualized in Figure 4.1. It can be seen that the largest difference between the modalities is in the place descriptions. Moreover, it can be seen that in average there are more landmarks in the region descriptions than in the place and route description. Comparing Table 4.2 and Figure 4.1 it is noted that the table shows the mean values for the data, whereas the plot shows among others the median value.

<table>
<thead>
<tr>
<th></th>
<th>Text</th>
<th>Sketch</th>
<th>Text+Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>M(SD)</td>
</tr>
<tr>
<td>Place</td>
<td>5.83(2.46)</td>
<td>7.1(3.07)</td>
<td>9.47(3.77)</td>
</tr>
<tr>
<td>Route</td>
<td>6.63(2.94)</td>
<td>6.67(1.99)</td>
<td>8.77(3.15)</td>
</tr>
<tr>
<td>Region</td>
<td>12.23(3.6)</td>
<td>12.13(4.22)</td>
<td>16.47(5.18)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Text</th>
<th>Sketch</th>
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<tr>
<td>Region</td>
<td>12.23(3.6)</td>
<td>12.13(4.22)</td>
<td>16.47(5.18)</td>
</tr>
</tbody>
</table>

Table 4.2: Number of Landmarks.

The number of landmarks was further investigated by subdividing the groups by the self-rated familiarity of the participants. The plotted results can be seen in Appendix B in Figures B.1 to B.3. Although partly differences occur between related textual and graphical descriptions, these are not very expressive because of small sample sizes. The difference between the textual and graphical place description in the "not so good"
familiarity group, for example, is based on the results of three participants \( t(4) = -3.78, \ p = 0.02 \).

Additionally the proportions of landmarks were calculated, once with respect to the sum of landmarks per participant within the three dimensions and once with respect to the sum of all landmarks given by all participants within the three dimension of spatial description. The average number of landmarks per participant is equivalent to the numbers in third column of Table 4.2. The sums of all distinct landmarks for all participants within the three dimensions are place = 86, route = 74, region = 129. The proportions can be seen in Table 4.3.

In order to compare the number and proportions of landmarks within the three dimensions of descriptions between the textual and the graphical mode, two-sample t-tests were conducted for the particular categories. This method was chosen to test if the mean values of the textual and graphical descriptions are equal or not. Considering the numbers of landmarks (see Table 4.2) the statistical tests do not provide evidence for a significant difference between the textual and the graphical modality within the route and the region descriptions (Route: \( t(51) = -0.05, \ p = 0.959 \); Region: \( t(57) = 0.1, \ p = 0.922 \)). Within the place descriptions there is no significance but a trend that there are more landmarks in the graphical descriptions (Place: \( t(55) = -1.76, \ p = 0.083 \)). Considering the proportions of landmarks (see Table 4.3), this difference becomes clearer as there are proportionally, with respect to the sum of landmarks per participant, significantly more landmarks in the graphical descriptions (t(58) = -2.53, p = 0.01). For route and region descriptions there is no statistical evidence for differences in the proportions (Route: \( t(55) = -0.74, \ p = 0.46 \); Region: \( t(58) = 0.64, \ p = 0.52 \)).

![Table 4.3: Proportions of Landmarks.](image)

### 4.2.1 Distances

As outlined in the methodology, the distances are calculated differently for the route descriptions and the place and region descriptions. For route descriptions a distinction is made between landmarks that are located at the route (near landmarks) and landmarks that are distant to the route (distant landmarks). In average participants mentioned 83.46% (SD = 15.25) near landmarks and 16.54% (SD = 15.25) distant landmarks. For each category a further distinction is made between the landmarks in
the two modalities (see Figure B.4).

A two-sample t-test was conducted to compare the number of near landmarks in textual and graphical descriptions. The tests shows that there are no significant differences in the numbers of landmarks for the textual (M = 6.03, SD = 3.09) and the graphical (M = 5.43, SD = 1.76) descriptions: t(46) = 0.92, p = 0.36. Another two-sample t-test was conducted to compare the number of distant landmarks in textual and graphical descriptions. This test as well shows that there are no significant differences in the numbers of landmarks for the textual (M = 1.5, SD = 0.67) and the graphical (M = 1.95, SD = 1.35) descriptions: t(28) = -1.22, p = 0.23. A two-sample t-test to compare the proportion of near landmarks in the textual and the graphical descriptions, with respect to the total number of near landmarks per participant, resulted in no significant difference in the proportions for textual (M = 81.67, SD = 16.44) and graphical (M = 78.31, SD = 16) descriptions: t(58) = 0.8, p = 0.427. A two-sample t-test to compare the proportion of distant landmarks in textual and graphical descriptions, with respect to the total number of distant landmarks per participant, resulted in a significant difference in the proportions for the textual (M = 43.02, SD = 45.12) and the graphical (M = 85.56, SD = 31.33) descriptions: t(36) = -3.55, p = 0.001.

<table>
<thead>
<tr>
<th>Route</th>
<th>Near M(SD)</th>
<th>Distant M(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text</td>
<td>28.71(42.75)</td>
<td>348.33(217.41)</td>
</tr>
<tr>
<td>Sketch</td>
<td>35.41(46.45)</td>
<td>236.1(208.18)</td>
</tr>
</tbody>
</table>

Table 4.4: Distances of Landmarks in Route Descriptions.

Table 4.4 shows the mean distances and distinguishes in the columns between all landmarks, near landmarks and distant landmarks and in the rows between the landmarks in textual descriptions and the landmarks in graphical descriptions. Near landmarks are marked with a zero distance, which distorts the average distance of all landmarks and makes the results for the near landmarks in the second column of Table 4.4 redundant. However, distances of the distant landmarks are most meaningful for the investigation of the distances between textual and graphical route descriptions (see Figure B.6). A two-sample t-test was conducted to compare the distances of the distant landmarks in textual (M = 348.33, SD = 217.41) and graphical descriptions (M = 236.1, SD = 208.18), but there is not a significant difference between the distances for textual and graphical descriptions (t(23) = 1.4231, p = 0.168).

For the place and region descriptions, for each participant a distinction is made between the landmarks within a distance of the nearest 90% of the landmarks and the 10% outside this distance. This accounts for the consideration of the extreme values that distorts the averages. Table 4.5 shows the means and standard deviations of the data and Figure B.5 and Figure B.7 in Appendix B visualize the distribution of the data. It can already be inferred from the plots that there are no significance distances in the landmarks distance information between the textual and graphical modes in place and region descriptions, which is confirmed by the two-sample t-test: Place within nearest
4.3 Correctness

For the investigation of the correctness an error scoring scheme was presented in the methodology section (see Table 3.1). Again the analysis for the route descriptions is different from the analysis of the place and region descriptions. For place and region descriptions the scoring scheme for the investigation of the errors is the same. For the route descriptions there were no errors recorded with respect to non-existing or wrong landmarks. However, the errors were recorded for the wrong order of landmarks along the route and the wrong direction of landmarks. This allows a comparison of the specific errors between the textual and graphical modalities. Together an average number of 1.17 errors were recorded for the textual descriptions and an average number of 1.7 errors for the graphical descriptions (see Table 4.6). A two-sample t-test was conducted to compare the number of errors with respect to the temporal order in textual and graphical descriptions. There was no significant difference in the number of errors for textual ($M = 0.63, SD = 0.96$) and the graphical ($M = 0.3, SD = 0.6$) descriptions: $t(48) = 1.61, p = 0.114$. A two-sample t-test was conducted to compare number of errors with respect to the direction in textual and graphical descriptions. There was a significant difference in the number of landmarks for textual ($M = 0.53, SD = 0.78$) and graphical ($M = 1.4, SD = 1.73$) descriptions: $t(40) = 2.5, p = 0.017$. Aggregating the errors with respect to the temporal order and the direction levels out to a non significant difference between the number of errors in the route descriptions ($t(51) = 1.23, p = 0.223$).

