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More Than a List: What Outdoor Free Listings of Landscape Categories Reveal about Commonsense Geographic Concepts and Memory Search Strategies

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Abstract. Categorization is central to abstraction from real world geographic phenomena to computation representations, and as such has been the subject of considerable research. We report on one common approach, free listing, in an outdoor setting and explore terms elicited in response to the question '*What is there for you in a landscape?*'. We collected term lists, and explanations for the strategies used from 89 participants in two mountain and one parkland setting. We analyzed results not only using term frequency, but also by cognitive saliency, exploring list structures, and building aggregated networks visualizing links between terms. We observed memory search strategies, such as exploiting and switching semantic clusters in our data, with participants using for example not only the local setting to start clusters, but also memories of familiar landscapes to switch between clusters. Our results reveal that simple free listing experiments can help us understand how categories are linked, and also highlight ways in which landscapes are conceptualized.

Keywords: geographic categories; landscape categorizations; commonsense geography; GIS; memory search; free lists

1 Introduction

Fundamental concepts like categories [1] are important when considering abstractions from real world geographic phenomena to computational representations (e.g. [2-4]). Knowing how humans parcel up geographic space into objects – in other words how we form categories – is thus an essential step on the way to supporting non-specialist use of geographic information. However, gaining knowledge about categories is non-trivial, and a wide range of approaches have been used. These range from elicitation

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tasks based on a variety of stimuli in relatively controlled settings (e.g. [5,6]), through ethnographic methods [7], to crowd sourcing experiments [8] and, analysis of user generated content [9,10]. Recent work demonstrates empirically that categorization of landscape features varies linguistically and culturally [11,12]. Therefore, the importance, but also the challenge, of understanding categorization in a practical sense becomes increasingly apparent, since, as succinctly summed up by Smith and Mark, ontologies, and thus categories:

> *can help us to understand how different groups of people exchange (or fail to exchange) geographical information, both when communicating with each other and also when communicating with computers.*
>
> ([13], p. 592).

In this paper we explore free listing as one of the simplest, but also most common approaches to exploring categories. We do so by exploring an explicitly geographic domain (landscape categories), with real societal relevance – for example only defined categories can be considered in managing and quantifying landscapes [14,15]. We go beyond previous work on free listing of geographic categories, by exploring not only the frequencies of the terms stated, but also their order, their cognitive salience, and compare results in different landscape settings. In analyzing our results we set out to demonstrate how combining empirical fieldwork with theory from cognitive research can help us not only to better understand our data, but also suggest potential recommendations with practical implications.

In the following we first give an overview of the different disciplinary perspectives of categorization, providing the theoretical background for this paper, followed by the methods used to elicit and analyze free lists of landscape categories. We then show how the landscape in which outdoor experiments are conducted seems to influence the terms listed, their frequency and saliency, as well as the memory search strategies participants apply.

2 Background

Categorization has been a subject of study in various research fields ranging from anthropology, linguistics and psychology [16-21] to geography and information science [22,23]. For example, Rosch's seminal work on prototype theory and the existence and primacy of basic-levels established categorization as a major field of study within cognitive psychology [1].

One way of examining categorization is through the study of category norms. Free listing tasks (also known as semantic fluency tasks) are a common method of elicitation, in which participants are asked to list examples for named categories such as 'food items' or 'colors', the goal being to define the elements of a cognitive domain for a cultural group [17,24]. Another purpose is to define norms that serve as a basis for more in-depth psychological experiments [25,26].

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2.1 Research on Categories in the Geographic Domain

Early studies on geographic categories were conducted by psychologists as part of their free listing experiments. Of the 56 categories elicited in the classic category norm study by Battig and Montague one concerned the geographic domain [25]. As examples of ‘a natural earth formation’ participants most frequently listed mountain, hill, valley and river [25]. Tversky and Hemenway investigated basic-level categories of what they called outdoor ‘environmental scenes’ [5]. Based on the number of attributes, norms and activities listed for the four most frequently mentioned outdoor scenes (park, city, beach and mountains), these scenes were established as basic-levels. However, the scenes are not a taxonomy of the geographic domain, but rather serve as settings where geographic objects may be situated [22]. Lloyd et al. [27] postulated that categories of administrative units in the United States (e.g. country, state, and city) were basic level geographic categories. However, the members of categories investigated were not primarily sub-categories, but rather instances such as ‘Georgia’ for the category ‘state’.

Smith and colleagues argued that the domain of geography is ontologically distinct from other domains, in that geographic objects are characterized by specific properties that might influence category formation, for instance, a minimal scale, bona fide and fiat boundaries, and structural properties inherited from space [13,28,29]. Such considerations, in combination with a more general interest in how lay people conceptualize the geographic domain, triggered studies that specifically investigated commonsense geographic categories.

