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ORIGINAL ARTICLE

Analysis of verbal route descriptions and landmarks for hiking

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Abstract Along with the increasing number of mobile applications for pedestrian use a need arises for more intuitive wayfinding instructions, also for broader use such as hiking. To get a deeper understanding about what kinds of terms and concepts people use when moving in a natural environment and how they describe their surroundings, an empirical thinking aloud study was carried out in a national park during both winter and summer conditions. This study aims at providing additional knowledge on human verbal descriptions of routes and landmarks. The propositions of descriptions are classified into categories and analysed. The results of this study will be utilised for an implementation of a terrain navigator to support such leisure activities as hiking during different times of a year. The results of the analysis of verbal descriptions regarding hiking are discussed and compared with previous studies, and finally conclusions are given.

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1 Introduction

Although many research findings confirm the important role of landmarks for navigating, the use of landmark information is still rare in commercial navigation applications. Studies about landmark information are mainly focused on urban areas. To implement a location-based service (LBS) to serve such leisure time purposes as hiking, the question is in which way the landmarks, the spatial concepts and terms used, and the environment information needed for successful navigation are different for hiking in natural environments compared to, for example, the pedestrian case in built urban environments.

Let us call a device that supports us in hiking 'a terrain navigator'. A terrain navigator provides a digital map of the surroundings and it also supports us in several ways when hiking, cycling or skiing in a national park. In many aspects, it can be compared to a car navigator. It provides a route planning functionality along the hiking trails and also supports personal navigation while we are moving. It is also able to inform us about the accessibility of the trails or warn us of any obstacles on the trail. We have learned from car navigators that they can provide turn-by-turn directions in text form, which can also be given to the user as voice-based instructions, and similar functionality can be expected to be useful in the terrain navigator, especially to support such user groups as un-experienced hikers to ensure their safety.

To be able to provide sensible route guidance in environments such as national parks, a terrain navigator must have access to information about the hiking trails and their

surroundings. The information of the hiking environment is available to a terrain navigator through the digital maps, also called 'geographic information' (GI). From the GI it is possible to infer deeper information like spatial relationships between one or several geographic features, or between the user's current location and one or several geographic features.

The aims of our study are to collect and analyse spatial descriptions people use when hiking in the forest and to examine which kinds of landmarks they rely on. The final goal of our current research is to provide users with additional voice-based navigation instructions [13, 14] on top of a visual map in order to increase the hikers' safety and to ensure that they are on a right trail. Such voice-supported LBSs can only be based on appropriately formalised spatial knowledge. The purpose of the present study is to provide an empirical basis for the formalisation.

1.1 Previous studies

Routes have a particular role in human thinking of spatial reality. Route-like organisation of spatial knowledge is identified as part of the human spatial mental model, and often as an alternative for the survey-like model [11, 20–22]. Route knowledge is procedural knowledge in a form of sequence of locations and their characteristics. Route knowledge consists of trajectories having a starting point and an end point. It is linear and thus differs from two- or three-dimensional survey knowledge that forms an overall representation of the environment. Route-like representation of space is straightforward to be communicated orally, textually or graphically.

Route-like spatial knowledge is tightly linked to the wayfinding task that is one of the most frequent human activities performed through spatial cognition [12]. The route knowledge is an important research subject as comprehension of it gives answers to how route instructions should be communicated in automated navigation. The composition of route knowledge in the human mind can be modelled theoretically by identifying the primitive conceptual elements of wayfinding as presented by Klippel [12]. Klippel bases his model on so-called choremes with which all essential information about the routes to be navigated can be exposed. The choremes are combined into usable expressions of spatial entities through spatial cognitive processing called chunking.

The structure of route knowledge in the human mind can be experimentally studied through analysing verbal route descriptions. The verbal output reveals the characteristics of underlying spatial cognitive processes. The processes differ according to how the collection of descriptions is made. Route descriptions can be collected 'on route' or 'not on route', for example in laboratory circumstances. The descriptions given 'not on route' are based on long-term memory and often occur in the form of route instructions. Verbal formulation of route instructions is preceded by non-linguistic cognitive processes that include the construction of mental imagery and activation of spatial representations [1, 6]. In the data collection situations 'on route', verbal formulation is rather preceded by cognitive processes of perception that require mainly working memory [17].

Analysing verbal route descriptions is a linguistic task. Denis [6] observed his collection of descriptions to consist dominantly of propositions that introduced actions and landmarks. Based on his data, he created a five-class classification of spatial propositions: (1) action only, (2) action with reference to landmark, (3) landmark introduction, (4) landmark description and (5) commentary. Denis' classification provides a general framework for analysing route descriptions, and it has been used in several comparable studies. These studies and their respective distributions of propositions into Denis' classes are listed in Table 1.

