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The use of route and survey perspective in wayfinding direction given on small and large scale maps in a Dutch population.

Bachelor these

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Abstract

The purpose of this experiment was to investigate the use of route perspective (while driving through an environment) and survey perspective (while using a map) in giving wayfinding directions in a Dutch population. The main focus of the study was to examine the differences in navigation instructions given in a small scale environment (a model of a town) and a large scale environment (a map of a country). The hypothesis was that Dutch people, who made minimal use of cardinal terms in a small scale environment (see Bangel, 2009), would use cardinal terms when giving navigational instructions in a large scale environment. This hypothesis was not confirmed by the data of the experiment. Dutch people showed a clear preference for the use of left/right directions in both perspectives in both the small and the large scale environment, while cardinal terms where used scarcely. This indicates a preference for a relative frame of reference when giving navigation instructions unregarded of the scale size of the environment.

Introduction

On a daily basis people use their spatial cognition to find their way in a variety of situations. This provides the ability to navigate through a large city, to find your way in a building you have never been before or find an object because you remembered the place you have last seen it. Also this enables people to give navigational instructions to others in need of help to find a certain location or object.

In this study the focus is on spatial descriptions when giving navigation instructions. The purpose of the experiment is to investigate the use of different perspectives in giving navigational instructions in a Dutch population. The differences between giving instructions in a small scale environment and a large scale environment are investigated.

To describe a location of an object it is necessary to establish a frame of reference. Frames of reference are coordinate systems used to compute and specify the location

of objects with respect to other objects (Majid, Bowerman, Kita, Haun & Levinson, 2004). Just as frames of reference are required to specify location and orientation in physical space, human memory systems must also use frames of reference of some kind to specify the remembered locations of objects (Mou & McNamara, 2002). Majid et al. (2004) distinguish three frames of reference for describing spatial arrays: relative, absolute and intrinsic. A relative frame of reference is egocentrical, with no fixed angles, relying on relational concepts such as "in front of", "behind", "to the left of", and so forth, to describe the relative dispositions of objects from a particular point of view (Levinson, 1997). In an absolute frame of reference fixed references like cardinal points are used (Majid et al., 2004). The absolute frame of reference is not dependent on the human frame (unlike left and right) nor, essentially, on the speaker's viewpoint (unlike “in front of the tree”), although an egocentric position may optionally be used as a reference point (as in “north of me”) (Levinson, 1997). In an intrinsic frame of reference an object is described in relation to another object (e.g. “the fork is beside the spoon”) (Majid et al., 2004).

The process of spatial knowledge acquisition requires the division of spatial knowledge in route knowledge and survey knowledge; in which route knowledge is proposed to precede the development of survey knowledge (MacEachren, 1992). Route (or procedural) knowledge is conceived of as a sequence of features and/or actions that describe a path between two known points (MacEachren, 1992). In contrast, survey knowledge refers to knowledge of the topographic properties of an environment (Thorndyke & Hayes-Roth, 1982). These properties include the location of objects in the environment relative to a fixed coordinate system (e.g., compass bearings), the global shapes of large land features (e.g., streets, parks, lakes), and the interobject Euclidean (i.e., straight-line) distances. Such information is not available from direct experience in the environment, but is portrayed on maps (Thorndyke & Hayes-Roth, 1982). Because survey knowledge emphasizes the spatial relations among places and features this allows greater flexibility in navigation than route knowledge (Lawton, 1994; MacEachren, 1992). The linear representation of route knowledge makes it for someone who is relying on this knowledge more likely to become disoriented when deviating from a learned route (Hund et al, 2008; Lawton, 1994).

Lovelace, Hegarty, and Montello (1999) argued that the production of route directions could be described by a simplified theoretical model consisting of three steps. The first step involves the activation of a representation of the environment stored in a non-linguistic format. The second step requires the choice of a specific route through that environment based on the desired route characteristics. The third step is a translation of the chosen route into a set of verbal instructions.