A series of experiments with US-American university students [13,22] revealed that results were influenced by the choice of wording in the elicitation task. For instance, the phrase ‘something that could be portrayed on a map’ produced a higher mean number of terms per participant (8.21) and more anthropogenic elements such as road or city, while the phrase ‘a kind of geographic feature’ yielded a mean of 7.15 terms per participant, consisting predominantly of physical geographic features such as mountain, river, lake, ocean, valley and hill [13].

Replications of these experiments included a study with Portuguese university students [30], as well as a study with Greek students that further tested for the differences in understanding of geographic concepts between experts and non-experts [31]. For non-experts (Greek high-school students and first year college students) the most frequent categories were the Greek terms for mountain, sea, lake, plain, and river [31]. As these experiments in different language settings produced comparable top ten frequency terms, this gave rise to the argument that geographic category norms may be shared cross-culturally [30]. However, the ‘non-experts’ in the aforementioned studies were students who more or less recently had gone through geography classes at high school. Thus, whether results reflect similarity in geography curricula in these countries or are in fact generalizable to a broader population remains questionable.

A study in Portugal used videos of landscapes (one familiar and one unfamiliar to participants) as stimuli to elicit landform categorizations from people living in two different villages. The results showed how familiarity with landscapes increased the

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number of terms listed, as familiar landscapes triggered memories of nearby areas not shown in the videos, for which participants then also listed terms [32].

2.2 Free Listing and Memory Search

Most of the aforementioned studies of geographic categories used free listing, reporting the resulting frequencies of terms and/or the term order, but treating items in lists as independent. However, research in other domains has revealed structure of free lists to contain other interesting information, such as how participants perceive the relationships between categories in a domain [33] or how information is recalled from memory [34].

How humans perform memory search has been the subject of intensive investigations. For instance, in the spreading-activation theory of semantic processing, a semantic network consists of concepts seen as nodes that are linked to other concepts sharing the same properties [35]. The more properties, and thus links, two concepts share, the more closely related they are. In memory search, when the first concept is activated, it activates a semantically similar concept in turn. Semantically related terms are thus often produced together, indicating that people apparently come up with terms by searching in 'semantic fields' or clusters and listing whatever items they discover in these clusters [36]. As the links get weaker and the number of available links decreases, the production of terms slows down during free listing tasks [37].

Hills et al. [38] drew an analogy between heuristic animal foraging strategies (find a resource patch, exploit it, switch to the next patch) that follow the marginal value theorem [39] and memory search strategies applied by humans in free listing tasks (find a semantic cluster, exploit it, switch to the next cluster). In human minds, the two distinct processes of exploiting clusters ('clustering') and moving to the next cluster ('switching') are argued to be linked to specific regions in the brain [34]. Clustering is taken to reflect semantic storage searching in the temporal lobe and switching between clusters to represent frontal lobe executive control mechanisms [40]. The empirically demonstrated link between clustering performance in free listings and mental illnesses such as Alzheimer's have led to practical applications of free listings in clinical diagnostics [40,41]. The underlying assumption in these diagnostic tests is often that the existence of externally defined clusters indicates how "well" participants organized their memory. A cluster of the categories *orange-lemon-tangerine* is considered "organized", while a cluster of *apple–orange–cherry–blackberry–pear–tangerine–banana–raspberry–lemon–apricot* is considered "disorganized" [42].

However, assessing clusters on close semantic proximity (defined as a high number of common properties) alone fails to account for the fact that one shared property may be a sufficient link between two concepts. For some people, *penguins* and *pandas* form a cluster because they are both black and white [43]. Furthermore, using predefined semantic clusters to analyze free lists fails to account for idiosyncratic clusters formed as a result of experience, for instance "all the animals I saw yesterday in the zoo", making *pandas–gorillas–meerkats-polar bears* an organized cluster. Such clusters can only be explored by complementing free listing exercises with qualitative interviews on how participants came up with the terms in the task [43].

2.3 Research Gaps and Research Questions

Participants. With few exceptions (e.g. [32]), researchers studying geographic categories through free listing have typically recruited participants among university students. To draw conclusions reflective of commonsense geographic concepts, a broader range of people should be included in the sample.

Internal structure of free lists. How participants come up with geographic categories and what the resulting lists may reveal about how knowledge on geographic phenomena is stored in, and retrieved from, memory has so far remained uninvestigated. Methods for analyzing the internal structure in free lists exist, but these have not yet been applied to free lists of the geographic domain.

Outdoor elicitation. Participants of category norm studies using free listing usually complete the task in indoor settings without controlled visual stimuli (with the exception of [32]) It remains unknown whether outdoor settings influence the strategies of participants, resulting for example in different frequencies and clusters of categories for different landscapes.