For place and region description errors were scored according to non-existing landmarks and wrong landmarks, the RCC5, and the DCC (see Table 3.1 and Section 3.2.2). From the values in Table 4.6 and regarding Figure 4.2, it can already

<table>
<thead>
<tr>
<th></th>
<th>M(SD)</th>
<th>In90 M(SD)</th>
<th>Out90 M(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>Text</td>
<td>223.91(167.35)</td>
<td>139.63(135.61)</td>
</tr>
<tr>
<td></td>
<td>Sketch</td>
<td>250.12(198.18)</td>
<td>189.05(168.43)</td>
</tr>
<tr>
<td>Region</td>
<td>Text</td>
<td>472.99(530.65)</td>
<td>365.26(459.45)</td>
</tr>
<tr>
<td></td>
<td>Sketch</td>
<td>488.2(324.61)</td>
<td>367.41(183.88)</td>
</tr>
</tbody>
</table>

Table 4.5: Distances of Landmarks in Place and Region Descriptions.

90%: $t(55) = -1.25, p = 0.216$; Place outside nearest 90%: $t(56) = 0.22, p = 0.83$; Region within nearest 90%: $t(38) = -0.02, p = 0.981$; Region outside nearest 90%: $t(58) = -0.22, p = 0.827$.

For place descriptions it is, moreover, investigated if the descriptions are restricted to the vista space of Montello (1993) or if they cover larger areas. For textual descriptions it was found that 10 in 30 descriptions are restricted to the vista space and 20 in 30 descriptions contain landmarks beyond the boundary of vista space. Of the graphical descriptions only 7 in 30 descriptions are restricted to the vista space and 23 in 30 descriptions cover a larger area.
been assumed that there are differences in the number of errors between the textual and graphical modalities. A two-sample t-test for each dimension confirms this assumption. In the place descriptions there is a significant difference in the number of errors for textual (M = 0.6, SD = 0.86) and the graphical (M = 1.43, SD = 1.45) modality: t(47) = -2.71, p = 0.009. In the region descriptions there is a significant difference in the number of errors for textual (M = 1.2, SD = 1.45) and the graphical (M = 2.73, SD = 1.89) modality: t(54) = -3.52, p = 8.7e-04.

Regarding the error types for the place and the region descriptions, as presented in Table 3.1, Table 4.7 shows the proportions of errors for each description. It can be clearly seen that most errors were made according to the Double Cross Calculus and least for the Region Connection Calculus. Investigating the difference between the textual descriptions shows either no significant differences or trends towards a difference: landmarks place t(14) = 0.62, p = 0.543; RCC place t(11) = 1.39, p = 0.191; DCC place t(13) = -1.46, p = 0.167; landmarks region t(18) = 1.22, p = 0.238; RCC region t(21) = 0.44, p = 0.665; DCC region t(25) = -1.606, p = 0.121.

### 4.4 Richness

The richness parameter is not as obvious as the correctness parameter and an objective result on which spatial description is richer compared to others will not be answered in this subsection. This part, however, will present the partial results that will be used in the next section to discuss the richness of the textual and the graphical descriptions. It was mentioned in the previous section that the richness is distinct from

---

**Table 4.6:** Number of Errors in Place, Route and Region Descriptions.

<table>
<thead>
<tr>
<th></th>
<th>Text $M(SD)$</th>
<th>Sketch $M(SD)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>0.6(0.86)</td>
<td>1.43(1.45)</td>
</tr>
<tr>
<td>Route</td>
<td>1.17(1.34)</td>
<td>1.7(1.95)</td>
</tr>
<tr>
<td>Region</td>
<td>1.2(1.45)</td>
<td>2.73(1.89)</td>
</tr>
</tbody>
</table>

**Table 4.7:** Proportions of Errors in Place and Region Descriptions by Error Types.
how good a spatial description is and mainly considers the landmarks and the spatial relations. It is challenging to find parameters to compare the spatial relations in textual descriptions to the spatial relations in the graphical descriptions, as in contrast to textual descriptions in spatial descriptions all objects are more or less related to each other.

A minor step towards a comparison was made by calculating the proportions of the spatial relations in graphical descriptions towards the explicitly mentioned spatial relations in the textual descriptions. In average there were 5.23 (SD = 3.08) spatial relations in the textual place descriptions, 6.5 (SD = 2.89) in the textual route descriptions and 12.07 (SD = 5.32) in the textual region descriptions. Calculating the proportions of the landmarks in the textual descriptions that were also mentioned in the graphical descriptions, revealed the following (Figure 4.3): place descriptions M = 59.11% (SD = 33.47); route descriptions M = 70.13% (SD = 26.1); region descriptions M = 65.66% (SD = 25.21).

For route descriptions, however, two parameters that contain relation information were found that enable the direct comparison of textual descriptions and graphical descriptions. The temporal order and the direction of a landmark towards the route were already used in the previous subsection to score the errors and provide results with respect to the correctness of the descriptions. Moreover, a more comprehensive analysis of the temporal order and direction information was conducted. First the proportions of the missing and the given information were calculated. Table 4.3 shows in the first column the respective proportions. A two-sample t-test was conducted to compare proportions of missing temporal order information in textual and graphical descriptions. It shows that there is no significant difference in the scores for textual (M = 25.85, SD = 19.22) and graphical (M = 22.12, SD = 14.16) descriptions: t(53) = -0.86, p = 0.395. Another two-sample t-test was conducted to compare the proportions
of missing direction information in textual and graphical descriptions. It shows that there is a significant difference in the scores for textual (M = 45.83, SD = 19.6) and graphical (M = 21.69, SD = 13.97) descriptions: $t(52) = -5.492$, $p = 1.181e^{-06}$.

For all the not missing temporal order and direction information the textual and graphical descriptions, the proportions of correct and incorrect information were calculated. The results are shown in Table 4.8 in the second and third column and sum up do 100% in the rows. Two two-sample t-test were conducted to compare the proportions of correct (or incorrect) information once with respect to the temporal order and secondly with respect to the direction. There was no significant difference found in the proportions of correct (or incorrect) temporal order information for textual (M = 92.74 (7.26), SD = 9.71) and graphical (M = 96.14 (3.85), SD = 7.63) descriptions: $t(55) = 1.51 (-1.51)$, $p = 0.137$. Moreover, there were no significant difference found in the proportions of correct (or incorrect) direction information for textual (M = 86.07 (13.93), SD = 23.28) and graphical (M = 79.39 (20.61), SD = 22.5) descriptions: $t(58) = 1.129 (-1.129)$, $p = 0.264$.