When giving verbal instructions there are two spatial perspectives to distinguish; route perspective and survey perspective. For directions given from a route perspective a mental tour is required which includes references to segments of the route from the perspective that the traveler would experience when moving through the environment. Directions will be given from an egocentric frame of reference and will include left and right turns and descriptions of landmarks (Hund, Haney & Seanor, 2008). In a survey perspective a bird's-eye view is adopted which provides an overview of the whole environment and objects will be described with respect to one another (Noordzij, Postma and Zuidhoek, 2006). In this case directions will be giving from an exocentric frame of reference and will involve the use of cardinal terms (north, south, east and west) (Hund et al., 2008). Taylor and Tversky (1996) found a difference in verb use between route perspective and survey perspective. The single viewpoint used in survey descriptions, on the one hand, encouraged the use of primarily stative verbs. Route descriptions, on the other hand, have a changing viewpoint which encourages the use of more active verbs. Also a difference in hierarchical organization was perceived between the two perspectives (Taylor and Tversky, 1996). Survey descriptions are found to be more hierarchical, for example, at the start of a description the whole environment is divided into parts, and then each part is described in turn (Taylor & Tversky, 1992). Route descriptions, by contrast, are found to be linear (Levelt, 1982; Taylor & Tversky, 1992). Although Taylor and Tversky (1996) concluded that perspective was independent of hierarchical organization, indicating no difference in hierarchy between the two perspectives.

Hund et al. (2008) let American participants give wayfinding directions to fictional recipients to find if the participants would adapt their instructions according to the perspective of the recipient. It was expected that the participants would use a route

perspective when giving instructions to a recipient who was driving and use a survey perspective when the recipient was looking at a map. As predicted, the participants more frequently used landmarks and left/right directions when addressing a person who was driving through the town (route perspective). Cardinal terms were used more when addressing a person who was looking at a map (survey perspective).

By a replication of the study of Hund et al. (2008), Bangel (2009) found that Dutch people made minimal use of cardinal terms when giving wayfinding directions. In the study of Hund et al. (2008) and the first experiment of Bangel (2009) the four cardinal directions where explicitly mentioned by the experimenter at the beginning of the experiment. When, in a second experiment, the cardinal directions where not explicitly mentioned, Bangel (2009) found in a small sample that Dutch participants never mentioned any of these directions.

It is expected that cultural and environmental differences are causing the lack of agreement in these findings. The cultural differences could be due to the debated relation between cognition and language. The Sapir-Whorf (or Whorfian) hypothesis states that language influences thought (Hunt & Agnoli, 1991). Criticism of this hypothesis has usually focused on intertranslatability which implies that a statement in one language could be translated into a statement in another language. Since it is generally accepted that this translation is possible there is only room for a weaker form of the hypothesis. The weaker form of the Whorfian hypothesis states that each language favors some thought processes over others (Hunt & Agnoli, 1991). Differences in spatial cognition and spatial language across cultures could be the implication of the Whorfian hypothesis. Pederson, Danzigier, Wilkins, Levinson, Kita and Senft (1998) collected linguistic data for spatial relations across a varied set of languages. Linguistic coding was strongly correlated with the way spatial distinctions are conceptualized for nonlinguistic purposes (e.g. subjects from language communities where a relative frame of reference is dominant tend to perform nonlinguistic tasks using a relative frame of reference as well). Levinson (1997) explored the relation between cognition and language by comparing spatial descriptions of visual scenes in the Australian aboriginal language Guugu Yimithirr with a Dutch speaking sample. From the mixed results found in the Guugu Yimithirr population it was concluded that Guugu

Yimithirr speakers used both absolute and relative memory encoding for visual scenes while Dutch speakers only used a relative frame of reference when encoding visual scenes from memory.