Research questions. From the identified research gaps, the following research questions emerge:

- RQ1: Does the landscape in which a free list experiment is conducted influence the elicited terms?
- RQ2: What memory search strategies do participants apply in outdoor settings for listing landscape terms and are these strategies reflected in free lists?

Our first hypothesis was that location, especially the landscape elements visible from a location, influences the content of free lists. We expected to find similar terms for free lists elicited in similar landscapes, and different terms for free lists elicited in different landscapes. We therefore selected three study sites, two that were in similar landscapes in the Swiss mountains, and one that was in a park on the Swiss central plateau. Based on the finding that the order of terms in free lists is important and reveals memory search strategies [38,43], our second hypothesis was that landscape influences the memory search strategies and therefore the structure of terms in free lists. We expected to find evidence for clustering in free lists, with clusters consisting of elements that are perceived as belonging together in the landscape based on topological relations or spatial proximity.

3 Methods

3.1 Data Collection Protocol

We conducted free listing tasks on landscape categories with participants in outdoor areas. Between 20 and 30 participants are usually considered sufficient to establish a cognitive domain, with 80 to 90 participants considered a good sample [44]. We

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therefore aimed for at least 80 participants for our study. Participants were recruited on site by the field researchers, asking people present in the location if they would volunteer to take part in a study. If they agreed, we informed them about the procedure of the survey and handed them an informed consent sheet. The verbatim statement posed to participants in Swiss German was: '*Was hätts für Sie inere Landschaft drin?' ('What is there for you in a landscape?')*. In a pre-test, other statements such as '*What geographic categories can you name?*' or '*What landscape elements can you identify?*' were not well understood, leading to questions of understanding, which we aimed to avoid in the free listing tasks.

The field researchers noted down elicited landscape terms by hand on a sheet of paper in the order stated by the person taking the survey. There was no time constraint for the task, and participants often indicated that they had finished the listing task by stating: '*that's all I can think of*'. They were then asked to explain how they came up with the terms during the task, and their answers noted. We conducted the elicitation in February 2015 during sunny and clear days at three different sites in Switzerland.

3.2 Study Sites

We selected two study sites in mountainous areas in the Canton of Grisons, and one site on the Swiss Central Plateau in Zurich.

a) b) c)

Fig. 1. View from the survey locations in a.) Val Müstair, b.) Flims, and c.) Irchel Park

Val Müstair in the south-easternmost part of Switzerland bordering Italy is a mountain valley characterized by forests of arolla pine (*Pinus cembra*), alpine meadows and mountains. In winter, tourists visit Val Müstair to practice snowshoe-hiking and skiing. The elicitation tasks mainly took place in the small ski area Minschuns in the outside seating area of the restaurant Alp da Munt at an elevation of 2150m (Fig. 1a.). We collected 19 interviews for Val Müstair, 12 with tourists and 7 with local people. We attempted to collect more data, but the weather conditions drastically changed after the first three days of data collection and when we returned to collect data again 2 weeks later, snow melt had set in and changed the visible aspects of the landscape. The second study site in the mountains was Flims, a major winter sports destination in the Canton of Grisons. The landscape is characterized by alpine meadows, pine forests and mountains. We conducted elicitation tasks with 40 participants (all tourists) in the ski area of Flims in the outside seating area of the restaurant at Nagens at an elevation of 2127m (Fig. 1b.). The third study site was in Irchel Park, a public park

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area in Zurich near a university campus at 479m above sea level. Irchel Park is centered on a pond surrounded by jogging and pedestrian paths, benches, barbecue places, grass areas, stands of deciduous and coniferous trees as well as shrubs. The park is frequented by people from Zurich city as an urban recreation area. The elicitation tasks took place during weekends and on afternoons during the week to avoid sampling university students. The tasks were conducted on the walkways around the pond (Fig 1c.).

3.3 Data Analysis

We analyzed the data collected at the three sites using the combination of quantitative and qualitative methods described below.

Description of Free Listing Data. Descriptive statistics provided a first overview of the free listing data. Furthermore, we identified location specific terms that only occurred in one study site. To exclude idiosyncratic terms, we removed terms only listed by one participant. Although the oral responses by participants were in Swiss German, we present the results in Standard German, the official written language used in the German speaking part of Switzerland. Terms are presented in singular or plural as elicited, since singular and plural forms may represent different categories.

Cognitive Salience Index. For the analysis of free lists, term frequencies are often used (e.g. [44]). Another common measure is mean rank, which often correlates with term frequency [45]. Both measures assess aspects of psychological salience: a tendency to occur at the beginning of lists and to be referenced across participants [17]. However, the two measures generate two different sets of terms as potential candidates for basic terms. Therefore, in order to combine term frequency and mean rank into a single measure, Sutrop [46] developed a cognitive salience index (S) calculated as:

$$S = F/(NR) \qquad (1)$$

where F is term frequency, N is the number of participants, and R the mean rank A term named by all participants, and always in the first rank thus has a maximum cognitive salience of 1. Less salient terms, mentioned by few participants, and towards the end of lists approach a minimum salience value of 0. Based on the cognitive salience index, we compared the top ten salient terms across the study sites. Furthermore, we determined the number of shared terms between sites as an approximation for similarity, using the thirty most salient terms to strike a balance between highly salient and less salient terms that may contain particular terms describing a study site.