The authors of the previous studies [3, 5, 6, 17] applied Denis' definition of a landmark. Denis [6, p 418] defined landmarks to be 'mainly three-dimensional physical objects, of which some are natural parts of the environment and some are artifacts designed to signal directions. The two-dimensional entities on which displacements are executed can also be used as landmarks'. Daniel and Denis [5] did not give any additional definition. Brosset et al. [3, p 22] added that 'places were identified as landmarks' and Rehrl et al. [17, p 474] that 'for the classification we treated all kinds of [spatial] entities as landmarks'. It appears to us that these statements accord with Denis' definition, and the results of the previous studies are comparable.

According to Table 1, landmarks are a prominent part of verbal route descriptions as they have been used in at least 78% of propositions among the cited studies (Classes 2, 3 and 4). The amount of landmarks is especially notable in the experiments of Rehrl et al. [17] in which the propositions containing only actions (Class 1) are noteworthy rare. This might be explained by the data collection method as Rehrl et al. are the only reference listed who collected the descriptions 'on route'.

Intuitively, the environment should have an effect on the contents of the route descriptions. For instance, urban and natural environments differ essentially from each other as the former mainly consists of distinguishable objects with clear boundaries and the latter is full of fuzzy objects with indetermined boundaries (for discussion on geographic objects with indetermined boundaries see e.g. [4]). So far, few studies have been made in non-urban environment. Brosset et al. [3] collected their route descriptions in the natural environment and found the portion of landmark

Table 1 Distributions of route propositions into Denis' classes [6] in comparable studies

Author	Year	Output	Data collected	Environment					
Denis	1997	Speech	Not on route	Urban	17%	34%	36%	11%	2%
Daniel&Denis	2004	Text	Not on route	Urban	16%	41%	28%	13%	2%
Brosset et al.	2008	Speech	Not on route	Natural	17%	35%	16%	27%	5%
Rehrl et al.	2009	Text	On route	Urban	4%	44%	24%	24%	4%

action | action & landmark | landmark | landmark description | comment

descriptions become larger than in preceding comparable studies (Table 1). Rehrl et al. [17] found a similar phenomenon in their study in an urban environment and explained this as resulting from the collection of descriptions 'on route'. Still, Brosset et al. [3] found fewer landmark introductions (Class 3) that might be peculiar to natural environments where landmarks in propositions are often combined with actions to specify the direction.

The communication channel might also have an influence on the route descriptions. Daniel and Denis [5] collected their descriptions in written form and this resulted in larger frequency of action-related propositions (Classes 1 and 2) than in other studies where the data were collected 'not on route'. The explanation might be that writing produces more processed descriptions than spontaneous speech.

The research on integrating landmarks into wayfinding descriptions mostly covers studies in urban environments. Elias et al. [8] stated that humans prefer to communicate navigation instructions in a more natural way, namely in terms of landmarks that are the prominent objects along their route. Therefore in their study, similar to Raubal's and Winter's [16] study, the routing directions are enriched with landmarks. The landmarks may support wayfinding as decision points [7]. Elias et al. [9] studied landmarks as important part of effective wayfinding instructions. The question in their study was whether the use of objects as landmarks in pedestrian navigation in built environment is varying between user groups. They found that the five most frequently used landmarks worked for all groups studied.

Contrary to the studies above, in the study of Snowdon and Kray [19], the importance of natural landmarks when navigating in the wild was addressed. Their study consisted of two parts: firstly a questionnaire-based study that aimed at establishing current practice (e.g. what technology people use and what kinds of natural landmarks they use when navigating in the wild); secondly Snowdon and Kray used a video based-approach that resulted in a realistic visual simulation of the natural environments. According to their results, the most frequently used landmarks were peaks and water courses. Further popular landmarks included woods, rocks, locks and gorges. Although they asked the participants to list natural landmarks also man-made structures were listed. It should be notified that pathways and routes in their study were considered as important landmarks by the participants.

In Ishikawa's and Montello's [10] research on landmarks, they regarded spatial knowledge as knowledge about the identities of discrete objects or scenes that are salient and recognisable in the environment. Raubal and Winter [16] stated that research in spatial cognition has shown that people use landmarks during spatial reasoning and communication of routes. They discussed about the meaning of landmark and said that being a landmark is a relative property, and the landmark saliency of a feature depends on the distinction to attributes of close features. In defining landmarks, also Presson and Montello [15] emphasised the relational nature of the cognitive space. Whether the term 'landmark' is comprehended as spatial or cognitive reference points, the context in which they are reviewed is important. In our present study, one of the aims is to identify which kind of landmarks are most prominent when moving in the wild, and therefore, we follow the practice shown by Snowdon and Kray [19], according to which even paths and types of woods or particular features of the landscape may be considered as landmarks supporting the navigational decisions during the hikes.

