Perspectives in externalizations of mental spatial representations

Heinrich Löwen, Angela Schwering, Jakub Krukar and Stephan Winter

Abstract Place is a core component of human spatial knowledge and therefore a central topic in GI Science. People use externalizations of mental spatial representations to communicate about space. Textual descriptions and graphical descriptions are the two main modes of communication. In this paper a distinction of three scales of spatial descriptions is assumed and textual and graphical descriptions are collected and analyzed in order to investigate the differences between the spatial descriptions. Thereby the focus lies on the properties and perspectives of the descriptions. It is found that within the textual descriptions people tend to not consistently use one perspective, but switch perspectives and predominantly apply the route perspective. For the graphical descriptions there has been no clear categorization of description perspectives. However, there are differences in the properties of these descriptions that indicate different perspectives.

Key words: spatial information extraction; communication modes; spatial description perspectives

1 Introduction

Externalizing *mental spatial representations* always involves cognitive transformation processes, which include invoking parts of the mental representation and encoding it into a chosen modality (Richter and Winter, 2014). The two main communication modes for externalizing mental spatial representations are on the one

H. Löwen (✉) · A. Schwering · J. Krukar
Institute for Geoinformatics, University of Muenster, Heisenbergstraße 2, 48149 Muenster, Germany
e-mail: loewen.heinrich@uni-muenster.de

S. Winter
Department of Infrastructure Engineering, The University of Melbourne, Victoria 3010, Australia

hand spoken or written language and on the other hand graphical configurations, i.e. drawn sketches. In order to externalize spatial information into one of the communication modes, people must take a perspective on it (Taylor and Tversky, 1996). The perspectives of spatial descriptions imply certain properties of how space is described, e.g. viewpoint, frame of reference[1] and terms of reference[2] (Taylor and Tversky, 1996). These might differ with respect to the scales of spatial descriptions. Three scales of spatial descriptions are distinguished here, which will be outlined in the following section: (1) place descriptions, describing where something is located, (2) route descriptions, describing a suggested path between locations, and (3) region descriptions, describing the configuration of whole regions.

In order to improve the understanding of how spatial descriptions are structured and how they differ from each other, the following questions will be investigated:
(1) Do the properties of spatial description differ between the modes of communication?
(2) Does the choice of perspectives differ between the scales of spatial descriptions?
(3) What are the preferred perspectives that people choose in spatial descriptions?

The underlying hypothesis of this paper is that the driving force for choosing a particular perspective is the mode of communication and not the scales of spatial descriptions. The perspectives of externalizations of mental spatial representations will be investigated by comparing the textual and the graphical descriptions within the three scales of spatial descriptions. Empirical data will be collected for all modes and scales of spatial descriptions.

This understanding is applicable in the field of Human-Computer Interaction, for designing systems which communicate spatial information to its users across different scales and context of use. Similarly, Volunteered Geographic Information applications can benefit from better understanding the perspectives naturally preferred by humans to communicate spatial information across different scales. The next two sections will review the related work and expound the methodology with respect to previous research in this area. This will imply the design of a user experiment to collect different spatial descriptions. The descriptions will be analyzed by the properties of textual and graphical descriptions and the results will be presented in Section 4 and discussed in Section 5.

2 Related Work

This section will review the relevant literature on communication modes for externalizing mental spatial representations, perspectives of spatial descriptions and

[1] Taylor and Tversky distinguish three frames of reference: (1) *relative*, where the origin of the coordinate system is one of the participants, the speaker or the addressee, (2) *intrinsic*, where the origin of the coordinate system is a specific object, and (3) *extrinsic*, where the origin of the coordinate system is external to the scene.

[2] The two different terms of reference are (1) LRFB = left, right, front, back, and (2) NSWE = north, south, west, east.

scales of space. The latter will be the base for the distinction between scales of spatial descriptions, which will be presented in the Section 3.

2.1 Communications modes

As mentioned above, the two main communication modes for externalizing mental spatial representations are the textual and the graphical mode. The process of externalizing mental spatial representations into communication modes involves cognitive processes which lay a filter between the mental spatial representations and the spatial descriptions. These 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 and 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 and Winter, 2014).