Interviews on Participants' Free Listing Strategies. We first applied open coding to derive codes from the actual interview data consisting of: 'senses' (see, smell, taste, touch, and hear), 'personal memories', 'expertise' (job-related or other), 'value-judgement' (positive and negative) as well as the code 'inner picture'. Secondly, we applied structured coding using the codes derived from the data as well as Rosch's [1]

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criteria: attributes, activities, and parts. In addition, we analyzed the raw free list data for evidence of search strategies not mentioned by participants, but that could be expected for the geographic domain, namely scale (e.g. listing landscape terms ordered from large scale to small scale), partonomy (listing parts of mountains) and topology (listing topologically related objects in a landscape).

Network Visualizations. Networks are well suited to visualizing internal structure of free lists, for instance, as they allow display of sequentially adjacent terms as nodes connected by edges. The form of the network allows identification of grouped terms, which in our case are candidates for semantic clusters. Only terms listed by more than two participants, and occurring sequentially adjacent in more than one list were included. For example, if in one list the sequence *mountain–river* occurred, and in another list *river–mountain*, we included this pair of terms in the network. We produced the networks using R [47], where edge width represents frequency of a link, node size cognitive salience (calculated as Sutrop's index,[46]), and the node label size the connectivity or betweenness of a node ([48]). For the node distribution, we used the Fruchterman-Reingold force directed graph algorithm [49] that applies attractive force to connected nodes and repulsive force to unconnected nodes. Furthermore, chi-values were also calculated between all connected nodes to indicate which connections are overrepresented, given their expected probability based on frequency.

4 Results and Interpretation

First, we report on the descriptive statistics of the free listing data and the results for the cognitive saliency index, before presenting analysis of participants' explanations for strategies used during the free listing tasks. Finally, the links between sequentially adjacent terms are visualized in network diagrams for each study site as a way to explore the internal structure of free lists. Comparing the resulting networks with qualitative interview data from participants on their strategies during the free list tasks links our results to theories of memory search.

4.1 Description of free listing data

In total, we elicited 89 free lists (Table 1). Flims had the highest mean number of terms per list, and Irchel Park the lowest. For all the sites, the number of location specific terms (unique terms) was more than half of all the terms. Often, unique terms were low frequency terms, which we can further distinguish. On the one hand, unique terms were listed only once, and in many of these cases we could not establish a semantic link between the term and the study site. On the other hand, unique terms listed by or more people are candidates for being particular location-specific terms for which instances occur in the landscape of the study site. For example, in Val Müstair, two participants named *Arven* (arolla pines), a characteristic tree species of the valley and *Kloster* (monastery), with the world heritage monastery of the Convent of St. Johns in the village of Müstair. In Flims, four participants mentioned *Gletscher* (glacier), probably because of the Vorab glacier accessible from the ski area. In Irchel

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Park, two or more participants listed *Enten* (ducks) and *Möwen* (gulls), as well as *Haselstrauch* (hazel bush), instances of which occur in Irchel Park, but not in mountain locations.

Table 1. Descriptive statistics of free listing data from the three different study sites

	Val Müstair	Flims	Irchel Park
N	19	40	30
Mean per participant (± StDev)	11.05 ± 3.17	14.88±7.44	10.77±4.55
Median	12	12.5	10
No. of terms	159	291	179
No. of terms >1	32	75	41
No. of location specific terms	103	211	116
No. of locations specific terms >1	8	34	13

4.2 Cognitive salience index

For both Val Müstair and Flims, *Berge* (mountains) was the most salient term, while for Irchel Park, *Bäume* (trees) was most salient term (Table 2).

Table 2. The top 10 most salient categories ranked according to Sutrop's index [46]

Val Müstair			Flims			Irchel Park		
(S)	German	English gloss	(S)	German	English gloss	(S)	German	English gloss
0.32	*Berge*	mountains	0.38	*Berge*	mountains	0.37	*Bäume*	trees
0.11	*Tal*	valley	0.11	*Bäume*	trees	0.13	*Wiesen*	meadows
0.11	*Wald*	forest	0.05	*Felsen*	rocks	0.06	*Wasser*	water
0.07	*Hügel*	hill/hills	0.05	*Wald*	forests	0.05	*Tiere*	animals
0.06	*Wälder*	forests	0.04	*Seen*	lakes	0.05	*Hügel*	hill/hills
0.04	*See*	lake	0.04	*Wiesen*	meadows	0.04	*Berge*	mountains
0.04	*Gipfel*	peak	0.04	*Wälder*	forests	0.04	*Teich*	pond
0.04	*Felder*	fields	0.04	*Hügel*	hill, hills	0.04	*Vögel*	birds
0.04	*Bach*	stream	0.04	*Schnee*	snow	0.04	*Sträucher*	bushes
0.03	*blauer Himmel*	blue sky	0.04	*Wasser*	water	0.04	*See*	lake