1.2 Goal of the research and research questions

This study is part of two ongoing research projects. The goal of the HaptiMap project is to make LBSs and map applications accessible for user groups with various disabilities, including elderly people with reduced vision. The goal of the second project, UbiMap, is to develop new knowledge, theoretical understanding and research methodology related to ubiquitous spatial communication. In focus is the interactive 'map' that is explored as a user interface between the user and the surrounding environment. The case studies of these projects the Finnish Geodetic Institute is focusing on are related to hiking in the wild. From the user studies, we have identified that audio

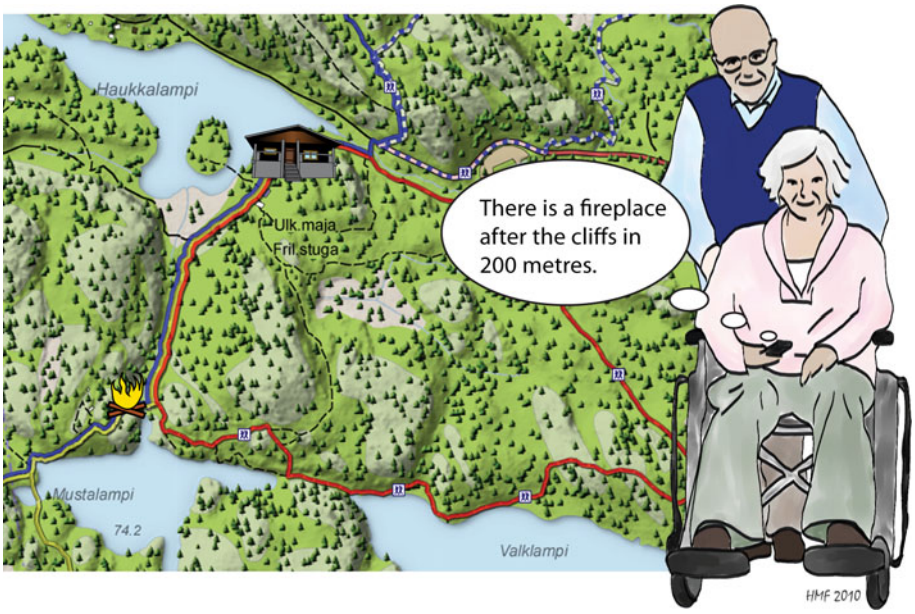

Fig. 1 The results of this study will be utilised in the implementation of a terrain navigator

channel could potentially be a valuable additional channel besides visual representation, to support people hiking in such places as a national park. At a later stage of the projects, our aim is to implement a mobile application (coined a terrain navigator by us) that will provide simple speech descriptions of the surrounding and navigation instructions for hiking purposes. Figure 1 illustrates the overall scenario of the two projects.

The purpose of the present study is to provide a theoretical basis for the design of our terrain navigator. The next step will be to study how the spatial terms should be formalised, so that they can be utilised in the implementation of the navigator. The central question regarding a terrain navigator is what kind of spatial concepts and terms people use when hiking. Are the concepts and terms different from navigating in urban environments? We are also interested in what kind of role do the seasons have in navigating. Do we need remarkably different instructions during winter compared to summertime?

2 Methods

This empirical study aims to provide additional knowledge on human verbal descriptions of routes and landmarks compared to the results from previous studies. Denis' [6] classification has been used in several studies [3, 5, 6, 17] and provides a means to compare verbal route descriptions collected in experiments in different environments, conditions and with different kinds of participants. Rehrl et al. encouraged colleagues to carry on similar set-ups in order to widen the empirical foundation. We applied Denis and Rehrl et al. in our study but expanded their method to cover such a natural environment as a national park. Furthermore, we carried out our study and repeated the same test set-up both in the summer and in the winter. In the following, the method used in the present study is described.

2.1 Experimental set-up

Verbal route descriptions were collected in an experiment during which the test persons were taken into a national park where they had to walk through a route that they did not know beforehand. Before the test, the instructor explained the task both verbally and on paper. The assignment was as follows: 'Describe everything you find remarkable in the surroundings and explain their locations. Stop when you have to make a decision about which route to take. Describe the options in detail'.

The participants did not use any navigational aids such as maps, compasses or navigators. Each participant conducted the route individually with the instructor who kept quiet. The instructor asked the participants simply to follow the route until she/he came to a point where she/he had to make a decision about the way to continue. At the decision point, the participant had to describe the possible options by thinking out loud [2]. After the participant had introduced the alternatives, the instructor pointed the direction to continue. Our main interest was on the decision points, but we also wanted to involve continuous observation of the surroundings during the test, as there are relatively few decision points on the footpaths in the forest. In addition, especially in a natural environment, it is important to be able to assure one's location frequently. We also assumed that describing continuously would keep the participant's attention on the surroundings and on the given task.