Environments or parts of environments are also found to affect the perspective in which directions are given (Taylor and Tversky, 1996). Taylor and Tversky (1996) found that environments which contained only a single path and landmarks of approximately equal size stimulated a route perspective. A natural starting point was found to be related to a single path and therefore increased the likelihood of a route perspective. Survey descriptions were more likely when the environment had multiple paths or landmarks of different sizes. Relatively large and open spaces also promoted a survey perspective even as a natural external frame of reference. When cardinal directions are unknown, relatively large environmental features could serve this purpose. In case of a sea the frame of reference could be 'inland' and 'seaward'. Lawton (2001) found that participants referred more often to cardinal directions if they lived in the Midwest/West of the USA or when they lived in areas where the roads were arranged in a grid-like pattern. This could be an explanation for the different results found by Hund et al. (2008) and Bangel (2009). The participants in Hund et al. (2008) were students of an university in the Midwest of the USA were the land was surveyed using a systematic method known as the U.S. Public Land Survey (Lawton, 2001). This is in contrast to the Dutch participants in the study of Bangel (2009) who live in a country were 'blokverkaveling' is the traditional method of land partitioning. This method is used since the Iron Age for systematic mining of so called Celtic fields (Klok, 1977). This is analog with the metes-and-bounds system used in the rest of the states in the U.S.A. (Lawton, 2001). The patch shapes and boundaries reflect the underlying landforms. Majid et al. 2004 researched the association between ecological factors and the use of a particular frame of reference in a sample of 10 different communities around the world. Living in an urban environment was found to be associated with the use of a relative frame of reference and living in a rural environment with the use of an absolute frame of reference (Majid et al., 2004).

Because larger spaces promote the use of a survey perspective (Taylor and Tversky, 1996) it is expected that the Dutch population will mention more cardinal terms

when referring to a country scale environment than when referring to a smaller environment like a town. For example, the use of cardinal terms for a country scale environment is common in the Dutch weather forecast: “Landinwaarts wordt het overwegend droog, maar in de loop van de nacht neemt in het zuiden en zuidoosten de kans op regen opnieuw toe.” (“Inland it will be mostly dry, but during the night the likelihood of rain increases in the south and southeast.”) and “In de rest van het land laat de zon zich soms zien en komen vooral in het noordelijk kustgebied nog enkele (onweers)buien voor.” (“In the rest of the country there is the possibility of sunny weather and especially in the northern coastal area there will be some (thunder) storms.) (Koninklijk Nederlands Meteorologisch Instituut [KNMI], 2009).

The aim of this study is to compare the use route and survey perspective in a small and large scale environment. First more data for the second experiment of Bangel (2009) is collected to get a large enough sample size for a more reliable statistical comparison to the land map data. Second, the experiment will be repeated with a larger scale map of a country. The following hypothesis will be tested: are Dutch participants more likely to use cardinal terms when they are provided with a map of a larger environment (a map of a country) then when provided with a small scale environment (a town map)?

Method

Participants

40 Native Dutch speaking students (13 male, 27 female) from the University of Twente were participating in this study. The data of one female participant was excluded because one of the twelve route descriptions was missing. Most of the 39 participants (35) participated as partial fulfillment of course requirements. The other four students participated unrewarded. Age ranged between 18 and 27 years, with a mean age of 19.4 years. All participants gave informed consent and the experiment was approved by the local ethics board.

Apparatus

In the “town map condition” a fictitious model town on a 1.20 m x 2 m piece of white cardboard was used. The town contained 17 landmarks (e.g. hospital, park) marked by unique pictures and labels (see figure 1). The same pictures and labels were used as in the experiments of Hund et al. (2008) and Bangel (2009). 31 Streets were marked by purple tape and printed street names (see Hund & Minarik, 2006). In the “land map condition” a map of a fictitious country was used (1.20m x 2m). To differentiate between both maps, the map of the country contained 17 landmarks (e.g. beach, amusement park) which are not usually found in every town but on a more country based scale. These landmarks were marked by unique pictures and labels like in the town condition. To further empathize the scale of the map, highways instead of streets were marked on the land map. The highway system contained 31 highways marked by purple tape and printed road numbers (X1 – X31). The four cardinal directions were presented in a compass rose (9.5 cm x 9.5 cm) in the corner of both models. A red toy car was used to mark the starting locations. For the collection of the data participants were asked to type their route descriptions on a mini laptop (Compaq mini 700ED) with a 10.2 inch screen.