The two mountain sites Val Müstair and Flims shared 15 out of the 30 most salient categories, followed by Flims and Irchel Park sharing 13 categories. Val Müstair and Irchel Park shared only 8 categories of 30. The most cognitively salient terms of all three study sites include several highly frequent terms, indicating that frequent categories are often also named first.

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4.3 Interviews on participants' free listing strategies

The following results illustrate what free lists in combination with interviews can reveal about possible memory search strategies, such as exploiting clusters (clustering) and switching. We documented interview data from 63 participants. Each participant described one or more strategies that he or she had used during the free listing.

A total of 25 participants said they used visual stimuli provided by the landscape. For instance: *'I looked around and named what I saw'* or *'I looked at the landscape'*. 22 participants used past memories of landscapes they had visited, while 20 conjured up what they called 'an inner image'. For example: *'I had an image in my mind of different landscapes'*. This strategy was also used to come up with additional terms for the landscape the participants found themselves in, for instance: *'I made myself an inner image of this landscape how it looked like in summer'*. This participant in Val Müstair looked around and first named visible elements of the landscape such as *Hügel–Bach–Bäume–Felsen–Wälder* (hill–stream–trees–rocks–forests). Then, the switch to memory took place and the participant listed non-visible elements such as *Magerwiesen* (rough pastures). Such a combination of visual stimuli and personal memories was mentioned by 7 participants.

A similar switching strategy 21 participants said that they used was recalling geographic locations different to their current position. This was indicated by use of toponyms in explanations, as well as sometimes in free lists themselves. For example, a participant in Irchel Park stated that:

> *First I looked around and thought of why I come to the Irchel Park, then my holidays last week in Engelberg next to Titlis and the hike we did there.*

The strategy of recalling particular places is reflected in the free list. After naming categories visible in Irchel Park such as trees and walking paths, the participant stated *Titlis.* This mountain toponym indicates a switch, followed by a new cluster: *Luftseilbahn–See–Skifahrer–Skipisten* (cablecar–lake–skier–ski slopes). It thus seems that toponyms may be indicators for switches in memory search. However, toponyms are not always named directly in free lists, as sometimes a generic is used: '*I started with the Irchel Park and then where I was at the weekend, there I was at the lake.'* In this case, 'the lake' is a reference to the Lake of Zurich, the largest instance of its kind around Zurich. Based on the interview data, this switch was visible in the free list. After terms such as *Haselstrauch–Park–Studenten–ältere Leute* (hazel bush–park–students–elderly people), the switch took place and the participant started a new cluster *See–Schilfgürtel* (lake–reedbed).

A complete free list from a participant in Irchel Park illustrates how the interviews can be used to identify potential clusters and switches (Table 3). While some semantic clusters in free lists are identifiable from the lists alone, switches are more challenging to identify, unless participants themselves provide additional information. For instance, this participant explained: *'I first thought of the Irchel Park, and then of my home, where there are many birches and birch forests'.* Only with the qualitative data from the interview is this switch from Irchel Park to a landscape remembered as 'home' identifiable. Furthermore, the free list in Table 3 exhibits indications for hierarchical clustering, with several sub-clusters for the landscape in Irchel Park, and a sub-cluster for the landscape 'home'.

Table 3. Free list and interview data of a participant showing indications for clustering and switching

German	English gloss		
Bäume	trees		
Birke	birch		
Buchen	beech	*clustering:* trees	
Tannen	firs		
Blätter	leaves		
Natur	nature		
Büsche	bushes	*clustering:* bushes	
Haselstrauch	hazel bush		
Primeln	primroses		*clustering:* Irchel Park
Vögel	birds		
Möven	gulls	*clustering:* birds	
Graureiher	gray heron		
Kormoran	cormorant		
zauberhaft	magical		
Vielfalt	diversity		
Wiesen	meadows		
Birken	birches		*switching*
Tannenwälder	fir forests	*clustering:* forests	
Buchenwälder	beech forests		*clustering:* 'home'
Moos	moss		

4.4 Network visualizations

The participants stated several strategies for coming up with terms in a free list. We then tested whether these strategies are also visible in aggregated data for all free lists at a study site by visualizing sequentially adjacent terms for all lists at a single location as a network. Because the same criteria for including nodes and links in the networks were applied, but the sample sizes between the study sites differ, the graphs are differently populated. Therefore, rather than comparing the networks, the focus lies on qualitatively assessing what relationships between sequentially adjacent terms emerge for the three sites.

