Soil, Rock and Snow: on Designing for Information Sharing in Outdoor Sports

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ABSTRACT
While outdoor sport activities keep gaining popularity as part of a global trend to maintain a healthier lifestyle, current technology offers limited support for activity-specific needs. Therefore, a greater understanding of information sharing behaviours is necessary in order to build comprehensive, socially-embedded sports applications. To this purpose, we interviewed 46 practitioners in three outdoor sports: trail running, climbing, and skiing. Our qualitative study investigates how participants share information in the context of outdoor sports and how current technology supports this practice. Through thematic analysis, we derived five themes that describe the current information sharing practices: nature, risk and planning, content selection, audience selection, and privacy. Based on these themes, we present five recommendations for design that can inform, inspire and refine future sharing technologies for outdoor sport.

Author Keywords
Information sharing; skiing; climbing; trail running; communication; qualitative study.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION
Participating in outdoor sports activities is becoming an integral part of daily routines in western societies[1]. Nevertheless, in her keynote at CHI 2010 [3], Genevieve Bell argued that Human-Computer Interaction (HCI) pays much less attention to sports than the majority of the population. In fact, although there is a considerable number of papers presenting systems that support training, HCI still lacks a systematic knowledge of the lived practices and experiences within this domain. Sportspeople often rely on the motivational support of their friends and families to keep up with their demanding training routines [2]. Nevertheless, current tracking devices and apps on the market do not fully address the social and emotional demands of sportspeople. Workout statistics, competition performance or training routes can be shared widely via social media or selectively to followers within an application ecosystem. However, apps like Runkeeper, Endomondo, Nike+ do not address some of the social needs of outdoor sports, like finding training partners or sharing the information needed to achieve athletic goals. In these situations, extra effort is required to manage the preparation of the information they want to share and the target audience [31], hence it may result in decreased motivation or reduced social connection. On the other hand, researchers in Communication Sciences (e.g. [17]) have demonstrated that sharing not only facilitates creation and maintenance of social ties, but also promotes egalitarianism, mutuality, openness and trust within a community; particularly when it comes to sharing personal emotions and feelings, which are common in sports [21]. In conclusion, current designs do not reflect the social character of sports, and an increased understanding of the information sharing practices of amateur sportspeople is needed to build technology that will improve their sport experience and sustain their motivation.

To that end, we took a closer look at how sportspeople currently share information using technology in the context of three outdoor disciplines, namely skiing, climbing, and trail running. Outdoor sports are interesting because people practise them widely in western societies; not just to get fit or to experience the 'game' aspect of team sports, but to measure themselves against natural elements and challenge their skills. All the sports we considered require the participants to immerse themselves in nature and challenge themselves by facing a natural element (steep slopes, high mountains, long distances on uneven trails), however they differ in the degree of social interactions in which they are performed (groups, pairs, individuals). Therefore, by investigating and comparing them we aimed to gain an overview of insights relevant to outdoor sports in general.

[1]The number of physically active individuals in the EU is increasing according to Eurostat cf. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=hlth_ehis_pe2e&lang=en

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We contribute to the HCI for sports community by outlining five themes resulting from interviews on three different outdoor sports practised in three different countries (NATURE, RISK AND PLANNING, AUDIENCE SELECTION, CONTENT SELECTION and PRIVACY) and five recommendations for designing socially-embedded technology for information sharing in outdoor sports. By conducting in-depth interviews, we aimed to explore the existing information sharing practices and to discuss the relation between content, audience, and timing of the sharing. Our findings highlight that sportspeople expect to be offered extended means to easily manage content and audience. The analysis also shows that sports technology needs to embrace the intricate issues of timing to facilitate outdoor sharing practices.

The paper is organized as follows: in the next section, we discuss previous HCI works exploring designing for sports and information sharing research in general. We then provide the details of our study and analysis, and our five themes of information sharing in outdoor sports resulting from this analysis. We conclude the paper with design recommendations for future sport technology that can help designers create engaging socially-embedded experiences.

RELATED WORK

In this section, we review past research efforts that influenced our study. First, we provide the broader context of our inquiry in the domain of HCI for sports. Later, we look at past inquiries into information sharing and collective content creation beyond the context of sport.