Sketch maps are two-dimensional pictorial representations and descriptions of spatial locations, spatial configurations and routes. They depict a filtered, abstracted and schematized subset of a mental spatial representation and reflect cognitive distortions of mental spatial representations. In contrast to sketch maps, textual descriptions are linear descriptions of locations, configurations or routes (Richter and Winter, 2014). Richter and Winter state that textual descriptions will have less impact on route descriptions, as routes are linear and textual descriptions have a linear structure as well. Therefore, textual descriptions have a stronger impact on location and configuration descriptions because they require cognitive linearization strategies (Richter and Winter, 2014).

2.2 Perspectives of spatial descriptions

2.2.1 Textual descriptions

In literature three kinds of reference frames as well as three kinds of perspectives are distinguished for textual spatial descriptions (e.g. Buhler, 1982; Carlson-Radvansky and Irwin, 1994; Levelt, 1984, 1989; Levinson, 1996; Taylor and Tversky, 1996). Levinson summarizes 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 (ternary relation), e.g. "the man is to the left of the house".
(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 object's

intrinsic *front, back, left, right, top* and *bottom* (binary relation), e.g. “the man is in front of the house”. In this case, the origin could also be a person as for example 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* (binary relation), e.g. “the man is north of the house”.

Taylor and Tversky suggest the distinction of three perspectives of describing environments. These are related to the three reference frames and reflect a natural way of experiencing and describing an environment (Table 1):
(1) The *gaze* perspective takes a stationary viewpoint from which the entire scene can be viewed (horizontally displaced) and applies the *relative* reference frame for the description. It is restricted to the vista space.
(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 (vertically displaced) and corresponds to the *extrinsic* reference frame. It is analogous to the descriptions from the birds-eye-view (e.g. Ehrich and Koster, 1983; Levelt, 1982; Taylor and Tversky, 1996).

Table 1 Properties of Types of Description Perspectives (reproduced from Taylor and Tversky (1996)).

	Description perspective		
Properties	Gaze	Route	Survey
Viewpoint	fixed, external	changing, internal	fixed, external
Verbs	stative	active	stative
Referent	object (or person)	person	object
Terms of reference	LRFB	LRFB	NSEW
Frame of reference	relative	intrinsic	extrinsic
World analog	View entire scene from fixed point, horizontally displaced	View while exploring	View entire scene from fixed point, vertically displaced (map)

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 and 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 and 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 are the referent object, the viewpoint and the terms of reference. These are related to the cognitive costs and may change when the perspective changes.

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).

2.2.2 Graphical descriptions

As verbal and graphical descriptions are fundamentally different, graphical descriptions do not necessarily have to fit the properties and types of verbal descriptions. Graphical descriptions mainly depict objects in an environment and the spatial relations among them. Bryant and Tversky distinguish between the *inside* and *external* perspective within graphical descriptions (Bryant and Tversky, 1999). The inside perspective uses an references frame that is centered to a person and describes relations with respect to the person's *front, back, left, right, head* and *feet*. The external perspective is looking from an external position onto the scene and uses a reference frame that is centered to an external object or a person. It describes the directions according to the objects' *front, back, left* and *right*. Other studies term the two perspectives *route perspective*, which adopts a first-person perspective from within the scene (e.g. a mental tour), and *survey perspective*, which adopts a third-person top-down perspective onto the scene (e.g. a map) (e.g. Galea and Kimura, 1993; Hund et al., 2012; Kato and Takeuchi, 2003; Lawton, 1996; Lawton and Kallai, 2002; Pazzaglia and Beni, 2001; Sholl et al., 2000). However, the boundaries might not always be that sharp because people might depict the environment from the top-down perspective but include for example detailed facades of buildings. The properties and perspectives that will be used for the investigation in this paper will be outlined in more detail in the following section.

2.3 Scales of space

The term *space* is often structured with respect to different scales, however, 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 (Montello, 1993). Freundschuh and Egenhofer, for example, distinguish between small- and large-scale spaces and Montello distinguishes four different categories of space (Freundschuh and Egenhofer, 1997; Montello, 1993):

- *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 can not 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 can not be apprehended directly through locomotion and has to be learned from representations such as maps (e.g. a country).