More parameters that are relevant for the discussion of the richness are the number and the proportions of the landmarks between the textual and the graphical descriptions. The results for this parameter were already presented above (see Table 4.2 and

### Table 4.8: Proportion of Missing, Correct, and Incorrect Relations in Route Descriptions

<table>
<thead>
<tr>
<th></th>
<th>Missing ($M(SD)$)</th>
<th>Correct ($M(SD)$)</th>
<th>Incorrect ($M(SD)$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TO</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text</td>
<td>25.85(19.22)</td>
<td>92.74(9.71)</td>
<td>7.26(9.71)</td>
</tr>
<tr>
<td>Sketch</td>
<td>22.12(14.16)</td>
<td>96.14(7.63)</td>
<td>3.85(7.63)</td>
</tr>
<tr>
<td><strong>D</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Text</td>
<td>45.83(19.6)</td>
<td>86.07(23.28)</td>
<td>13.93(23.28)</td>
</tr>
<tr>
<td>Sketch</td>
<td>21.69(13.97)</td>
<td>79.39(22.5)</td>
<td>20.61(22.5)</td>
</tr>
</tbody>
</table>

Figure 4.3: Proportions of Relations in Sketches.
4.5 Perspectives

Investigating the textual descriptions revealed that participants use different perspectives. For textual route descriptions participants used the route perspective consistently (see Table 4.9). More diverse are the results for the place and the region descriptions. Instead of using a consistent perspective, participants used different perspectives in the textual descriptions and even switched perspectives.

<table>
<thead>
<tr>
<th></th>
<th>gaze (16.67%)</th>
<th>route (46.47%)</th>
<th>survey (13.33%)</th>
<th>mixed (23.33%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place</td>
<td>5</td>
<td>14</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Route</td>
<td>0</td>
<td>30</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Region</td>
<td>0</td>
<td>11</td>
<td>12</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.9: Perspectives Chosen by Participants in Textual Descriptions.

In place descriptions almost half of the people chose to describe the place within the route perspective. However, these descriptions in the route perspectives are different from the route descriptions because the route descriptions generally describes just one route from an origin to a destination. The place descriptions in the route perspective, however, describes the routes from some arbitrary user-chosen origin to the destination of the particular point of the Lambertkirche. Moreover, the participants described in average 1.36 (SD = 0.74) routes instead of just one route. Considering the seven mixed perspectives of place descriptions it was found that six of these descriptions started with the survey perspective and then switched to the route perspective. One of the descriptions started with the gaze perspective and the switched to the route perspective. None of the perspectives changed from the route perspective towards other perspectives.

In region descriptions the participants used either route, survey or mixed perspectives. Approximately a third of the people applied the route perspective and a third of the people applied the survey perspective. The remaining participants mixed route and survey perspectives. For the mixed perspective it was again noted that six in seven participants started with the survey perspective and then switched to the route perspective. One participant switched from the survey perspective to the route perspective and gave a short summary in the survey description again at the end of his description. As in the place descriptions, the textual region descriptions in the route perspective were again different from the route descriptions. The participants described the region by describing several routes through the region. The descriptions consisted in average of 4.36 (SD = 2.54) branches and 0.73 (SD = 0.79) circuits.
5 Discussion

The hypothesis of this thesis is that within the three dimensions of spatial descriptions there are differences between the textual and graphical modalities. This hypothesis is tested by the investigation of the differences with respect to the landmarks, the differences in terms of the correctness of the information and differences with respect to the richness of the information. Throughout the thesis the goal is not to rate spatial descriptions for how good and helpful they are in navigation and wayfinding tasks but to test the related textual and graphical descriptions for differences. The overall answer is that with respect to all three research questions there are differences between the textual and the graphical modality. The textual and the graphical modalities are both used to externalize mental spatial representations (Richter & Winter, 2014) and previous research in this area already investigated differences between the textual and graphical modalities (e.g. Anacta, Wang, & Schwering, 2014; Taylor & Tversky, 1992a; Vasardani et al., 2013). This section reviews the results that were presented in the previous section and discuss the results and the methodology of the investigation against the background of the presented literature in Section 2.

<table>
<thead>
<tr>
<th></th>
<th>T-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of L in PL</td>
<td>t(55) = -1.76 p = 0.083</td>
</tr>
<tr>
<td>Number of L in RO</td>
<td>t(51) = -0.05 p = 0.959</td>
</tr>
<tr>
<td>Number of L in RE</td>
<td>t(57) = 0.1 p = 0.922</td>
</tr>
<tr>
<td>Proportion of L in PL</td>
<td>t(58) = -2.53 p = 0.01</td>
</tr>
<tr>
<td>Proportion of L in RO</td>
<td>t(55) = -0.74 p = 0.46</td>
</tr>
<tr>
<td>Proportion of L in RE</td>
<td>t(58) = 0.64 p = 0.52</td>
</tr>
<tr>
<td>Number near L in RO</td>
<td>t(46) = 0.92 p = 0.36</td>
</tr>
<tr>
<td>Number of distant L in RO</td>
<td>t(28) = -1.22 p = 0.23</td>
</tr>
<tr>
<td>Proportion of near L in RO</td>
<td>t(58) = 0.8 p = 0.427</td>
</tr>
<tr>
<td>Proportion of distant L in RO</td>
<td>t(36) = -3.55 p = 0.001</td>
</tr>
<tr>
<td>Distance of distant L in RO</td>
<td>t(23) = 1.4231 p = 0.168</td>
</tr>
<tr>
<td>Distant of nearest L in PL</td>
<td>t(55) = -1.25 p = 0.216</td>
</tr>
<tr>
<td>Distant of farthest L in PL</td>
<td>t(56) = 0.22 p = 0.83</td>
</tr>
<tr>
<td>Distant of nearest L in RE</td>
<td>t(38) = -0.02 p = 0.981</td>
</tr>
<tr>
<td>Distant of farthest L in RE</td>
<td>t(58) = -0.22 p = 0.827</td>
</tr>
<tr>
<td>Number of errors in PL</td>
<td>t(47) = -2.71 p = 0.009</td>
</tr>
<tr>
<td>Number of L errors in PL</td>
<td>t(14) = 0.62 p = 0.543</td>
</tr>
<tr>
<td>Number of RCC errors in PL</td>
<td>t(11) = 1.39 p = 0.191</td>
</tr>
<tr>
<td>Number of DCC errors in PL</td>
<td>t(13) = -1.46 p = 0.167</td>
</tr>
<tr>
<td>Number of errors in RO</td>
<td>t(51) = -1.23 p = 0.223</td>
</tr>
</tbody>
</table>
Number of TO errors in RO $t(48) = 1.61$ $p = 0.114$
Number of D errors in RO $t(40) = -2.5$ $p = 0.017$
Number of errors in RE $t(54) = -3.52$ $p = 8.7e-04$
Number of L errors in RE $t(18) = 1.22$ $p = 0.238$
Number of RCC errors in RE $t(21) = 0.44$ $p = 0.665$
Number of DCC errors in RE $t(25) = -1.606$ $p = 0.121$
Proportion of missing TO in RO $t(53) = -0.86$ $p = 0.395$
Proportion of missing D in RO $t(52) = -5.492$ $p = 1.181e-06$
Proportion of correct TO in RO $t(55) = 1.51$ $p = 0.137$
Proportion of correct D in RO $t(58) = 1.129$ $p = 0.264$

**Table 5.1:** Summary of the results of the two-sample t-tests (L = Landmark, PL = Place, RO = Route, RE = Region, TO = Temporal Order, D = Direction, RCC = Region Connection Calculus, DCC = Double Cross Calculus).