Designing technology for supporting sportspeople

Sports as an application area is an emerging topic in the HCI community [28]. Part of HCI research in this domain has focused on understanding motivation mechanisms and on designing systems aimed at persuading users less involved in sports to engage in regular activity. Knaving et al. [21] endeavoured to understand the motivational factors that influence amateur runners. Byrne and Mueller [4] proposed a comparison between the motivations of climbers to practise the sport derived from literature and the technology for climbing developed by HCI research with the purpose of highlighting the mismatch between theory and practice. Reynolds et al. [37] investigated how beginner and experienced sportspeople react to gamified physical activity features present in the game Wii Fit. Further, Purpura et al. [35] presented a critical design view on the ethical and sociocultural consequences of an interactive system designed to convince people to reduce obesity.

A different strain of research focused on improving the individual sport experience, both during training and competition. Tholander and Nylander [41] explored how technology can influence the experience of sport, concluding that the role of technology can be two-fold; on the one hand, it should be instrumental since it helps to measure the performance, and on the other it should be experiential and support reflecting and remembering the felt experiences. Among the works presenting technology to support the effectiveness of training, we note de Oliveira and Oliver [8] who developed and evaluated TripleBeat; a mobile application for helping runners maintain pace. Schneegaß and Voit [40] investigated in-run interaction using a wearable gesture device on the runner's hand. Hasegawa et al. [16] presented an application to support beginner skiers to adjust their centre of gravity through sonification and consequently to assume a correct posture. Past research has also recognised and addressed the need for increased playfulness of the sport experience: Dunlop et al. [10] proposed to interactively visualise data while skiing and Kajastila and Hämäläinen [18] offered new dynamic challenges to climbers by designing and developing a projection-augmented climbing wall.

More recently, researchers became more interested in the social aspects of sport and investigated the issues of temporal and spatial displacement between the different parties involved in the sport experience, such as team mates, sports buddies or supporters. In particular, Mueller et al. [29] presented Jogging over a distance, a system for enhancing the feeling of social connectedness of remote runners, and Woźniak et al. [47] investigated how technology can allow family and friends to support runners during long-distance performances. Similarly, Romanowski et al. [38] used drones to mediate cheering during running races. These works, however, focused on remote users, and did not address the needs of co-located sportspeople or supporting groups.

Co-located interaction was explored by Mauriello et al. [25], who explored spontaneous interactions prompted by wearable displays during running races, and Walmink et al. [46], who observed the reactions to a cyclists heart rate being displayed on her helmet. Mencarini et al. [26] outlined suggestions to use wearable devices for augmenting the communication between climber and belayer in order to enhance the experience and reduce the negative emotions of an ascent. Desjardins et al. [9] reflected on the design of avalanche beacons to facilitate collaborative rescue operations. This strain of research explored on-the-spot reactions and simple information processing, while a few works explored also complex two-way information exchange in the sport context. For example, Fedosov et al. [12] engaged in a co-design activity with a group of backcountry skiers to meet their information sharing requirements before, during and after the descent. Based on collected requirements they developed SkiAR, the augmented reality system to support decision making within group of skiers through sharing personalized virtual content on panoramic resort maps [13].

The papers above are motivated by the fact that sportspeople's needs are not yet fully understood by HCI research nor by the market, and thus demonstrate the purposefulness of our work. So far, little work has addressed the question of which needs are sport-specific and which are true for the larger context of physical activity. We assume that a thorough understanding of sportspeople's needs is a prerequisite to develop new successful sport technologies. We believe that experience, sociality and motivational factors are intertwined in an eclectic gestalt (much like Dalsgaard et al.'s participation gestalt [7]) of sports systems. Our work answers to an emerging chal-

lenge of understanding how the social dimensions of everyday sports influence the user's perception of the sports experience.

Understanding information sharing practices

In order to study information sharing practices effectively, we reviewed past work that explores how users share information not only in the context of sports, but in other domains as well. Following research of Communication scholars such as John [17], we explore sharing as an act of *communication* in the context of sport. Although the logic of sharing as an act of *distribution* is also an interesting opportunity, it requires a separate inquiry outside of the scope of this study.

A large number of works has studied sharing focusing on personal digital data, for example personal data files [45], photos [1], or videos [22]. Olsson et al. [33] investigated what motivate users to create collective content. They observed how sports fans, scouts, online group chatters and fishing enthusiasts created shared repositories of online media. In a follow-up study, Olsson [32] showed that collective content could be described by the community's contribution, the relevance of the content and the level of sharing. Our work is inspired by Olsson's considerations and provided us with guidance for creating scripts for user interviews. Similarly, Leitner et al. [23] investigated the reasons for users joining online communities. They concluded that a key motivation was the access to a pool of shared information. Our work investigates whether similar information practices take place in the case of sports and, like Leitner et al., we relied primarily on semi-structured interviews to build our understanding of information sharing practices.