In the following section a distinction between three scales of spatial descriptions will be presented, which is related to Montello's categorization of space.

3 Method

As a central part of this paper an experiment will be designed, which will collect spatial descriptions. For each scale of spatial descriptions that will be presented in the first part of this section (place, route and region description), two spatial descriptions will be collected: one textual description and one graphical description. The descriptions will be collected from the same group of participant and the order of tasks will be randomized. In contrast to the experiments of Taylor and Tversky (1992a), where participants studied maps and recalled the maps in spatial descriptions, textual and graphical descriptions will be collected from participants by asking them to recall the information from memory only. The analysis of the description perspectives will, among others, involve categorizing the descriptions and measuring the frequencies of the different properties and perspectives of the descriptions. Thereby, the differences in the perspectives within the different scales of spatial descriptions and within the two modes of externalization will be investigated. Moreover, it will reveal which perspective participant preferably choose for the particular scales and modes.

3.1 Scales of Spatial Descriptions

A categorization of different scales of spatial descriptions is related to the scales of space, as outlined in the previous section. A clear categorization is challenging because different disciplines have a different understanding of the term *space* and there are often no clear boundaries between the classes (Montello, 1993). A categorization of different scales of spatial descriptions might therefore not be universal, but is defined here as follows:

(1) *Place descriptions* support the localization of objects in the environment and identify locations. Place descriptions are centered to one point which is the location of a clear figure on the ground of the environment. In case of an emergency, it

might be the description of the visual surroundings of the particular place or the description of the location in relation to nearby (global) landmarks. The intention of a place description is the identification of a particular location.

(2) A *route description* is sequential and focuses on the guidance through an environment or to a particular destination (Shanon, 1979). It thereby describes the location of a moving figure on the ground of the environment.

(3) *Region descriptions*, in contrast to place descriptions (and route descriptions), describe larger environments by describing the location and configuration of several objects (Emmorey et al., 2000; Taylor and Tversky, 1992b). It might be categorized by varying figure-ground relations. The intention of a region description is to answer the *where* question for several objects and locations and to answer the *how* question - "how is the environment structured?"

This categorization will be used for the data collection to request the different types of descriptions from the participants.

3.2 Perspective

The textual and the graphical modes are fundamentally different and it was reviewed that there exists no such clear categorization of perspectives in graphical descriptions as presented by Taylor and Tversky (1996) for textual descriptions. The suggested properties in Table 1 will be used to classify and compare the textual descriptions.

For the graphical descriptions, there are properties that can be applied for a distinction. The *reference frame*, which was mentioned by Bryant and Tversky (1999), might either be intrinsic or extrinsic. However, it is expected that participants will predominantly apply the extrinsic reference frame, which corresponds to the fixed, external viewpoint in Taylor and Tversky's distinction. Another property will be the *referent*, which will be distinguished here in three categories:

(1) The referent will be considered to be a *person*, if the participant, the addressee or the imagined location of a person is explicitly depicted and other objects in the sketches will be closely aligned to the location of the person. Moreover, the person will be predominantly, but not exclusively, depicted in the center of the sketch.

(2) The referent will be considered to be a *route*, if the sketch will be clearly limited to the space between the origin and the destination and most objects in the sketches will be closely related to the route itself (e.g. landmarks along the route or at decision points (Anacta et al., 2014)). However, routes might still be enriched with global landmarks, which are not sketched directly next to the routes (Anacta et al., 2014).

(3) If there is no clear referent or focus in the sketch, but the description might be categorized by multiple objects that form a larger two dimensional extend, the referent will be considered to be the *region*. In this case the purpose of the sketch will be the depiction of the configuration of the whole region.

A further property to analyze graphical descriptions of the environment is the *alignment*. It will be distinguished here between *north alignment*, *heading alignment* and *no alignment*. The alignment will be classified as heading aligned, if the sketch is aligned to the imagined viewing direction of the participant or the addressee, e.g. from the origin of the route to the destination. These properties are not exhaustive, as for example the *indication of the cardinal direction* or the *indications of the route* to follow might also be considered in graphical description.