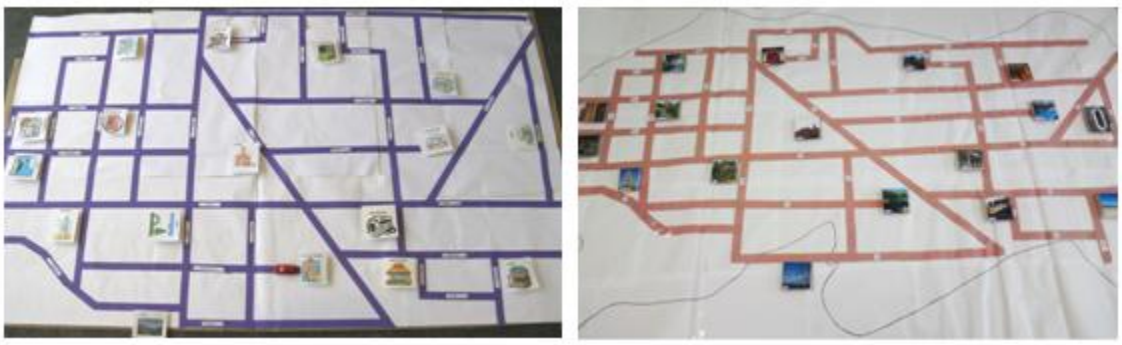

Figure 1. *The two maps used in the experiment: the town map (on the left) and the land map (on the right).*

Procedure and design

The participant was welcomed in a 12 m² room with one of the maps lying on a table (see figure 2). Participants were equally divided between the town map condition and the land map condition. The participant was asked to sit down at the table in front of a laptop. After the participant had filled out the consent form the experimenter explained the procedure of the experiment. Participants could look at the map for 30 seconds to familiarize with the model, after which the experimental twelve trials followed. Half of the participants started with the instruction to imagine giving navigation instructions to a person who has stepped out of his car and asks for directions using a map (survey perspective). The other half of the participants started with the instruction to imagine giving navigation instructions to a person who is driving through the town or the country (route perspective). At the start of each trial a red toy car was placed on the starting point and the destination was mentioned. Subsequently, the participant was asked to type the navigation instructions he or she would provide to the fictional recipient onto the laptop. No time restrictions were used during the experiment and the participants were allowed to walk around the map.

The order of routes (route perspective first/survey perspective first) was counterbalanced. For the first 3 trials of each perspective 3 of the 6 routes used in the study of Hund et al. (2008) where assigned randomly. For the other 3 routes in the two perspectives the 10 new routes used in the study of Bangel (2009) where assigned randomly.