The test route with a total length of 1.2 km was defined prior to the test sessions. Walking through the route took about half an hour, and we calculated it to contain 24 decision points (Fig. 2). A half of the route consisted of marked hiking routes, while the other half consisted of small non-marked paths in the forest.

The extraction of route propositions began by writing transcripts of the audio records word by word, only excluding exclamations such as 'well'. Next, the transcripts were split into expressions that included one entity each. An example of splitting can be seen in Table 2, which also explains the next phase, i.e. the extraction and classification of propositions. The propositions are elementary constituents of the expressions that can be identified and classified according to Denis [6].

The classification of propositions was an extensive work in the present study and needed attention. As the expressions sometimes contained multiple propositions, we might classify one expression into multiple proposition classes. At decision points, we made an interpretation that the introduction of directions involved an action (path to the right → turn to right) and a landmark (path). This is the case with the first row in Table 2 where 'path to the right' consists action (turn to right) and landmark (path) and 'very small' a landmark description. This kind of multi-classification was not made in the reference studies [6, 17], which transformed the original expressions into more elementary parts before classifying them. However, we split the expression to different rows if it contained more than one proposition in one class. We argue that our method of classification produces comparable results because the overall amount of propositions is not affected.

The classification of different transcripts was first made by individual researchers. To avoid subjective outcomes, the classification was then revised in the group of the same individuals. We established some classification rules in order to handle common vague cases congruently, for example 'Description of the path on which the person walks is always classified as "Landmark description".'

2.2 Test environment and routes

The experiments were carried out in the Nuuksio National Park in southern Finland that is a popular outdoor area inside the capital region. The area consists of conifer forest with small hills and many well-maintained hiking routes as well as footpaths originating from numerous hikers in the area. There are a few buildings for recreational purposes, such as an information centre.

The winter experiment was carried out during winter 2009–2010. The amount of snow on the ground varied from a few centimetres to 40 cm, and the temperature decreased down to −20°C (Fig. 3). To make it possible for the participants to recognise the snowy footpaths and to prevent them from only following the routes marked by footsteps of former hikers, we walked through the paths to make them recognisable before the test session. The summer experiment was organised during summer 2010. The trees had leaves, and the undergrowth was full-grown then. The weather conditions regarding clouds, temperature and the depth of snow were recorded for each separate test session.

Each test session was documented by audio and video. The video recording was challenging on the narrow

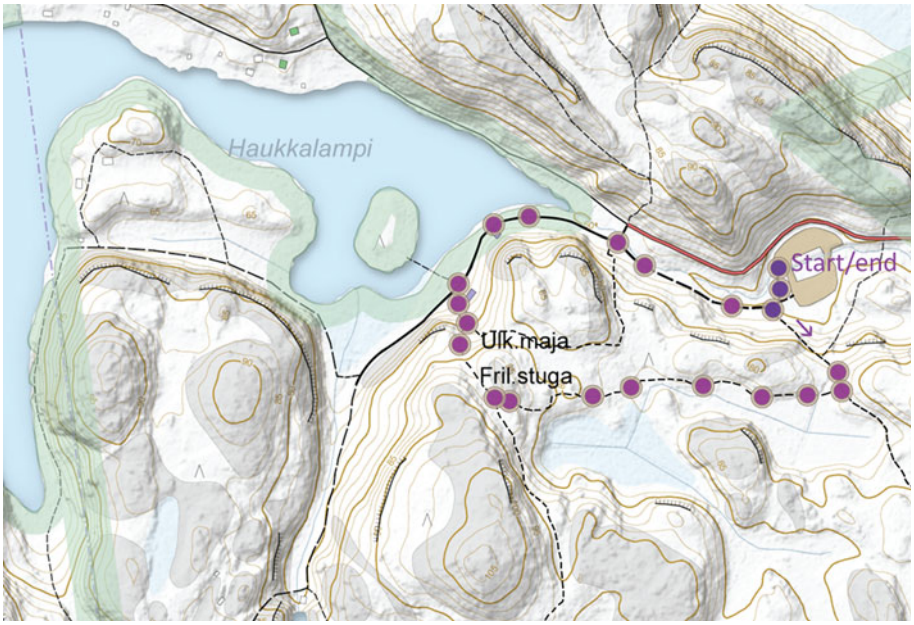

Fig. 2 Participants followed a route defined prior to the experiment. The route consisted of 24 decision points

Table 2 Examples of expressions and the classification of propositions according to the route description classes of Denis [6]

Expression	Action	Action & landmark	Landmark	Landmark description	Comment
There was a very small path to the right and		1		1	
There are some tracks on the path but it's…					1
The trees are growing very near to the path and				1	
If there were no tracks it wouldn't be visible at the moment					1

Fig. 3 Snow conditions varied from 3 to 40 cm during the experiment in December–January

paths, and therefore, two complementing recordings were necessary.