**Multiple Comparison Problem**

The main method for the investigation of the differences between textual and graphical descriptions was the two-sample t-test. Running multiple t-tests on the same dataset, however, invokes the problem of false positives which is described by the multiple comparison problem (Dunn, 1961; Simes, 1986). Table 5.1 shows the results of all t-tests that were run on the dataset of the experiment. The Bonferroni procedure is a way to consider the possibility of false positives by adjusting the p-value of significance by dividing the p-value of 0.05 by the number of statistical tests. This is equivalent to the R-function `p.adjust` which multiplies the p-values by the number of statistical tests and collates the results with the critical significant p-value of 0.05. In the results section 30 t-tests were performed on the dataset. Performing this p-value adjustment leads to an adjusted p-value of 0.002. Looking at the significant results, this adjustment affects the result of three statistical tests: the significant difference in the proportions of landmarks in the place descriptions between the textual and the graphical modality ($t(58) = -2.53$, $p = 0.01$), the significant difference in the number of errors in the place descriptions between the textual and the graphical modality ($t(47) = -2.71$, $p = 0.009$), and the significant difference in the number of direction errors in the route descriptions between the textual and the graphical description ($t(40) = -2.5$, $p = 0.017$). Taking the multiple comparison problem into account, these three results would not be considered as significant any more; they only show a trend towards a difference.

**Context**

The results of the general analysis showed that participants were reasonably familiar with the area of interest. Only 10% reported on a “not so good” familiarity and no participant reported on a bad familiarity with the area of interest. Analyzing the influence of the self reported familiarity on the included number of participants in the single spa-
tial descriptions did not reveal any significances. Moreover, subdividing the dataset by familiarity led to a small sample size. Because of the small proportion of participants, the impact of outliers especially in the "not so good" category is huge. An overall good familiarity with the area of research was assumed and expected for the experiment because the experiment required that the participants had been living in the city of Münster for at least half a year. Being familiar with the city, moreover, permitted the assumption that the main means of transport of the participants in the area of interest would be the bike. The results confirmed this assumption and showed that the least used means of transport in the inner city of Münster is the car.

Reviewing the contexts, which the participants were provided with for the spatial descriptions, shows that each dimension of spatial description connects to one means of transport. For the context of the place description the related means of transport is the car, as the participants must have expected the emergency responder to arrive with a car. For the route descriptions the participants were explicitly provided with the context of the bike as means of transport. It can, lastly, be assumed that the participants interpreted the context for the means of transport of the region descriptions as afoot because a lot of participants referred to it in their textual descriptions. The participants assumed their friends to arrive in Münster by train, bus, or car and explore the city afoot. Considering the assumption of the main means of transport within the city of Münster, the context within the tasks should have been considered in the experiment design. Although there is no direct statistical comparison between the different dimensions of spatial descriptions, a consistent context for the tasks in the experiment would have been a better basis for the discussion of the results.

5.1 Landmarks

The differences with respect to the landmarks in the textual and graphical descriptions were investigated by comparing the number, proportions and distances of the landmarks.

5.1.1 Number and Proportions of Landmarks

The number and proportions of the landmarks were compared for all three dimensions of spatial descriptions. The resulting statistical tests show a trend of a difference in the number of landmarks in place descriptions towards more landmarks in graphical descriptions (see Table 5.1 Number of L in PL) and a trend or even a significant difference, when not considering the multiple comparing adjustment, in the proportions of landmarks in place descriptions between the textual and the graphical modality (see Table 5.1 Proportions of L in PL). For the route and region descriptions there are no significant differences in the number and proportions of landmarks between the textual and the graphical modality.

The question that arises is, what the reasons for this difference in the place descriptions but not in the route and the region descriptions are. It was reviewed before

that the cognitive step of invoking portions of the mental spatial representations, which shall be externalized into working memory, is prior to the step of externalizing the representation into the communication modalities (Richter & Winter, 2014). Reasons for the differences are therefore likely to be found either in the mapping process or in the structure of the modalities with respect to the dimensions of spatial descriptions. As the mental spatial representations are in all three dimensions mapped into both the textual and the graphical modality the question is what invokes the particular differences between the two modalities in the place descriptions but not in the route and the region description.

The purpose of place descriptions, in contrast to the route and the region descriptions, is to answer the where question for a single object or a location (Shanon, 1979). A reason for a minor impact might be that in textual descriptions it is possible to locate an object without even mentioning the object itself because this is already mentioned in the question or the task. The instruction giver could for example ask “Where is the Lambertikirche?” and the respondent would start an answer with “It is ...” (see Klein, 1979). For graphical descriptions locating and denoting the object and location of interest is crucial. However, looking in particular at the occurrence of the Lambertikirche in the place descriptions reveals that only one in thirty participants did not include the Lambertikirche in the textual description. Therefore, although a plausible reason, this is not causally for the difference in the place descriptions. Moreover, this reasoning would apply to the route descriptions as well. In this case region descriptions are different because they are not about concrete single landmarks that are given in the instructions.

A further suggested reason for the proportionally significantly more landmarks in the graphical place descriptions is that single locations might be textually easier located unambiguously by referring to fewer landmarks than in graphical descriptions. Or, after unambiguously locating the object, an individual would stop or proceed to other tasks. Graphical descriptions could either require more landmarks for an unambiguous identification of a place or a further possibility is that individuals do not stop after unambiguously locating the particular place, but add further landmarks to support an easier identification of the location or to fill the empty spaces of the sketch. Comparing this suggestion to the more complex dimension of region descriptions indicates that the purpose of the region descriptions is to describe the configuration of the whole environment anyway, so that a possible space filling strategy does not lead to a difference compared to the textual descriptions.

Furthermore, the investigation of the distance information in the place descriptions could be raised to suggest possible reasons for the difference. It was shown that in place descriptions there are no significant differences in the distances of the landmarks between the textual and the graphical description. Only comparing the descriptions with respect to the covered areas (vista vs. more than vista) shows that slightly more graphical descriptions cover an area beyond the boundary of the vista space (20 textual and 23 graphical descriptions). The sample size of 30 participants, however, is
too small to conclude a difference, so this suggestion is rejected.

5.1.2 Distances

Route
Anacta et al. distinguish between local and global landmarks (see Figure 2.4) (Anacta, Schwering, & Li, 2014; Anacta et al., 2016). Considering the position of the landmarks in route descriptions, this classification is applied to the route descriptions. Local landmarks are considered as landmarks that are located at the route (AL and DP). Landmarks that are not located at the route are called distant landmarks and meet the definition of global landmarks (GL) of Anacta et al. (2016). For the analysis, local landmarks were marked with a default distance of zero, as they are located directly at the route. This, however, makes the calculation of the average distance of the landmarks in the route descriptions redundant because it is distorted by the zero distances of the local landmarks.