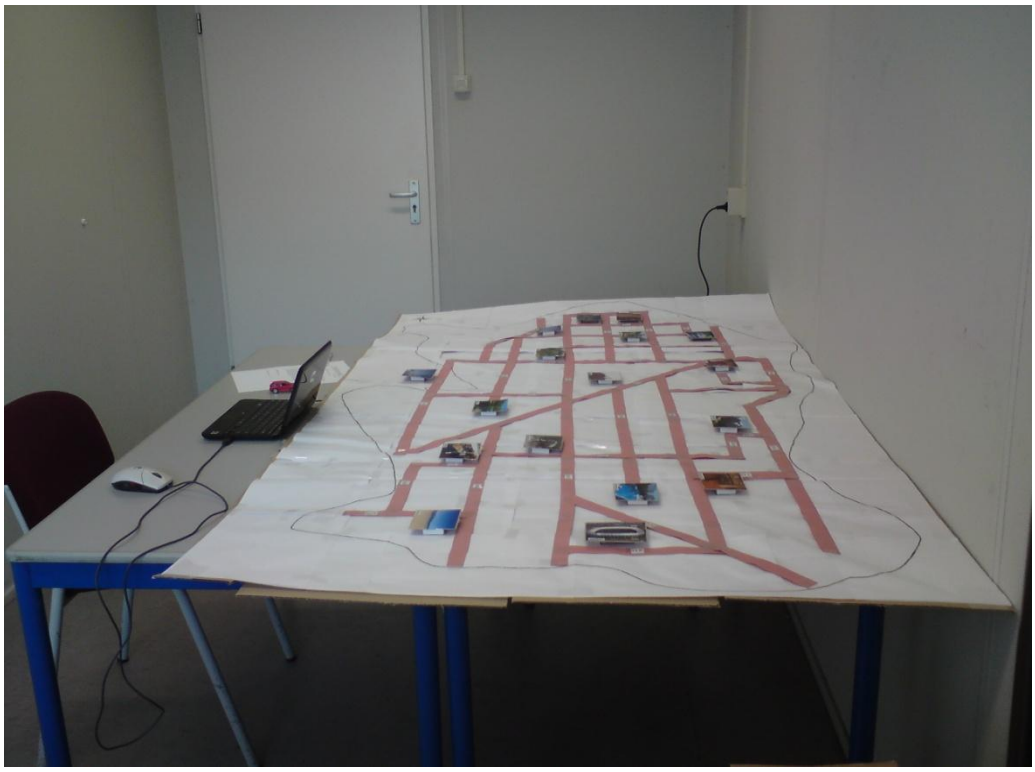

Figure 2. *The experimental setting in the land map condition.*

Data analysis

The navigation instructions given by the participants were coded by counting the frequency of each of 6 descriptive features (see Bangel, 2009). The navigation instructions given in the route and survey condition where counted separately for each participant. The 6 descriptive features were: cardinal directions (north, south, east and west), landmarks, street names/road numbers, left/right directions, distance in number of streets/roads and “distance other”. The independent variables of the experiment where: map, perspective and order, “descriptive features” was the dependent variable.

A statistical analysis was done using a 2x6x2x2 repeated measures ANOVA to analyze the use of the descriptive features all at the same time. Using perspective (route, survey) and descriptive features (cardinal directions, landmarks, street names/ road numbers, left/right directions, distance in number of streets/roads and “distance

other") as within-subject variables and map (town, country) and order (route-survey, survey route) as the between-subject variables.

Results

The effect of map was not statistically significant, $F(1) = .073$, $p = .79$ (see table 1). The analysis yielded a significant effect for perspective ($F(1, 35) = 5.04$, $p = .03$); more descriptive features where used in the survey condition ($M = 11.10$, $SE = .43$) compared to the route condition ($M = 10.27$, $SE = .28$). A significant difference in the use of the descriptive features was found ($F(5, 31) = 190.6$, $p < .01$). An interaction effect between perspective and descriptive features was found ($F(5, 31) = 2.57$, $p = .05$). The analysis did not yield any other significant effects (All $Fs < 3.65$, $ps > .06$).

A paired-samples t-test was used for further analysis of the interaction effect between perspective and descriptive features. There was a significant difference found between the use of street names/road numbers in route perspective ($M = 10.59$, $SD = 9.64$) and the use of street names/road numbers in survey perspective ($M = 14.97$, $SD = 11.58$); $t(38) = -3.13$, $p < .01$.

Table 1

Mean frequencies of the use of descriptive features in the two map conditions and the two perspectives. Standard errors are listed in parenthesis

Descriptive features	Town		Country	
	Route	Survey	Route	Survey
Cardinal	.00 (.00)	1.30 (.94)	.00 (.00)	.11 (.96)
Landmarks	7.15 (.70)	7.15 (.78)	7.34 (.71)	8.72 (.80)
Street names/road numbers	10.45 (2.03)	14.90 (2.66)	10.93 (2.09)	15.19 (2.73)
Left/ right	25.85 (.76)	23.55 (1.51)	23.82 (.78)	24.86 (1.55)
Distance (No. of streets/roads)	10.85 (1.01)	9.10 (1.12)	11.44 (1.03)	10.48 (1.15)
Distance (other)	8.80 (.97)	10.15 (1.04)	6.60 (.99)	7.72 (1.07)

Use of cardinal terms

Cardinal terms where only used by two participants and only in the survey condition. One of the participants mentioned a cardinal term 2 times. The other participant used 26 cardinal terms in the 6 survey descriptions. Because of the differences in the responses given by this last participant compared to the rest of the participants a closer look to this data was taken (see table 2). The most striking findings are seen in the survey condition. The use of cardinal terms of this participant is extreme compared with the no mentioning of any cardinal terms in 37 of the 39 participants. In the survey condition there is an extremely low frequency of the descriptive feature “left/right” in the navigational instructions of this participant (1 time compared to the average of 24.52 times (see table 1)). This indicates that this participant had substituted left/right directions for cardinal terms at the survey perspective. While the other participants made extensive use of left/right directions in both perspectives (see figure 3).