2.3 Participants

At this early stage of our research, the aim was to gather qualitative data on the terms used in hiking. Twenty test persons aged from 19 to 53 years participated in the experiment, six women and fourteen men (Table 3). All participants spoke Finnish that is their mother tongue. In Table 3, the 'Experience' column describes the frequency of visits to the forest. It was measured according to the following categories: never (0), fewer than once a month (1), few times a month (2), few times a week (3) and daily (4). The 'Familiarity' column refers to the former knowledge of the test area, and it was divided into three categories: never visited (0), visited 1–3 times (1) and visited more than 3 times (2).

The participants filled in a background questionnaire before they started the experiment. Contact information of the participants and some background information, such as birth year, profession and previous hiking experience, were asked. The participants received instructions on the thinking aloud method and the experimental set-up, but they were not told about the specific aim of the study. They were asked to stay on the paths and speak out loudly and clearly and to describe their observations in detail. They were also informed that the instructor would remain silent during the experiment and just point the right way to continue. However, if necessary, the instructor might ask the participants to elaborate if the description was too short at the decision points (Fig. 4).

After the test sessions, the research group conducted a transcript of each participant's observations with the aid of the audio and video recordings. The transcript was then divided into expressions, as shown in Table 2.

3 Results

Table 3 shows the amount of decision points found by the participants, calculated during the transcription. The amount varied from 7 to 18 between the participants. The participants who found the most decision points had not earlier visited the test area.

After the transcript, all expressions were further processed into propositions. The participants stated a total of 2,508 propositions in the winter and 2,614 propositions in the summer experiments. The propositions were grouped into classes of 'Action', 'Action and landmark', 'Landmark', 'Landmark description' and 'Comment' after Denis [6]. The propositions were examined as the sets of (1) all propositions, (2) propositions stated at decision points and (3) propositions between decision points. Figure 5 shows the distributions of the propositions in the three sets.

Table 3 Participants' background information and the amount of the found decision points

Participant	Gender	Age	Experience [0–4]	Familiarity [0–2]	Decision points found
Winter					
a	M	42	3	2	10
b	F	35	2	2	10
c	M	26	2	1	9
d	F	53	3	2	10
e	F	36	3	0	10
f	M	22	2	1	11
g	F	19	2	0	18
h	M	26	4	1	11
i	M	27	3	1	10
j	M	41	2	0	12
Summer					
k	F	25	3	2	11
l	M	28	3	1	13
m	M	27	3	0	9
n	M	29	2	0	10
o	M	25	2	0	10
p	M	25	3	0	12
q	M	28	1	2	9
r	M	34	3	2	11
s	F	40	2	0	18
t	M	51	2	1	7

Landmark-related propositions ('Landmark' and 'Landmark description') comprised 55% of all propositions in the winter and 66% in the summer. Propositions related to action ('Action' and 'Action and Landmark') covered 20% of the total amount in the winter and 15% in the summer (Fig. 5). At decision points, there were more action-related propositions introduced, and the actions were more often related to landmarks. For example, the participants rather than saying 'Turn left' preferred to say 'Turn left towards the big stone'. The percentage of action-related propositions at decision points was 36% both in the winter and in the summer.

Between decision points, the class of landmark descriptions was the dominant one in both seasons. Landmark-related propositions were used more between decision points than at decision points (60% in the winter and 68% in the summer). The amount of action propositions ('Action') used in expressions was low, and the role of landmarks was significant. In the winter, there were many remarks on snow conditions included, such as 'Someone else has walked here' or 'There are trails in the snow'. In the summer, many propositions mentioned temporary phenomena such as flowers or birds. This explains the relatively high amount of 'Comments'.

The amount of propositions varied significantly between participants (Fig. 6). The distribution of propositions among different classes is nearly similar between participants. Most participants had either of the landmark-related categories as the largest one except 'h' and 'i' who introduced more commentary expressions.

At decision points, the 'Action and landmark' class was frequently used to introduce route alternatives. While classifying the propositions, all the introductions of route alternatives were categorised in the 'Action and landmark' class. Still the 'Landmark description' class was most frequently used. Between decision points, the propositions were mainly observations of the surroundings, categorised in 'Landmark' and 'Landmark description' classes. The number of propositions varied noticeably between the participants.