The most meaningful results in this part are the number and proportions of the local and distant landmarks and the distances of the distant landmarks. A significant difference was found for the proportion of distant landmarks between textual and graphical route descriptions (see Table 5.1 Proportion of distant L in RO). By describing routes from an origin to a destination people include significantly more distant landmarks in the graphical descriptions compared to the textual descriptions. This agrees with the results of Anacta, Wang, and Schwering (2014), who suggested the provision of a better global orientation as a reason for the participants to include distant landmarks in the route descriptions. Anacta, Wang, and Schwering, however, did not investigate the reasons for the difference between the textual and the graphical modality. A reason for the difference in the proportions of distant landmarks between textual and graphical descriptions is suggested be the two-dimensional layout of the graphical descriptions which, in contrast to the textual descriptions, might allow an easier integration of distant landmarks in the description. This might be related to the different perspectives in the two modalities. The textual route descriptions are given in the route perspective which has a changing viewpoint with respect to the changing position of the imaginative route following individual (Taylor & Tversky, 1996). Although there are structural differences between the graphical route and graphical region descriptions (see Lynch, 1960), the perspective remains the same, which can be called the survey perspective for graphical descriptions. This aims to show the environment as it is seen from a fixed point above. Moreover, the graphical modality enforces the survey perspective. The difference in the proportion of global landmarks between the textual and the graphical modality might be due to differences between the survey perspective and the route perspective, which invokes this difference. As the survey perspective shows an overview of the environment a global orientation might be more crucial or just easier to convey. This suggestion, however, requires a further investigation of the differences between the perspectives and the impact on the number, proportion, and location of the landmarks.
Place and region
For the place and region descriptions a distinction between local landmarks and global landmarks as for the route descriptions could only be partly achieved. In order to consider the outliers, for each participant and description a distinction is made between the distance of the 90% of the nearest landmarks and the 10% of the farthest landmarks. For the place descriptions a distinction is, moreover, made between the landmarks within and outside the vista space, as categorized by Montello (1993). This last parameter was already invoked above and is similar to the approach for the route descriptions. Landmarks within the vista space can be considered as local landmarks in place descriptions, and landmarks outside the boundary of the vista space can be called global landmarks that provide global orientation. Global landmarks, in this categorization, can still be subdivided into visible and not visible global landmarks (Anacta, Schwering, & Li, 2014). Visible global landmarks could for example be steeples that, although being visible, are located outside the actual vista space. The results of the investigation of the differences in the place and region descriptions were presented in the previous section and it was shown that there are no significant differences between the textual and graphical modalities. For the region descriptions a distinction between local and global landmarks could not be achieved as there is no discrete point of interest or a route that can be considered as the origin. In order to measure the spatial extend of the descriptions the distances of the landmarks were calculated towards the center of the city, which is the Dom. However, this origin does not allow a distinction between local and global landmarks for the region descriptions.

A future step for a comparability of the distance information between the three dimensions of spatial descriptions would be the definition of a distance schema that distinguishes between local and global landmarks and applies to all three dimensions of spatial descriptions. A schema like this could help to investigate the number and proportions of local and global landmarks in all three dimensions of spatial descriptions and investigate the differences between textual and graphical modalities. By now it remains untested whether similar differences would be found in the proportion of global landmarks for place and region descriptions as for the route descriptions.

5.2 Correctness
The investigation of the correctness of the spatial descriptions mainly relies on the presented errors scoring scheme and a distinction is made between place and region descriptions and route descriptions (see Table 3.1).

Route
For route descriptions errors in the textual and the graphical descriptions were scored for non-existing or wrong landmarks and spatial relation errors in terms of the temporal order and the direction of the landmarks with respect to the route. For the investigation of the errors with respect to the direction information the presented abstraction of the $OPR.A_{16}$, considering the direction front, back, left and right, was implemented
Discussion

The results section showed that, although there is no overall difference in the number of errors between the textual and the graphical route descriptions, there are significantly more errors with respect to the direction information in the graphical descriptions. Looking at the proportions of errors (TO and D) that are calculated at this point seem to confirm the difference (see Table 5.2). An assumed reason is that in graphical descriptions there are absolutely more direction information compared to the textual descriptions. This is confirmed by consulting the comparison of the proportion of missing direction information between textual and graphical descriptions. The results show that there are significantly more direction information missing in the textual descriptions (see Table 5.1 Proportion of missing D in RO). Consulting, moreover, the proportions of incorrect direction information shows that proportionally, with respect to all given direction information, there is no significant difference between the textual and the graphical descriptions ($t(58) = -1.129, p = 0.264$). This concludes to the result that there is no difference between the textual and graphical route descriptions with respect to the correctness of the information. However, there are differences in the absolute number of errors that are due to proportionally more missing direction information in the textual descriptions, which refers to the richness parameter.

### Table 5.2: Proportions of Errors in Route Descriptions.

<table>
<thead>
<tr>
<th></th>
<th>Text</th>
<th>Sketch</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO M(SD)%</td>
<td>6.3(8.74)</td>
<td>3.23(6.25)</td>
</tr>
<tr>
<td>D M(SD)%</td>
<td>6.51(10.07)</td>
<td>15.88(16.8)</td>
</tr>
</tbody>
</table>

Place and Region

Richter and Winter mention another important point about differences between textual and graphical descriptions. This does not directly relate to the correctness of the information, but shares an important point that might be casual for other differences between textual and graphical spatial descriptions.

*Human place descriptions almost exclusively use qualitative spatial or temporal relationships to link a locatum with its relatum. While graphic languages (maps, sketches) still convey some geometric meaning, verbal place descriptions would know order (“behind the library”) and even comparison (“a larger building”), but rarely metric information.* (Richter & Winter, 2014, p.93)

The investigation of the place and region descriptions showed that in both dimensions of spatial descriptions there are significantly more errors in the graphical descriptions. Breaking down the errors to their categories did not reveal any significant differences. It showed that most errors were recorded for the DCC (see Wallgrün et al., 2006). However, trends showed up in both dimensions of descriptions towards less landmark errors but more DCC errors in the textual descriptions. The least errors were recorded
for the RCC category (see Randell et al., 1992). The region connection calculus, as presented before, classifies the topological relationships between region and thereby offers a way to compare real world relations with described or sketched relations. The small number of errors induced by this calculus relates to the small number of regional landmarks that were mentioned by the participants of the experiment. The main regional landmark that appeared in the descriptions of the participant is the Promenade in Münster. Although not explicitly recorded, the participants predominantly mentioned point landmarks so that the Double Cross Calculus was applied for the investigation of the correctness.

As seen in the previous part, comparing the absolute number of errors between the textual descriptions and graphical descriptions might invoke statistical significances that are due to other differences. For the route descriptions it was about the difference in spatial relations. Although there is no comprehensive analysis of the spatial relation in the place and region descriptions, it is suggested, against the background of the previous discussion, that the differences in the number of errors between the textual and graphical descriptions are due to richer graphical descriptions in terms of spatial relations. More spatial relations invoke more possible errors. Because of missing parameters for a comprehensive comparison of the spatial relations between the textual and the graphical descriptions, the proportions towards the total number of relation can not be calculated. This will have to be further investigated in future work in order to proof the reasoning. Turning the reasoning around and assuming that there are no differences in the proportions of errors, as for the route description, permits the assertion that, because of the higher number of errors in the graphical descriptions, the graphical place and region descriptions have to be richer in terms of spatial relation information.

Restating Richter and Winter from the Related Work section suggests, however, that differences between the textual and the graphical descriptions in place and region descriptions are more likely as in route descriptions. Richter and Winter state that textual descriptions will have less impact on route descriptions, as they have a linear structure as well, but a stronger impact on place and region descriptions because they require cognitive linearization strategies (Richter & Winter, 2014).

5.3 Richness

The question about the differences in the richness of the information content between the textual and the graphical modality has revealed itself as the most challenging part of this thesis. In the scope of this thesis richness is defined as the measure of the information content but not the quality of the spatial description. Solely this definition is discussable. Information itself is distinct from data in terms of the quality of the data in a certain context. The context provides the data with a value that shapes the information. Therefore, talking about the information content involves the quality of the information. However, a very rich description that contains a lot of qualitative information can still be an inferior route description. In this sense the richness can still
be regarded as the information content or even the aggregated qualitative information content of a description. This is distinct to the quality of a spatial description with respect to a certain context, i.e. a place, a route or a region description (e.g. Denis, 1997). The qualitative information of the spatial descriptions are mainly the landmarks in combination with the spatial relations.