In the network visualization for Irchel Park (Fig. 2) the most salient terms *Bäume* (trees) and *Wiesen* (meadows) are at the center of the network. These two nodes each have several links to other nodes and therefore a high value of betweenness, represented by a large label size. Several clusters are visible, for instance, *Tiere-Vögel* (animals-birds) and a cluster consisting of *Teich-Wasser-Bach* (pond-water-stream).

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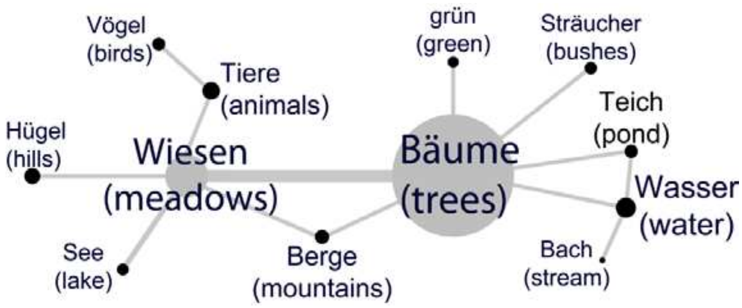

Fig. 2. Network visualization of sequentially adjacent terms in free lists for Irchel Park

For Flims, with a higher sample size, the network is more populated with a total of 33 nodes in one major network and two small unconnected networks (Fig. 3). In the main network, bio-physical elements of landscape such as *Berge* (mountains)*, Wald* (forest)*, Bäume* (trees)*, Hügel* (hill/hills)*, Seen* (lakes) form one part of the network, while anthropogenic landscape elements form a semantic cluster of 'human settlements' consisting of terms such as *Städte* (cities)*, Dörfer* (villages)*, Häuser* (houses)*, Weiler* (hamlet/hamlets). The network structure indicates that when listing landscape terms, people tend to list natural features separately from anthropogenic features. Several other clusters are identifiable, for instance the combination of *Sonne-Himmel-Wolken* (sun-sky-clouds) forming a separate small network. The third network consists of the two nodes *Bach* (stream) and *Fluss* (river) only, which form a small semantic cluster of 'bodies of flowing water'. Less prominent, and thus arguable relations, are identifiable between living things such as *Tiere-Pflanzen* (animals-plants), water related terms such as *Wasser-Fluss-Seen-Flüsse-Bäche* (water-river-lakes-sea-rivers-streams). Partonomic relations include for instance *Wald-Bäume* (forest-trees). Antonymic use of landscape terms may be expressed through the connection between *Berge-Täler* (mountains-valleys). Cognitively salient terms, due to their frequent occurrence, are often strongly linked (edge width) and interlinked, resulting in a spider-web pattern radiating out and around the salient central term *Berge* (mountains).

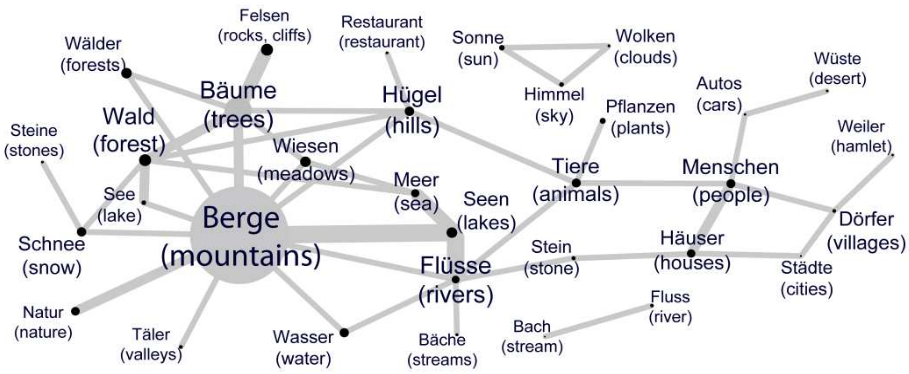

Fig. 3. Network visualization of sequentially adjacent terms in free lists for Flims

In addition to the network, we calculated chi-values to explore term associations which occur more often than expected based on raw frequencies. Table 4 illustrates chi-values for Flims showing pairs of terms that are overrepresented, forming parts of semantic clusters, such as *Bach-Fluss* (stream-river) and *Städte-Dörfer* (cities-villages). The term combination of *Autos-Wüste* (cars-desert) occurred in two lists, but we do not have information on whether participants considered them part of a cluster (e.g. 'car rally') or whether these terms were listed before and after a switch. High chi-values appear to be indicators for strong semantic relations. The pairs of terms with high chi-values cannot be explained by geographic characteristics such as collocation in a landscape or partonomy, but may be prototypical categories sharing a high number of properties.