Fig. 4 Each separate experiment was documented by audio and by video. The participants described their route possibilities and observations

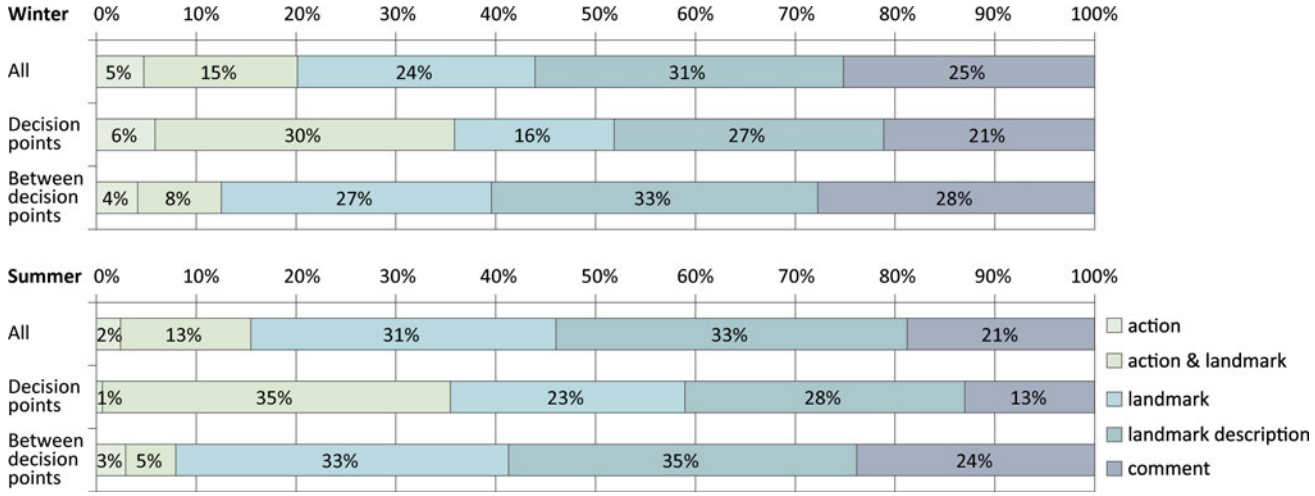

Fig. 5 The distribution of propositions in route descriptions

The distribution of classes between participants varied greatly both at decision points and between decision points. Naturally, the participant's personality and way of speaking affected the results. Most participants spoke more at the decision points than between decision points.

From the analysis, the importance of landmarks and their descriptions can be clearly noticed; in fact landmarks were included in most of the propositions (70% in the winter and 79% in the summer). Describing an action is also most commonly linked to landmarks. This shows the pronounce role of landmarks during hiking.

In order to further study the landmark usage in route descriptions, we extracted landmarks from the transcripts and grouped them into homogeneous landmark classes. We ended up in eight landmark classes and calculated the amounts of their usage in the transcripts. Landmark classes are seen in Table 4 in a descending order based on their amount of usage. Similarly, we identified spatial expressions used in route descriptions and calculated their amounts of usage. An example of expressions used in winter descriptions is shown in Table 5. 'Passages' had the greatest difference between the seasons. The 'passage' landmarks were used 11.0% units less in the winter than in the summer. The 'passage' landmarks, such as roads, paths and crossings, were more visible in the summer when they were not covered by snow, which seemed to lead the participants to mention them more often. The 'landforms' was another landmark class the usage of which differed considerably between the summer and the winter. The 'landforms' group was used 3.6% units more frequently in the winter experiments. The difference may result from the snow coverage that makes large landforms more visible as the ground details are hidden, but also because slopes were slippery in the winter experiments and the participants recognised the hills due to the slipperiness.

4 Discussion

Hiking in the forest is significantly different from walking in a built urban environment where, for example, street names and well-known buildings support navigation. It was found in this study that landmarks had a central role in verbal route descriptions in a hiking environment as well.

While classifying the propositions according to Denis [6], some interpretation was needed in order to place expressions in the corresponding classes. The research team's thorough knowledge of the test area supported the classification phase. For example, propositions about forest type could be classified as 'Landmark' or 'Landmark description' depending on how distinct the forest type was as a landmark.

Our Denis' classification of the propositions collected from the route description experiments resulted in dominant frequencies of landmark-related proposition classes both in the summer (79%) and in the winter (70%). The dominance of landmark-related propositions was similar to the earlier experiments that used the Denis' classification [3, 5, 6, 17]. Our results confirm the importance of landmarks in route descriptions in a natural environment. The importance appears to be more significant in the summer when more landmarks are visible than in the winter when terrain and many landmarks are covered by snow.

Our study differs from the set-ups in previous studies [3, 5, 6, 17] by being carried out both in a natural environment and 'on route'. Further, we collected route descriptions from the whole route that differs from Rehrl et al. [17] who collected the descriptions at decision points only. In addition, our analysis was separated into propositions at decision points and between decision points.