**Route**

An analysis of the richness in this sense has only been possible for the route descriptions by the investigation of the differences between the textual and the graphical descriptions in terms of the landmarks and the spatial relations. These two are still to be connected in a meaningful way. The analysis, as it has been performed, investigates the occurrences and the correctness of every landmark in terms of the temporal order and the direction of the landmarks with respect to the route. The temporal order and the direction are thereby considered as the spatial relations in the route descriptions. Therefore the investigation of the richness breaks down to the investigation of the proportions of the available and missing temporal order and direction information which are presented in Table 5.2. It is shown that there are significantly more direction information missing in the textual descriptions. In this sense the graphical route descriptions are richer than the textual ones. The most likely reason for this difference is that graphical descriptions do not make a difference between mentioning an object and locating the object. Moreover, it enforces the localization of the object. Textual descriptions, however, do not enforce the concrete localization of the objects which leads to differences as in this case. A further revision of the data confirms that all the missing direction information in the graphical descriptions are induced by missing landmarks. All given landmarks induce a correct or incorrect direction information for the graphical descriptions. For textual descriptions a missing landmark induces a missing direction information as well. However, not all missing direction information are induced by missing landmark information.

What remains discussable is the selection of the spatial relations that were investigated and raised for the investigation of the richness of the spatial descriptions. In contrast to place and region descriptions the temporal order and the direction provides a comparability between the relations in the textual and the graphical descriptions. However, they still do not provide a comprehensive way of comparing all spatial relations between the descriptions and therefore a conclusion about the overall richness of the spatial descriptions is not valid. Calculating the proportion of the relations in the graphical descriptions towards the relations in the textual descriptions indicates that there are spatial relations that are in the textual descriptions, but not in the graphical descriptions. The other way around it seems obvious that there are relations in the graphical descriptions that are not in the textual descriptions.

**Place and Region**

A comprehensive analysis of the spatial relations and the differences in the relations
between the textual and the graphical modality will have to be investigated in future work. Interesting questions of the interest would be if there is a pattern of relations that are available in the textual descriptions but not in the graphical descriptions or the other way around. Moreover, it would be interesting to investigate the spatial relations that are not explicitly mentioned in the textual descriptions but seem to be inherent in the descriptions and how this information relates to the graphical descriptions.

5.4 Perspectives

Taylor and Tversky (1996) investigated the perspectives of textual spatial descriptions and presented three ways of textually describing space with different properties (see Table 2.1). In this thesis it was expected to find all three perspectives of textual spatial descriptions applied by the participants of the experiment. Moreover, a connection of the place descriptions towards the gaze perspective, of the route perspectives towards the route descriptions and of the region perspectives towards the survey perspectives was expected. Table 4.9 shows that all three perspectives are applicable in the textual descriptions of the experiment. The gaze perspective is exclusively used for place descriptions, however, is not the predominant choice of perspective for the place descriptions. 40% of the region descriptions implement exclusively the survey description. The other 60% of the region descriptions are either found to be in the route perspective or a mix of survey and route perspective. The most prominent perspective is the route perspective as a large degree of participants applied this perspective. Moreover, a considerable degree of participants who started the descriptions within the survey or the gaze perspectives in the place and region descriptions switched towards the route perspective.

In the study Taylor and Tversky (1996), moreover, investigated the perspective for each landmark in textual region descriptions and found that people often switch perspectives more than once. In contrast to the method of Taylor and Tversky the textual descriptions in this thesis are evaluated for the perspectives by each sentence. Only one description shows two switches of perspectives, whereas all other descriptions, which were evaluated as mixed perspective, show only one switch. Besides a switch from the gaze perspective in one description, the switches are exclusively from the survey perspective towards the route perspective. An investigation of the features that are described in the different perspectives, as Taylor and Tversky did, is not performed. However, qualitatively looking at the descriptions permits the assertion that participants start to give an overview of the environment or to locate one particular point in the environment within the survey perspective before they switch towards the route perspective. This suggestion requires further qualitative or even quantitative investigations in future work.

Another difference to the experiment of Taylor and Tversky is that participants in this study are provided with a context that relates to real world situations, where they have to give the descriptions from memory without explicitly studying a map in advance. The way of studying perspectives in descriptions of fictitious environments that are
learned from a sketch, as in the experiment of Taylor and Tversky, is most likely to be
influenced by the sketch, by the perspective of the sketch, and by the mental ability of
the individual to take a viewpoint within a scene which was exclusively learned from a
map. Mentioning the spatial abilities, the results of the perspectives were compared
to the results of the Questionnaire Spatial Strategies (Münzer & Hölscher, 2011) but
no correlations were found. This, however, would also require a more comprehensive
investigation because from an initial point of view the correlation of the perspectives
and the mental spatial abilities seemed to be reasonable.

The main question that has to be asked at this point is why people predominantly
use the route perspective, even to a large degree for place and region description, and
why most switches within the mixed perspective are towards the route perspective.
Again it can be referred to Richter and Winter (2014) who stated that textual descrip-
tions will have less impact on route descriptions, as they have a linear structure. It
is suggested to extend this statement to “textual descriptions have a less impact on
spatial descriptions in the route perspective, as they have a linear structure and do
not require a linearization.” The cognitive costs that are required for the lineariza-
tion might be high enough for people to predominantly use the route perspective or
switch towards the route perspective instead of consistently using the survey or gaze
perspective for the description.

\section*{5.5 Summary}

Summing up the main findings and the discussions of the differences between the
textual and the graphical modality within the three dimensions of spatial descriptions
shows that there are differences between the textual and the graphical modality within
the three dimensions of spatial descriptions and that there are leverage points for
future work in this area. Table 5.3 presents the findings and suggested reasons for the
differences.

For the place and the region descriptions it is found that there are significantly more
errors in the graphical descriptions compared to the textual descriptions and a sur-
prisingly high degree of textual descriptions applied the route perspective for the de-
scriptions. It is discussed that graphical descriptions in general contain more explicit
spatial relations and more quantitative information which lead to an overall higher num-
ber of errors in these descriptions. Similarly, the significantly higher number of direc-
tion errors in the graphical route descriptions is explained by the proportionally higher
number of available direction information in the graphical descriptions which again is
suggested to be due to the enforced localization of objects in the graphical descrip-
tions. The reasons for the high degree of route perspectives and switches towards the
route perspective is suggested to be due to the linearity of the textual descriptions as
well as the chosen routes.

A surprising finding for the place descriptions is the significantly higher proportion of
landmarks in the graphical descriptions which is discussed and suggested to be due to
a space filling strategy people apply in graphical descriptions. For region descriptions
this strategy can not be proofed, as they are meant and expected to describe the overall structure of the environment and therefore no differences between the textual and graphical descriptions are found. Another important finding is the significantly higher proportion of distant landmarks in the graphical route descriptions. It is discussed to be due to the different perspectives between the textual and the graphical modality which may invoke this difference.