Table 2

Frequency of use of the descriptive features in both perspectives for the subject who made extensive use of cardinal terms in the survey condition

	Perspective	
Descriptive feature	Route	Survey
Cardinal	0	26
Landmarks	6	1
Street names/road numbers	29	28
Left/right	29	1
Distance (No. of streets/roads)	11	0
Distance (other)	13	7

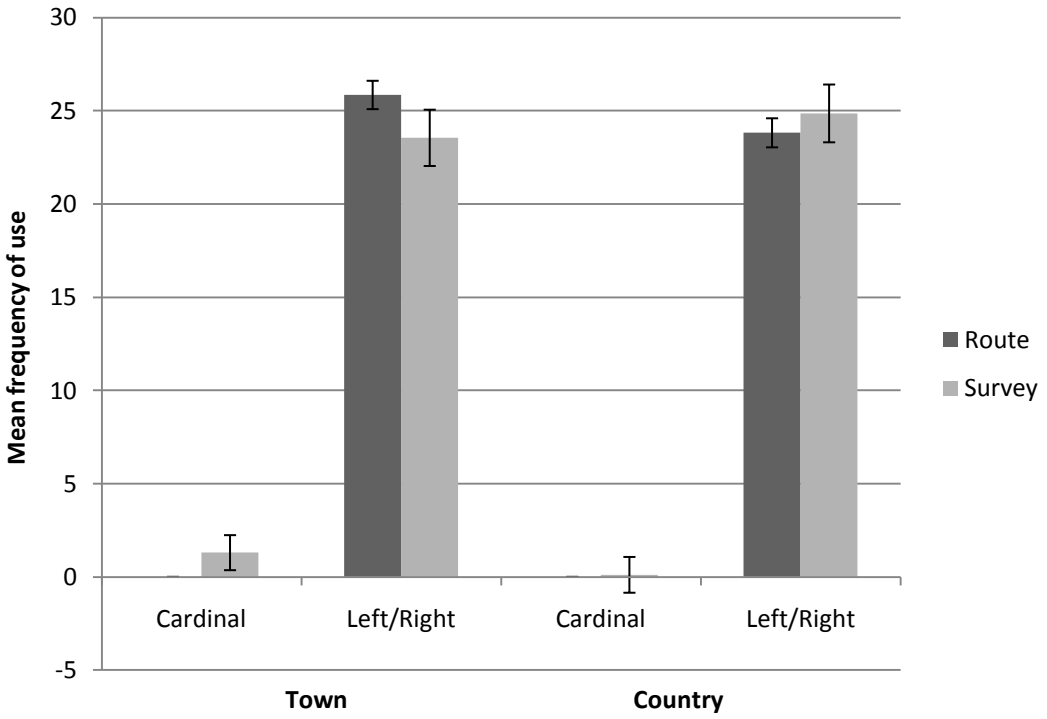

Figure 3. *Mean frequency of the use of cardinal terms and left/right directions (+SE) in route and survey perspective in the town and land map condition.*

Discussion

The main goal of the study was to examine the differences in navigation instructions given in a small scale environment (a model of a town) and a large scale environment (a map of a country). The hypothesis was that Dutch people, who made minimal use of cardinal terms in a small scale environment (see Bangel, 2009), would make more use of cardinal terms when giving navigational instructions in a large scale environment. This hypothesis was not confirmed by the data of the experiment.