3.3 Experiment

3.3.1 Subjects

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 to ensure the familiarity of the participants with the layout of the city. 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. Part 1 asked the participants some general questions regarding their familiarity with the city, in Part 2 participants gave in total six spatial descriptions and in Part 3 they answered the Questionnaire Spatial Strategies (Münzer and 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 order of the questions for the spatial descriptions in the second part was randomized. For each spatial description the participants were provided with a short explanation, some context, and the task. There were no further restrictions to the tasks, except an approximate time of five minutes per task was assigned, which, however, was not monitored. For the textual and the graphical descriptions the participants were provided with one plain page each, but they had access to further pages to extend their descriptions.

For the *place descriptions* participants were asked to give a description, where they were asked to imagine standing at a certain location in the city and describing their own location in case of an emergency. 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 person and would not have a large two-dimensional extend.

For the *route descriptions* the participants were asked to provide a route description between two prominent global landmarks in the city Münster to a cyclist. The bike is one of the main means of transport in Münster and the infrastructure is reasonably well developed. Geographically, the two landmarks are on opposing sides of the inner city, which itself is surrounded by a promenade. The route descriptions were expected to have a linear structure and it was expected that the participants would not only include landmarks along the route but also spatial information distant to the route that support the global orientation (Schwering et al., 2013).

For the *region descriptions* participants were asked to provide a spatial description of the inner city of Münster to an unfamiliar person. In contrast to the place and route descriptions, it was expected that the region descriptions would have a larger two-dimensional extend but no linear structure.

4 Results

4.1 Perspective in textual descriptions

For the textual route descriptions participants applied the route perspective consistently (Table 2). More diverse are the results for the place and the region descriptions. Instead of using one perspective consistently, participants used different perspectives in the textual descriptions and often switched perspectives. In place de-

Table 2 Perspectives Chosen by Participants in Textual Descriptions.

	gaze	route	survey	mixed
Place	5 (17%)	14 (47%)	4 (13%)	7 (23%)
Route	0	30 (100%)	0	0
Region	0	11 (37%)	12 (40%)	7 (23%)

scriptions 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 route descriptions generally describe 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 imaginary location of the user. Moreover, the participants described in average 1.36 (SD = 0.74) routes instead of just one route. Considering the seven place descriptions with mixed perspectives, it was found that six of these descriptions started within the survey perspective and then switched towards the route perspective. One of the descriptions started within the gaze perspective and then switched to

the route perspective. None of the perspectives changed from the route perspective towards other perspectives.

For the region descriptions 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 the description within 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 their description. As in place descriptions, the textual region descriptions in the route perspective were different from the route descriptions. The participants described the region through several routes. The descriptions consisted in average of 4.36 (SD = 2.54) branches[3] and 0.73 (SD = 0.79) circuits[4].

4.2 Perspective in graphical descriptions

The analysis of the *referent* property in the graphical descriptions shows clear results for the route and the region descriptions. As can be seen in Table 3, for all route descriptions the referent is classified to be the above mentioned *route* referent and for all region descriptions the referent is classified to be the above mentioned *region* referent. For the place descriptions the results are diverse: for the majority of descriptions the referent is classified as *person* (73%), however, for 13% of the descriptions the referent is classified as route or region. For the same amount of descriptions it can not be clearly distinguished between the person and region referent. Three of the place descriptions (10%) for which the referent was unambiguously

Table 3 Referent Property in Graphical Descriptions.

	person	route	region	ambiguous
Place	22 (73%)	1 (3%)	3 (10%)	4 (13%)
Route	0	30 (100%)	0	0
Region	0	0	30 (100%)	0

classified as person, the location of the person was not depicted in the center of the sketch, but at the bottom or at the top. However, all the other objects in the sketch were closely aligned to this location.

The *alignment* property was more diverse than the referent property. For the place descriptions slightly more than half of the descriptions were north aligned (57%),

[3] A *branch* is defined here as an alternative path through the region. A description with two branches thereby consists of two integrated route descriptions.