What definitely needs further investigation in future work is the difference in the richness of the information between the textual and the graphical descriptions because this could only been achieved unsatisfyingly due to missing parameters that would allow a comparison between the two modalities. However, the analysis revealed crucial parameter that will need to be considered in future work.
<table>
<thead>
<tr>
<th>Place</th>
<th>Findings</th>
<th>Suggested reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Trend to more landmarks in the graphical descriptions and a significantly higher proportion of landmarks</td>
<td>• Space filling strategy in graphical descriptions</td>
</tr>
<tr>
<td></td>
<td>• Significantly more errors in the graphical descriptions</td>
<td>• Graphical descriptions contain more spatial relations</td>
</tr>
<tr>
<td></td>
<td>• Almost half the descriptions are in route perspective</td>
<td>• Qualitative information in textual vs. quantitative information in graphical descriptions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Linearity of textual descriptions and route perspective</td>
</tr>
<tr>
<td>Route</td>
<td>• Significantly higher proportion of distant landmarks in graphical descriptions</td>
<td>• Route perspective in textual and survey perspective in graphical descriptions</td>
</tr>
<tr>
<td></td>
<td>• Significantly more direction errors in graphical descriptions</td>
<td>• Difference due to proportionally higher number of available direction information in graphical descriptions</td>
</tr>
<tr>
<td></td>
<td>• Significantly higher proportion of missing direction information in textual descriptions</td>
<td>• Graphical descriptions enforce the localization of objects</td>
</tr>
<tr>
<td>Region</td>
<td>• Significantly more errors in the graphical descriptions</td>
<td>• Graphical descriptions contain more spatial relations</td>
</tr>
<tr>
<td></td>
<td>• Only a third of the descriptions are in survey perspective</td>
<td>• Qualitative information in textual vs. quantitative information in graphical descriptions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Linearity of textual descriptions and route perspective</td>
</tr>
</tbody>
</table>

Table 5.3: Main Findings and Suggested Reasons.
6 Conclusion

This thesis investigates the question if there are differences in the externalizations of mental spatial representation within the three dimensions of spatial descriptions - place, route and region descriptions - between the textual and the graphical modality. In the light of the title “An investigation of the differences in conveying spatial information” it seems to be only half the work. Conveying information implies two main processes: transmitting the information and receiving the information. The focus and scope of this thesis is the investigation of differences within the transmitted spatial information, or in the language of the thesis, the investigation of the differences in the externalizations of mental spatial representations. However, the best or the most natural human way of transmitting information is not necessarily the best way of receiving information. People might be used to a way of receiving information because they transmit the information as such, but it is possible that another way might be even better. Therefore the finding of this thesis only allows a conclusion on the differences in the externalizations of spatial information, but not an overall conclusion on the differences in conveying spatial information.

A step towards the investigation of how people receive the spatial information could be made in future within another experiment where the participants would get the descriptions of the first experiment as an input and would have to solve some specific tasks. The performance of the participants on these tasks could be compared to the performance of the same participants on the same tasks based on different predefined descriptions. Based on the research parameters, an answer could be given on which descriptions are suited better for humans to receive spatial information and how this possibly differs across the different modalities. Other indications to future work have already been presented in the discussion section and mainly consist of three things:

1. In order to provide a better comparability across the dimensions of spatial descriptions the context of the instructions has to be adjusted and a common scheme for the consideration of local and global landmarks has to be defined.
2. The investigation of the richness of the spatial information has to be founded in investigation parameters that provide a comparability between the different modalities.
3. The perspectives in the textual descriptions have to be further investigated in order to explain why people predominantly use the route perspective and why they most frequently switch towards the route perspective in the mixed perspective descriptions.

Considering the use case of modern navigation devices, the content of the research of this thesis is in some sense different to these devices. Against the background of the previous discussion, this thesis does not provide evidence for an improved way of conveying spatial information through these devices. As the name already suggests, the main use case of navigation devices is to support the navigation from an origin to a destination. This is strongly related to the route descriptions that were investigated in this thesis, but less to the place and region descriptions. In the current devices place and region descriptions, as they are defined and used in this thesis, are hardly applicable. A place description could be suggested to be the description towards
a place, but in this case it is again a route description from the current location of the user, which can be inferred by the device via using GPS, towards the particular place. Especially at this point some participants seemed to struggle as well because they either asked for an origin of the place description or choose some arbitrary point in the city to describe the location of the place by describing the route towards the particular place. Enabling the navigation devices to additionally convey place and region descriptions would introduce a whole new paradigm and it would have to be investigated in how far this is worthwhile and would meet the user's expectations and requirements towards the devices.

The route descriptions that were investigated in this thesis show some differences to common navigation devices. As discussed, textual descriptions almost exclusively use qualitative spatial or temporal relationships which is different from the turn-by-turn instructions and metric distance information of the navigation devices (Richter & Winter, 2014). Moreover, the individual’s textual descriptions refer to local as well as global landmarks to provide orientation. Without properly investigating, it can be stated that by now most navigation devices do not provide this information, at least not verbally. The graphical modality that is used by the devices enables, in contrast to the perspective of the graphical descriptions drawn on a paper, a route perspective that is similar to the route perspective of the textual descriptions. Depending on the position and the viewing direction of the user the devices are able to dynamically adjust the shown spatial information in the map. Moreover, the navigation devices combine textual and graphical modalities, whereas in this thesis the single descriptions were separate from each other. The main purpose of navigation devices can be restricted to supporting and enabling the flawless navigation. The descriptions in this thesis, in contrast, were meant to provide orientation information that help people in the localization of locations and navigation towards a destination. Thereby the scope of this thesis is related to the scope of the WayTO (Wayfinding Through Orientation) project at the Institute for Geoinformatics, University of Münster, Germany. The WayTO project investigates a new paradigm of assisted wayfinding that supports cognitive mapping and orientation and is suitable for both the acquisition of survey knowledge as well as for following a route (Schwering, 2014). Knowing about the differences between the textual and the graphical modality in spatial descriptions contributes to the understanding in the investigation of the new paradigm of assisted wayfinding.
References


A Experiment (German)

Das Experiment

Das folgende Experiment besteht aus drei Teilen. Im ersten Teil beantworten Sie zunächst einige generelle Fragen zu Ihrer Person und Ihrer Ortskenntnis. In dem darauf folgenden Teil geht es darum, unterschiedliche Beschreibungen für bestimmte Alltagssituationen zu geben. Sie werden jeweils gebeten, sich bestimmte Situationen vorzustellen und aus der Situation heraus eine Beschreibung zu geben. Bei den Beschreibungen handelt es sich zum einen um textuelle Beschreibungen, wo Sie gebe
ten werden, eine schriftliche Beschreibung anzufertigen, und zum anderen um visuelle Beschreibungen, wo es um die Anfertigung von Skizzen geht. Im dritten Teil beantworten Sie noch einige abschließende Fragen.


Für die Beantwortung der Fragen im dritten Teil benutzen Sie bitte den Computer, der vor Ihnen steht.

Teil 1: Allgemeine Fragen

1. Alter: ____
2. Geschlecht: □ männlich □ weiblich
3. Wohnort: □ Münster □ nicht Münster
   (a) Falls Münster: _____ Jahre _____ Monate
   (b) Falls nicht Münster: Wohnort? Woher kennen Sie Münster?
4. Wie gut kennen Sie sich in der Innenstadt von Münster aus?
   □ sehr gut □ gut □ nicht so gut □ schlecht
5. Wie häufig nutzen Sie die folgenden Fortbewegungsmittel in der Innenstadt von Münster?