In our study, we followed Denis' definition of a landmark. However, Denis' study was carried out in a built

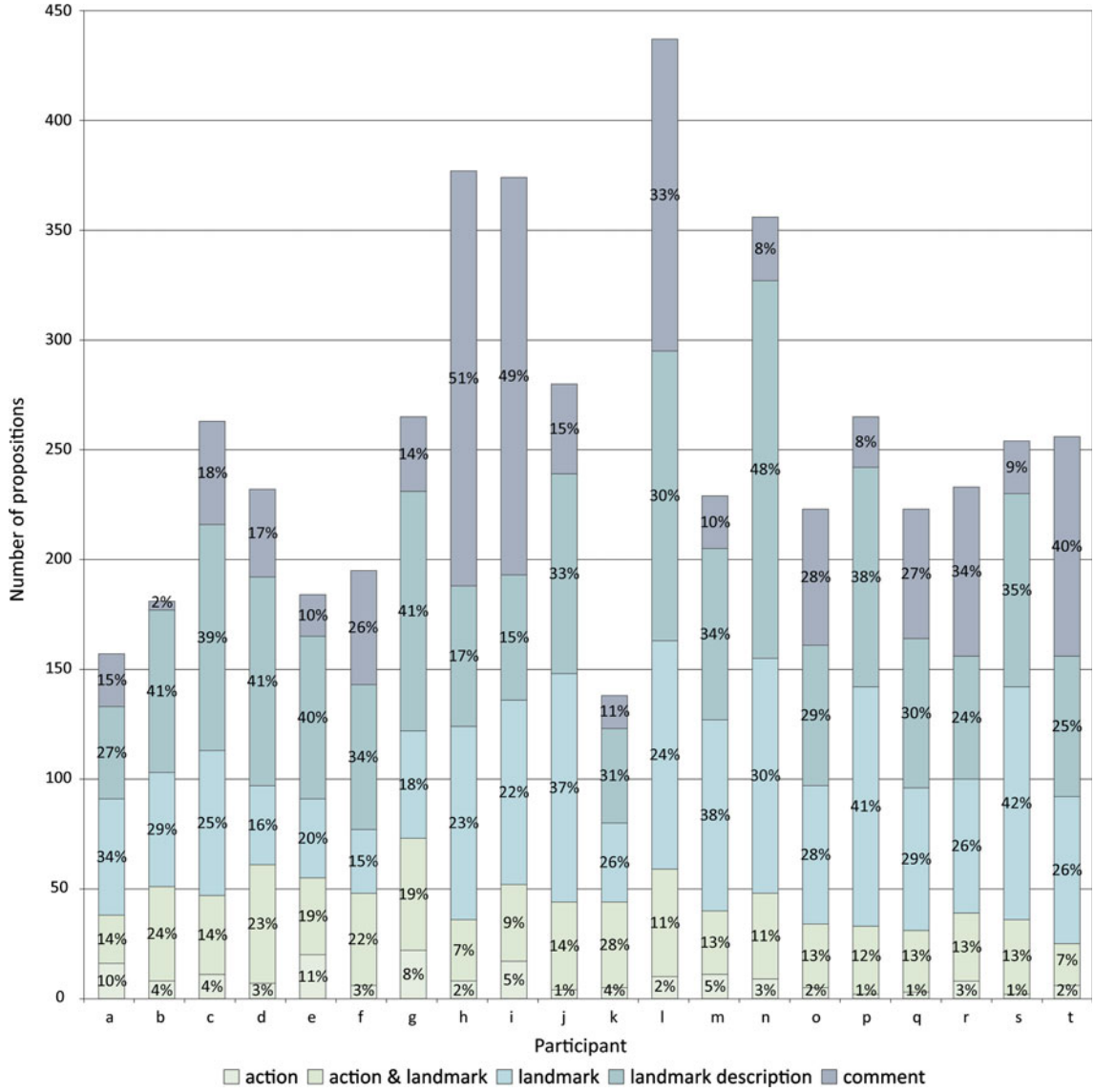

Fig. 6 The distribution of all propositions between participants. Participants *a–j* took part in the winter experiments and *k–t* in the summer experiments

environment, while our study was in a natural environment. Our finding was that it is harder to identify the landmarks in a natural environment than in an urban environment because the landscape is dominated by continuous objects and objects with indetermined boundaries, such as vegetation and landforms. For example, the forest may be present everywhere around, but it may also include separate patterns that can be used as landmarks, such as thickets. Our requirement for an object to be considered as a landmark was that it is clearly distinguishable from its surroundings. In addition, we excluded temporary objects, such as flowers, spoors or cars.