[4] A *circuit* is defined here as a route descriptions through a region with the destination equals the origin.

but almost the same number of descriptions (13 out of 30) were not north aligned. Slightly more that half of the route descriptions (57%) were aligned to the users heading direction. For the majority of these descriptions (15 out of 17) the origin of the route is depicted at the bottom and the destination at the top of the sketch. For the remaining two descriptions the depiction of origin and destination are swapped. The route descriptions that are not aligned to the users heading direction are split between north alignment (6 out of 30) and no alignment (7 out of 30). The most

Table 4 Alignment Property in Graphical Descriptions.

	heading	north	not aligned
Place	0	17 (57%)	13 (43%)
Route	17 (57%)	6 (20%)	7 (23%)
Region	0	23 (77%)	7 (23%)

significant results regarding the alignment property are obtained for the graphical region description, where more than 75% of the descriptions are aligned to north and less than 25% of the descriptions are not aligned to north.

The *viewpoint* of all graphical descriptions was external to the scene. However, in total 10 descriptions contained objects that were not sketched according to this viewpoint, but were horizontally displaced: 6 (20%) place descriptions, 1 (3%) route description, and 3 (10%) region descriptions. Furthermore, it was found that only one out of 90 graphical descriptions in total contains an indication of cardinal directions, although almost 50% of all descriptions are aligned to north. Moreover, 80% of the graphical route descriptions contained indications of the route to follow, e.g. in the form of arrows.

5 Discussion

5.1 Perspective in textual descriptions

Taylor and Tversky (1996) investigated the perspectives of textual spatial descriptions and presented three ways of textually describing space with different properties (see Table 1). In this paper it was expected to find all three perspectives of textual spatial descriptions applied by the participants of the experiment. Moreover, it was expected that there would be 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. Table 2 shows that all three perspectives are applied 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 their study, Taylor and Tversky investigated the perspective for each landmark in textual region descriptions and found that people often switch perspectives more than once (Taylor and Tversky, 1996). In contrast to that, only one description in the experiment presented in this paper 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 towards the route 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. Participants had 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, like 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 that was exclusively learned from a map (Taylor and Tversky, 1996).

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 who stated that textual descriptions will have less impact on route descriptions, as they have a linear structure (Richter and Winter, 2014). It is suggested to extend this statement to “textual descriptions have less impact on spatial descriptions in the route perspective, as they have a linear structure and do not require further linearization.” The cognitive costs that are required for the linearization might be low 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.

5.2 Perspective in graphical descriptions

Regarding the graphical descriptions a set of properties to analyze the perspectives in the sketches was presented in the methods section and results were presented

in the previous section, respectively. For the *referent* property, it was expected that there would be a preference of the participants to apply the person referent to the place descriptions, the route referent to the route descriptions and the region referent to the region descriptions. The results in Table 3 meet these expectations, however, the result for the place descriptions are not as clear as for the route and the region descriptions. The four ambiguous descriptions, where the referent could not be clearly classified between the person and the region, can be explained by the objects in the sketches. The objects covered an area that was not necessarily centered to the location of the person only, so that the referent might already be considered to be the region. However, the location of the person was explicitly depicted in the sketch, which suggests the referent to be a person instead of a region.

For the *alignment* property the results show that, although not exclusively, only route descriptions are aligned to the heading of the person, whereas place and region descriptions show only differences with respect to the north alignment. The other way around, a heading alignment might clearly identify a description as a route description. Noting that only one in 90 descriptions contains a indication of the cardinal direction, whereas almost 50% of all descriptions are aligned to north, shows that a significant amount of people apply the cardinal directions for the alignment of the sketches. In contrast to the textual mode, an explicit indication of the cardinal directions within the graphical mode is not mandatory. Moreover, participant did not consider the indication of the cardinal directions as important, which contrasts the indication of the routes in the route descriptions. An indication of the route is as well not mandatory, which is affirmed by the 20% of route descriptions that do not contain indications, however the majority of participants must have considered the indication of the route to follow as important for the graphical route description.

Considering the properties that have been outlined for the graphical descriptions, a distinction between three description perspectives in graphical descriptions might be suggested here: (1) place perspective, (2) route perspective, and (3) region perspective. These perspectives are clearly related to the three scales of spatial descriptions and shall constitute an equivalent of the graphical descriptions to the suggested perspectives for textual descriptions as shown in Table 1.