<table>
<thead>
<tr>
<th></th>
<th>mehrmals täglich</th>
<th>mehrmals wöchentlich</th>
<th>mehrmals monatlich</th>
<th>selten/(so gut wie) gar nicht</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto</td>
<td>□</td>
<td>□</td>
<td>□</td>
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</tr>
<tr>
<td>Fahrrad</td>
<td>□</td>
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<td>□</td>
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<tr>
<td>Bus</td>
<td>□</td>
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<td>□</td>
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<tr>
<td>Zu Fuß</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
Teil 2: Räumliche Beschreibungen

Auf den folgenden Seiten geht es um die räumlichen Beschreibungen. Wichtig dabei ist, dass Sie nicht zurückblättern und jede Aufgabe unabhängig von den vorherigen Aufgaben lösen.

Place Descriptions – Beschreibung von Orten

Textuell

Erklärung:
„Place Descriptions“ sind Beschreibungen von Orten einer Größe, die ohne beachtliche Bewegung wahrgenommen und erkundet werden können (z.B. Plätze).

Kontext:
Stellen Sie sich vor, Sie stehen vor dem Haupteingang der Lambertikirche. Sie haben einen Notfall und müssen den Notarzt anrufen. Allerdings weiß der Beamte, der Ihren Anruf entgegen nimmt, nicht, wo die Lambertikirche ist, sodass Sie ihm Ihren Standort anders erklären müssen.

Aufgabe:
Nutzen Sie den Platz auf der nächsten Seite, um dem Notarzt Ihren Standort zu beschreiben.

Beschränkung:
Platz: maximal 1 Seite
Zeit: maximal 5 Minuten

Place Descriptions – Beschreibung von Orten

Visuell

Erklärung:
„Place Descriptions“ sind Beschreibungen von Orten einer Größe, die ohne beachtliche Bewegung wahrgenommen und erkundet werden können (z.B. Plätze).

Kontext:
Stellen Sie sich vor, Sie stehen vor dem Haupteingang der Lambertikirche. Sie haben einen Notfall und müssen den Notarzt anrufen. Allerdings weiß der Beamte, der Ihren Anruf entgegen nimmt, nicht, wo die Lambertikirche ist, sodass Sie ihm Ihren Standort anders erklären müssen. Stellen Sie sich weiter vor, Sie haben mittels eines Gerätes die Möglichkeit, eine Skizze von Ihrem Standort anzufertigen, die Sie anschließend dem Notarzt übermitteln können.

Aufgabe:
Nutzen Sie den Platz auf der nächsten Seite um dem Notarzt Ihren Standort zu skizzieren.

Beschränkung:
Platz: ca. 1 Seite
Zeit: maximal 5 Minuten
Route Descriptions – Beschreibung von Routen

Erklärung:
„Route Descriptions“ sind Beschreibungen von Routen von einem Startpunkt zu einem Endpunkt.

Kontext:
Stellen Sie sich vor, Sie stehen am Hauptbahnhof in Münster und jemand fragt Sie, wie man mit dem Fahrrad zum Schloss kommt.

Aufgabe:
Nutzen Sie den Platz auf der nächsten Seite, um dieser Person den Weg zum Schloss zu beschreiben.

Beschränkung:
Platz: maximal 1 Seite
Zeit: maximal 5 Minuten

Region Descriptions – Beschreibung von Regionen

Erklärung:

Kontext:
Stellen Sie sich vor, ein Freund/eine Freundin plant, nach Münster zu kommen und sich die Innenstadt anzuschauen. Er/Sie fragt, ob Sie ihm/ihr eine Beschreibung der Innenstadt anfertigen können, mit der er/sie sich in der Stadt zurechtfinden kann und alles wichtige sieht, was es in der Stadt gibt.
Aufgabe:
Schreiben Sie den Platz auf der nächsten Seite, wie Sie dem Freund/der Freundin die Innenstadt von Münster beschreiben würden.

Beschränkung:
Platz: maximal 1 Seite
Zeit: maximal 5 Minuten

Region Descriptions – Beschreibung von Regionen

Visuell

Erklärung:

Kontext:
Stellen Sie sich vor, ein Freund/eine Freundin plant, nach Münster zu kommen und sich die Innenstadt anzuschauen. Er/Sie fragt, ob Sie ihm/ihr eine Skizze der Innenstadt anfertigen können, mit der er/sie sich in der Stadt zurechtfinden kann und alles wichtige sieht, was es in der Stadt gibt.

Aufgabe:
Nutzen Sie den Platz auf der nächsten Seite um dem Freund/der Freundin die Innenstadt von Münster zu skizzieren.

Beschränkung:
Platz: ca. 1 Seite
Zeit: maximal 5 Minuten

Teil 3: Fragebogen Räumliche Orientierung

Dieser Fragebogen enthält Aussagen zu Verhaltensweisen beim Zurechtfinden in räumlichen Umgebungen. Wir bitten Sie, für jede Aussage anzuzeigen, inwieweit Sie der Aussage zustimmen. Die Möglichkeit zur Ablehnung bzw. Zustimmung hat die folgende Form:

lehne stark ab 1 2 3 4 5 6 7 stimme stark zu

Bitte markieren Sie für jede Aussage diejenige Position, die dem Grad Ihrer Zustimmung am besten entspricht.


2. Wenn mich jemand in meiner Stadt nach dem Weg fragt, dann stelle ich mir meine Stadt wie auf einer Karte vor und ermitte daraus den Weg.

4. Ich bin sehr gut darin, von meinem gegenwärtigen Standort aus Richtungen zu anderen Orten anzugeben.


6. Ich kann spontan zeigen, wo Norden, Süden, Osten und Westen liegt.

7. Ich stelle mir die Umgebung stets wie auf einer „mentalen Karte“ (Überblicksansicht) vor.

8. Ich finde stets ohne Probleme zu meinem Ziel.


10. In einer unbekannten Umgebung finde ich mich gut zurecht.


12. Ich bin sehr gut darin, mir Wege zu merken und finde auch ohne Mühe den Rückweg.


14. Mein Orientierungssinn ist sehr gut.

15. In meiner Stadt kann ich von einem beliebigen Punkt aus spontan angeben, in welchen Richtungen markante Gebäude oder Bezugspunkte liegen.


19. Wenn ich mich in einer unbekannten Stadt bewege, dann bilde ich in meiner Vorstellung eine Art „mentale Karte“.
B  Statistical Analysis

Figure B.1: Number of Landmarks in Place Descriptions by Self Rated Familiarity.

Figure B.2: Number of Landmarks in Route Descriptions by Self Rated Familiarity.
Figure B.3: Number of Landmarks in Region Descriptions by Self Rated Familiarity.

Figure B.4: Number of Near and Distant Landmarks in Route Descriptions.
Figure B.5: Mean Distances between Place Descriptions.

Figure B.6: Mean Distance in Distant Landmarks in Route Descriptions.
Figure B.7: Mean Distances between Region Descriptions.
C Disc Attachment

Experiment material
All material that was needed for running the experiment.
Location: disc://01_Experiment/

Experiment data
The data that was collected through the experiment.
Location: disc://02_Data/

Analysis
The script that was written for the statistical analysis of the data.
Location: disc://03_Analysis/

Thesis
A PDF version of this thesis.
Location: disc://MA_Thesis_Loewen.pdf
Declaration of Academic Integrity

I hereby confirm that this thesis on “Talking about space versus sketching space: An investigation of the differences in conveying spatial information” is solely my own work and that I have used no sources or aids other than the ones stated. All passages in my thesis for which other sources, including electronic media, have been used, be it direct quotes or content references, have been acknowledged as such and the sources cited.

(Date and signature of student)

I agree to have my thesis checked in order to rule out potential similarities with other works and to have my thesis stored in a database for this purpose.

(Date and signature of student)