Table 4. Chi-values for overrepresented pairs of sequentially adjacent terms

Term A	Term B	Observed	Chi-Value
Bach (stream)	*Fluss* (river)	2	12.42
Autos (cars)	*Wüste* (desert)	2	9.81
Städte (cities)	*Dörfer* (villages)	2	9.32
Dörfer (villages)	*Weiler* (hamlet)	2	7.94
Sonne (sun)	*Wolken* (clouds)	2	5.8

For Val Müstair with relatively low sample size (n = 19), the network visualization consists of two unconnected networks with 3 nodes each (Fig. 4). The term *Berge* (mountains) at the center of one network is most cognitively salient for that location.

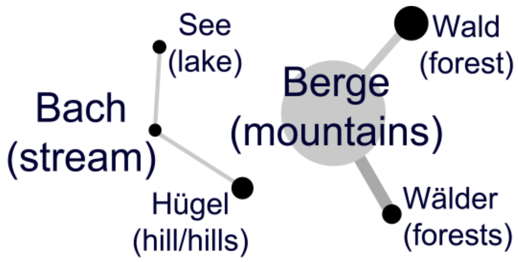

Fig. 4. Network visualization of sequentially adjacent terms in free lists for Val Müstair

In general, the cluster 'water bodies' occurred with variations in the nodes in all three networks, indicating that participants often consecutively list water features while exploiting a cluster in memory. The nodes in all the networks were predominantly terms of which instances occur in all the study sites. The most obvious exception is the node *Berge* (mountains) in Irchel Park that was listed despite the lack of mountains visible from Irchel Park.

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5 Discussion

We aimed to study landscape terms as elicited in a free listing task and explore memory search strategies linked to such terms. Using free listing and interviews in outdoor settings in three study sites, we aimed to investigate the influence of landscape on *what* terms participants listed, as well as *why* they listed these terms, that is, their memory search strategies. In the following, we discuss our findings with respect to the research questions set out in § 2.3, before making some more general observations on the wider implications of our results.

5.1 RQ1: Does the landscape in which a free list experiment is conducted influence the elicited landscape terms?

Differences between the study sites are visible in the ranking of the most salient terms. The cognitive salience value for the term *Berge* (mountains) differs considerably from the mountain study sites, where it is the most salient term, to the city park, where it is only the 6th most salient term. Interestingly, in previous studies, students in classroom settings in an urban environment listed mountain as one of the most frequent terms (e.g. [13,25,31]). Half of the 30 most salient terms were listed for all three study sites. This high number of shared terms could imply that participants listed basic terms, effectively category norms, such as forests, lakes, and mountains relatively early in their lists. In addition to the difference in ranking of salient terms, we observed that good candidates for describing particularities of a landscape occur in the long tail distribution of less cognitively salient terms. Summing up, to determine the influence of landscape, both ranking of cognitively salient terms, as well as (some) terms in the long tail distribution contain the most useful information, whereas a set of more basic terms is shared between different landscapes. Importantly, many previous works have only reported the most frequent terms [13,31], but we would argue that discarding this information makes replication and detailed comparative analyses difficult.

In interviews, participants stated that they looked at the landscape for coming up with terms, indicating that visual stimuli play a major role for free listing. In our case these visual stimuli take the form of the landscape where the free listing task was carried out and we discuss this in more detail below.

5.2 RQ2: What memory search strategies do participants apply in outdoor settings for listing landscape terms and are these strategies reflected in the free lists?

Our methodical approach combining free listing with interviews allowed us to better understand memory search strategies for landscape terms. For instance, the most prominent strategy participants mentioned was to start naming terms by first looking around and using the visual stimuli the landscape provided. This resulted in what we called 'geo-semantic' clusters in free lists consisting of terms for which instances occur in the landscape. Such instances are perceived as spatially related, for example,

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the forest is on the mountain, the trees are in the park or the lake is near the hill. The second most prominent strategy was to recall memories of particular familiar places.

Participants often combined these two strategies, whereby they first listed visible elements of the landscape (geo-semantic clustering), and then used the memory of a familiar place (switching) to name terms for that landscape (geo-semantic clustering). Additionally to published findings [34,50], we found that each of the landscape clusters (surroundings and familiar place), was associated with a number of (sub-)clusters, consisting of geographic features found in that particular landscape. This indicates that memory search strategies for landscape terms as part of the geographic domain consist of clusters at multiple hierarchies, often at differing spatial scales.