Table 5 Criteria for a categorization of graphical descriptions (LRFB (HF) = left, right, front, back (head, feet); NSEW = north, south, east, west)

	Description perspective		
Properties	Place	Route	Region
Viewpoint	fixed, external	fixed, external	fixed, external
Frame of reference	extrinsic	extrinsic	extrinsic
Referent	person	route	region
Alignment	none or north	heading	none or north
Indication	persons location	route to follow	

The description within the *place perspective* might mainly be identified by the referent classified as person. The indication of the person's location in the sketch and a small number of objects that are centered to the location of the person distinguished it from the region perspective. A *route perspective* for graphical descriptions might be classified by the referent in the sketch, which is the route, and the alignment of the descriptions from the origin to the destination. Moreover, an indication of the route in the descriptions might confirm the classification of the route perspective. A *region perspective* for graphical descriptions, in contrast, might be identified by a referent that is regarded to be the region and a preference of an alignment to north. However, the north alignment itself does not explicitly related to one of the perspectives. In Table 5 the suggested description perspectives and their properties are listed.

5.3 General discussion

In general, there were differences found between the properties of different spatial descriptions and it is assumed that there exist different "perspectives" in both textual and graphical descriptions. For the textual descriptions the perspectives that were presented by Taylor and Tversky were used to classify the descriptions and it was found that participants chose different perspectives for the three different scales of spatial descriptions and even switched perspectives. For the graphical descriptions it was shown that there are differences between the description properties and it was suggested to summarize these properties to different perspectives of graphical spatial descriptions. These perspectives differ between the three scales of spatial descriptions, however not all graphical descriptions can clearly be classified towards one perspective.

Considering the two modes of externalizations of mental spatial representations, the textual and graphical descriptions are hardly comparable, because they are different in their underlying structure and their properties. On the one hand textual descriptions might differ with respect to their viewpoint, whereas graphical descriptions do usually not. On the other hand graphical descriptions might have a clear alignment, whereas the alignment property does not apply to the textual descriptions as it applies to the graphical descriptions. Within both modes of communication a tendency towards different perspective was shown and discussed. Moreover, the perspectives seem to be related to the scales of spatial descriptions. Therefore it can be said that there are differences in externalizations of mental spatial representations, both, between the three scales of spatial descriptions and between the two modes of communication.

6 Conclusion

In this paper it was assumed that there are three different scales of spatial descriptions and that people mainly externalize mental spatial representation within the textual and the graphical communication mode. It was proposed that there are differences in the perspectives of spatial descriptions, that are mainly induced by the structural differences of the communication modes and not by the different scales of spatial descriptions. However, it was found that in both modes of spatial descriptions there are differences between the descriptions of the different scales of spatial descriptions. Moreover, the descriptions of the two modes of externalization show structural differences with respect to their properties and perspectives.

Overall, these finding do only relate to one part of human communication about space, which is the externalization of mental spatial relations. This, however, does not allow any inferences about how people receive spatial information. The best and most natural way of people to externalize spatial information might not necessarily be the best way to receive and understand spatial information. However, as already mentioned above, the knowledge about the naturally preferred way of humans to communicate spatial information across context and scale is applicable to the fields of Human-Computer Interaction and Volunteered Geographic Information. Future work will have to further investigate on the one hand the proposed perspectives of graphical descriptions and on the other hand how people naturally receive, process and understand spatial descriptions.

References

Anacta VJ, Schwering A, Li R (2014) Determining Hierarchy of Landmarks in Spatial Descriptions. In: Eighth International Conference on Geographic Information Science, Vienna, Austria

Bryant DJ, Tversky B (1999) Mental representations of perspective and spatial relations from diagrams and models. Journal of Experimental Psychology: Learning, Memory, and Cognition 25(1):137–156

Buhler K (1982) The deictic field of language and deictic words. In: Jarvella RJ, Klein W (eds) Speech, place, and action, Wiley, New York, pp. 9–30

Carlson-Radvansky LA, Irwin DE (1994) Reference Frame Activation during Spatial Term Assignment. Journal of Memory and Language 33(5):646–671