No difference in the use of descriptive features was found between the map of the town and the map of the country. This finding indicates that the scale of the environment will not influence the perspective in which Dutch people provide navigation instructions to a recipient. Although in the weather forecast cardinal terms are often mentioned,

Dutch people did not use the cardinal terms themselves when giving instructions when provided with a land map. This finding could indicate that Dutch people would benefit from the use of left/right directions and would be handicapped by the use of cardinal directions in wayfinding instructions unregarded of the size of the environment.

However the limitations of the use of maps in this study should be kept in mind. Both the town map and the land map could be overseen entirely by the participants. The maps had the same physical size; the difference in scale size could have been too subtle to elicit a difference in navigational instructions by the participants. Further research should focus on a more realistic manipulation of the size of the environment to explore the relation between navigational descriptions and the size of the environment more thoroughly.

A difference was found in the frequency in which descriptive features where used. Cardinal terms where used scarcely while left/right directions where most mentioned in both perspectives. The other descriptive features where used intermediate in this order from lowest to highest frequency: Landmarks, distance other, distance in number of streets/roads and street names/road numbers. This indicates a clear preference for using left/right directions and a clear rejection of the use of cardinal terms when giving navigational instructions.

The change in instructions (from one perspective to the other) announced by the experimenter made most participants aware that they were expected to make a change in their navigational instructions. Most participants asked the experimenter during the experiment or afterwards what difference they should make/should have made in their navigational descriptions. Even though a difference in instructions was perceived and some participants felt a strong expectation to change something, only two participants came up with the use of cardinal terms in the survey perspective. The other participants used left/right descriptions to the same extent in both perspectives. Bangel (2009) explicitly mentioned the cardinal terms at the beginning of the experiment, still participants made minimal use of the cardinal terms in their navigational instructions. This indicates that native Dutch people are not used to use cardinal terms when giving directions. A limitation of this study is the artificial manner in which participants had to change perspective halfway in the experiment.

More descriptive features where used in the survey perspective compared to the route perspective. Street names/road numbers where more used in survey perspective than in route perspective while the rest of the descriptive features were used to the same extent. Bangel (2009) found the same result for the use of street names. However Bangel (2009) also found significant differences for the use of cardinal terms, landmarks, distance in number of streets and left/right descriptions.

According to the study of Bangel (2009) Dutch people, like American people (Hund et al., 2008), seem to adapt to the perspective of the addressee. This result was not replicated in this study. Participants hardly adapted their use of descriptive features to the perspective of the addressee. The difference in findings in the study of Bangel (2009) and this study could be due to the difference in instructions at the beginning of the experiment. The explicitly mentioned cardinal terms in the experiment of Bangel (2009) has induced the use of cardinal terms. This could have made survey knowledge and related descriptive features more available to the participants.

The extensive use of left/right descriptions compared to cardinal terms in this study indicates a preference for the use of a relative frame of reference in the Dutch population. Levinson (1997) also stated that Dutch people use a relative frame of reference in both their speech and in coding for nonverbal memory (e.g. remembering that you left your coffee “on the left side of the table” in stead of “on the west side of the table” when using an absolute frame of reference). Though it was found that Dutch people construct less effective spatial mental models of an environment when provided with a route description compared to a survey description (Noordzij and Postma, 2005; Noordzij et al. 2006). This could indicate a discrepancy between preference of perspective when getting from one place to the other or having to get a mental overview of an environment. However this research has only focused on the preferred perspective when giving navigational instructions. Further research is needed to conclude which perspective provides Dutch people the best information to get from one place to the other.

A preference for a certain perspective has implications for the way effective wayfinding instructions could be provided to Dutch people. This study indicates that

Dutch people are more comfortable with the use of left/right terms and are not used to cardinal terms in navigational instructions.

To sum up, this experiment showed that Dutch people tend to be uncomfortable with the use of cardinal terms when giving navigational instructions. This was found both in a small scale environment (a town map) as well as in a large scale environment (a land map). The use of cardinal directions in the study of Bangel (2009) seems to be the result of survey knowledge activated through priming. A clear preference for a relative frame of reference is shown by the extensive use of left/right instructions given by the participants.

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