Another particularity of the geographic domain was that in this study, toponyms indicated a switch between clusters. The listing of toponyms rather than generic terms in free listings has been documented before for categories such as 'outdoor scenes' [5]. However, in the absence of toponyms in free lists, switches are difficult to identify without the use of additional data from the participants themselves. In our experimental setting, where we directly interacted with study participants, it was possible to elicit qualitative information about memory search strategies participants were conscious of having used. The combination of free listing tasks followed by interviews has been productively used before to study memory search strategies in clinical patients, documenting a diversity of sometimes idiosyncratic ways of clustering and switching [43]. To go beyond descriptions at the individual level, we used network visualizations for each study site to explore the aggregated internal structure of free lists. When idiosyncratic switching strategies were filtered out, several groups of terms were retained, which often represent semantic clusters, such as 'water bodies' or 'settlement types', which also had a high chi-value, as well as geographic partonomies (forest-trees), and co-occurrence in a landscape (mountains-valleys). The network visualizations therefore provide a means to go beyond the individual level by exploring whether certain clusters are occurring repeatedly in the data.

5.3 Implications

While it is important to recognize the relatively small number of participants and sites at which we performed our research, we nonetheless believe that some more general implications can be drawn from our work.

Firstly, in previous work where participants were limited to 30 seconds to write their responses [13,31] the mean number of terms per participant was lower than in our study. Our participants were not time limited, but typically rapidly listed terms within less than a minute. Since we found important information in the long tail, we suggest that imposing an artificial temporal limit may obscure relevant ways in which terms are used. In our context this is particularly important, since we are interested in finding out how landscapes are conceptualized. Our results suggest that lists contain many relevant terms, but not all of these are to be found in the most common terms.

Secondly, it is apparent from our results and previous work [32] that the setting of a free listing task plays an essential role in the responses gained. This points to the importance of not just the ethnopysiographic hypothesis [51], but also the notion that the same people might respond differently in different settings. However, by exploring not only term lists, but also cognitive saliency values and network visualizations, we can learn both about the ways in which individuals addressed this task, and how we might design a task to more exhaustively capture landscape terms. For example, participants recalled memories of previous experiences in the landscape such as journeys by train, bicycle or hiking trips, as well as memories of familiar places (identified by toponyms) as effective switching strategies. This suggests that we might make use of activities, experiences or toponyms as prompts to elicit landscape terms (c.f. [32]).

Since the outdoor experimental setting in this study differs from other studies on geographic categories [13, 31], resulting differences may also reflect methodological differences rather than differences in categorizations. The closest experimental setting to our study used videos of landscapes for elicitation [32]. However, substantial filtering was applied to the elicited terms based on notions of what constituted valid answers. For instance, vegetation terms listed by participants in the original free lists [52] were not reported in the final publication [32]. We urge researchers to also report unfiltered results of what people stated to be part of landscape or the geographic domain, rather than what researchers think are participants' correct answers to the elicitation task, since we observe that such terms may also link clusters. For example, in Table 3 birds (gray heron – cormorant) are linked to landscape qualities (magical – diversity) and lead back to landscape terms (meadows). Such linkages are, from a geographic perspective, essential in understanding how landscapes are conceptualized, suggesting, for example, issues of scale [53] and the use of partonomic relationships [28] (for instance in Table 3 the participant firstly positioned her/himself in Irchel Park, identifying elements and qualities of this landscape, before zooming out to another landscape 'at home').

Finally, though toponyms do not appear in our aggregated data, they had an important bridging role in lists, and might provide examples of instances of particular landscapes. This further points to the status of toponyms in language [54], and the rich potential of structured free lists for exploration.

6 Conclusions and Further Work

We believe that our results suggest a number of important methodological and thematic avenues for further research on geographic categories, through both simple methods such as free listing, and more complex qualitative studies:

1. Free lists contain more information than simply frequencies – by considering sequential adjacency of terms and calculating cognitive salience we were able to extract candidates for semantic clusters and build useful aggregating network visualizations.

2. By combining the free listing task with short interviews, it was possible to link theory on memory search strategies directly to our data and thus to identify meaningful structures not possible from the free lists alone.

3. The setting of the elicitation task has clear implications for the terms and linkages used. Nonetheless, some terms appear to be shared across our three landscapes, and may represent more basic categories of landscape terms [5], providing potential insights as to variation in landscape perception.

4. Our lists, and their analysis reveal once again the richness of the geographic domain for such analysis – and importantly that landscapes are conceptualized in a multitude of, equally valid, ways extending far beyond the simple listing of geographic features.

We close this paper by suggesting avenues for further research. When we started this work we simply aimed to replicate some previous studies [13,25,30,31,32] in a new setting. However, we believe that the combination of methodologies applied here and the richness of geographical settings clearly illustrates the potential for further studies exploring the semantics of landscapes, and linking this back to the ways in which we represent these in information systems.

In an era of big data, crowd sourcing and Citizen Science, we note that a simple free listing experiment, with roughly 90 participants who also explained their strategies in a few sentences, combined with hypotheses derived from existing theory in cognitive research, was a very rich source for analysis.

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