Ehrich V, Koster C (1983) Discourse organization and sentence form: The structure of room descriptions in Dutch. Discourse Processes 6(2):169–195

Emmorey K, Tversky B, Taylor HA (2000) Using space to describe space: Perspective in speech, sign, and gesture. Spatial Cognition and Computation 2(3):157–180

Freundschuh SM, Egenhofer MJ (1997) Human Conceptions of Spaces: Implications for Geographic Information Systems. Transactions in GIS 2(4):361–375

Galea LAM, Kimura D (1993) Sex differences in route-learning. Personality and Individual Differences 14(1):53–65

Hund AM, Schmettow M, Noordzij ML (2012) The impact of culture and recipient perspective on direction giving in the service of wayfinding. Journal of Environmental Psychology 32(4):327–336

Kato Y, Takeuchi Y (2003) Individual differences in wayfinding strategies. Journal of Environmental Psychology 23(2):171–188

Lawton CA (1996) Strategies for indoor wayfinding: The role of orientation. Journal of Environmental Psychology 16(2):137–145

Lawton CA, Kallai J (2002) Gender Differences in Wayfinding Strategies and Anxiety About Wayfinding: A Cross-Cultural Comparison. Sex Roles 47(9):389–401

Levelt WJM (1982) Cognitive Styles in the Use of Spatial Direction Terms. In: Jarvella RJ, Klein W (eds) Speech, Place, and Action, Wiley, Chichester, United Kingdom, pp. 251–268

Levelt WJM (1984) Some Perceptual Limitations on Talking about Space. In: van Doorn AJ, van de Grind WA, Koenderink JJ (eds) Limits in perception, VNU Science Press, Utrecht, The Netherlands, pp. 323–358

Levelt WJM (1989) Speaking: From Intention to Articulation. The MIT Press, Cambridge

Levinson SC (1996) Frames of Reference and Molyneux's Question: Crosslinguistic Evidence. In: Bloom P, Peterson MA, Nadel L, Garrett MF (eds) Language and Space, The MIT Press, Cambridge, pp. 109–156

Montello DR (1993) Scale and Multiple Psychologies of Space. In: Frank AU, Campari I (eds) Spatial Information Theory: A Theoretical Basis for GIS, Proceedings COSIT '93, Lecture Notes in Computer Science, Springer, pp. 312–321

Münzer S, Hölscher C (2011) Entwicklung und Validierung eines Fragebogens zu räumlichen Strategien. Diagnostica 57(3):111–125

Pazzaglia F, Beni RD (2001) Strategies of processing spatial information in survey and landmark-centred individuals. European Journal of Cognitive Psychology 13(4):493–508

Richter KF, Winter S (2014) Landmarks: GIScience for Intelligent Services. Springer

Schwering A, Li R, Anacta VJ (2013) Orientation Information in Different Froms of Route Instructions. In: Proceedings of the 16th AGILE Conference on Geographic Information Science, Springer, Leuven, Belgium

Shanon B (1979) Where Questions. In: Proceedings of the 17th Annual Meeting on Association for Computational Linguistics, Association for Computational Linguistics, La Jolla, California, pp. 73–75

Sholl MJ, Acacio JC, Makar RO, Leon C (2000) The relation of sex and sense of direction to spatial orientation in an unfamiliar environment. Journal of Environmental Psychology 20(1):17–28

Taylor HA, Tversky B (1992a) Descriptions and depictions of environments. Memory & Cognition 20(5):483–496

Taylor HA, Tversky B (1992b) Spatial Mental Models Derived from Survey and Route Descriptions. Journal of Memory and Language 31(2):261–292

Taylor HA, Tversky B (1996) Perspective in Spatial Descriptions. Journal of Memory and Language 35(3):371–391

Tversky B, Lee PU, Mainwaring S (1999) Why do speakers mix perspectives? Spatial Cognition and Computation 1(4):399–412

Vasardani M, Timpf S, Winter S, Tomko M (2013) From Descriptions to Depictions: A Conceptual Framework. In: Tenbrink T, Stell J, Galton A, Wood Z (eds) Spatial Information Theory: 11th International Conference, COSIT 2013, vol 8116, Springer, pp. 299–319