Our study indicated more frequent use of landmark-related classes ('Landmark' and 'Landmark description') and less frequent use of action-related classes ('Action' and 'Action & landmark') than the previous studies. In a natural environment, there are less easily identifiable landmarks than in urban environments and more landmark description is needed. In all of the five studies, actions were most commonly linked to a landmark, which seems to be a natural way to communicate spatial descriptions. At decision points, landmarks were referenced to actions more often than between decision points. This is because description of route alternatives at decision points involves actions. Our study included more propositions in the 'Comment' class than the previous ones. This is explained by numerous propositions concerning snow conditions, footprints, flowers and similar features that were not regarded as landmarks because of their impermanence.

Table 4 Distribution of usage of landmark classes

Landmark class	Percentage among landmarks in the winter (%)	Percentage among landmarks in the summer (%)
Structures (cabin, bridge, …)	24.1	22.0
Passages (road, crossing, …)	9.5	20.5
Trees and related (spruce, stump, …)	20.0	17.6
Waters (lake, ditch, …)	17.5	16.5
Landcover (spruce wood, marsh, …)	8.0	7.1
Rocks (stone and bare rock area)	5.9	6.9
Signs (route mark, information board, …)	8.5	6.4
Landforms (uphill, pit, …)	6.6	3.1
Landmarks/all words	10.2	10.1

Table 5 Ten most used spatial expressions in winter

Spatial expression	Amount	Percentage among spatial expressions (%)
Here	296	17.6
Right	225	13.4
There	219	13.0
Left	175	10.4
On the side of	98	5.8
Towards	61	3.6
Ahead	59	3.5
Forward	57	3.4
Downwards	36	2.1
Over	33	2.0
Spatial expressions/all words	1682/11092	15.2

In the winter, the snow and weather conditions affected the surroundings in many ways, such as covering the paths (Fig. 3). Footsteps of previous hikers in snow affected significantly the observation and use of footpaths. Some footpaths were impossible to see because of the snow. It improves the visibility since there are no leaves on the trees in the winter. On the other hand, snow-covered coniferous trees may reduce visibility. Seasons affect the observation of landmarks and different sets of landmarks are observed in winter and summer. Our study shows that the effect of season should to some extent be considered in the development of LBSs for such purposes as hiking. For example, Sarjakoski and Sarjakoski [18] have addressed the issue of using time and season as context parameters for adaptive mobile maps. In Snowdon and Kray's study [19], the most frequently used landmarks were peaks and water courses, and they state that the appearance of such natural landmarks vary little according to the time of the year. Their study was carried out in Newcastle, UK. It should be noted that in wintertime in such regions as Finland, water courses are covered with snow or frozen into ice, which makes them difficult to be identified. In addition, small lakes can be confused with clearings or fields.

The calculation of landmarks in the route descriptions showed that 'structures' was the most frequently used landmark class both in the summer and in the winter, although the number of structures was low by the route. The 'structure' features were good and reliable landmarks because they were clearly visible in the national park during both seasons. Our experiments verify that 'structure' landmark class should always be included when providing route instructions in this kind of environment. Other important landmark classes during both seasons were 'trees and related' and 'waters'.

Two considerable differences between summer and winter were seen in the usage of the landmark classes. The 'passage' landmarks were used less in the winter mainly because of the lack of visibility of footpaths. The result suggests that footpaths should not be given a large role in creating route descriptions during a snowy wintertime. The 'landform' landmarks were used more frequently in the winter than in the summer, which appeared to originate from the fact that landforms are more visible in the winter due to snow surface. Hence, landforms could be used in route descriptions in a natural environment in the winter, although they were the least used landmark class in our experiments. In the summer, the use of landforms as route landmarks must be considered more carefully.

5 Conclusions and future work

The results of the presented empirical study, carried out in a national park, emphasised the role of landmarks during hiking. The landmarks were included in most of the propositions (70% in the winter and 79% in the summer). This result supports the previous studies that have been conducted in urban environments for pedestrian navigation. In our study, more propositions on 'Landmark description' class were introduced, this is because it is more difficult to identify distinct landmarks in natural environments than in urban environments, and thus, more depiction is needed. The study classified the used propositions into the categories introduced by Denis [6] and identified the most commonly used hiking-related landmark classes from hikers' route descriptions. Summer and winter require different design of automated navigation regarding landmarks. For example, after heavy snowfall some, even prominent, landmarks are hidden.

The work continues by making an in-depth study of the landmarks and examining whether the participants have noticed the same landmarks and how significant they consider those landmarks to be. Since the landmarks are important in navigation in a natural environment, a question arises how the detail of landmarks can be extracted from geospatial data to better guide hiking.

The results of this study will be utilised for an implementation of a terrain navigator to support such leisure activities as hiking during different times of a year. Our study is still an ongoing research that will continue with the final goal of describing the most important spatial concepts and terms regarding hiking in such a formal way that they can be utilised when implementing a terrain navigator to support hiking purposes.

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