Past research also explored some aspects of the social setting of sports. Ojala and Saarela [31] summarized motivations for tracking and sharing details of training routines and physical exercises in online sports communities. Among the most frequent reasons to share to online communities based on previous research they outline four: (1) to get feedback and guidance; (2) to create and maintain social ties (e.g. through finding a running partner); (3) to build an attractive social profile; and finally (4) to compete among peers. Prior work confirmed that social sharing contributes not only to the overall user experience and enjoyment of workouts [29, 3, 30], but it could be also a powerful motivator for physical activity itself [42]. Curmi et al. [6] discovered that sharing real-time physiological data (e.g., heart rate) can create bidirectional social connection between sportsmen and their supporters. Consolvo et al. [5] with their deployment of Houston, a mobile application that encourages opportunistic physical activity by sharing step count within small group of friends, identified that competitiveness and social pressure are areas of influence for physical exercising. Nevertheless, the study conducted by Lin et al. [24] found that sharing physical activity through a chat with strangers is not always motivating and can be uncomfortable.

Previous work also looked at privacy concerns [20], associated risks [36] and preferences [34] regarding the tracking (and potentially sharing) of personal health data. Common concerns about sharing are (1) fear of appearing boring or boastful; (2) consequences of oversharing; and (3) insufficient support received from the community [30]. Informed by the rich insights of factors that support and inhibit sharing activity of personal exercise data, we aim to understand how interactive artefacts can better support social activity in outdoor sports. Our goals are also similar to those of Ahtinen et al. [2] who investigated how mobile applications can be improved to better support wellness through design-based research. Guided by the design framework for social sharing in personal informatics [11], we especially emphasise the importance of audience and content selection for designing technology across three distinct sports disciplines. Consequently, we conducted an interview study with participants practising running, climbing and skiing.

METHOD

Our study consisted of three qualitative inquiries into three different sports. For each of the disciplines we conducted a series of semi-structured interviews with amateur sportspeople practising regularly. Since we conducted our investigations in different moments and in different countries, we agreed on a common ground of tools and methods to guide the investigation, such as the research questions, the use of semi-structured interviews, and the topics to be investigated during the interview. Beyond these guidelines, each researcher was free to conduct the study as s/he deemed appropriate. Therefore, the composition of the participant groups, the recruitment methods and location, and the interviewing techniques were adjusted to best match the specific qualities of the three sports. We collected data from the one-on-one interviews with skiers and runners, and from the focus group interviews with climbers and skiers. Given that climbing and skiing usually have higher levels of social interaction in comparison to runners and that social dynamics were a matter of interest for the scope of this research, we deliberately employed a focus group format for these two sports.

Participants

Our study not only spans multiple sports, but also multiple nationalities. Runner interviews were conducted primarily in Sweden, but included also runners from Poland and the United States; climbers were recruited in Italy; the skiing resorts where skier/snowboarder interviews took place were located in Austria and France.

Runners

We recruited trail runners for semi-structured interviews by contacting a local running club and also spontaneously at a local well-known running spot. A total of 12 participants (2 females), aged $24 - 74$ ($M = 42$ yrs.) took part in the study. The majority of the interviews were conducted individually, but we also interviewed one pair and one group of three senior citizens. The interviews were always conducted in conjunction with a running-related activity (sometimes during organised races), so we interviewed participants directly post-run. Total interview time was 256 minutes.

Climbers

We recruited 15 climbers (4 females), aged $27 - 43$ ($M = 22$ yrs.) through the snowball sampling technique. We divided

participants into two groups according to their availability and then we conducted two focus groups. Focus group was chosen as investigation method due to the great difference in the participants level of experience (years of practice $M = 6$, the highest-grade climbed leading ranging from 4b to 7b[2]). By adopting this interviewing method, we aimed at considering and comparing all the possible different points of view on the topics investigated. During the discussion, we encouraged all participants to participate by actively inviting them to express their opinions. The focus groups were conducted at a researcher's workplace located in a well-known climbing area of Italy, and lasted approximately 90 minutes each.

Skiers

We recruited 12 skiers/snowboarders (3 females), aged 22−34 ($M = 32$ yrs.) with various levels of skiing experience both on and off-piste. Each semi-structured interview lasted 30 − 45 minutes and was conducted after a full skiing day in a resort in the Alps. This way, we strived to make it easier for the participants to reflect on their day of skiing. The participants were recruited through snowball sampling. Additionally, we conducted a focus group with 7 participants (3 females) aged 25 − 31 ($M = 26$ yrs.). These were experienced backcountry skiers and snowboarders spending a week together in an alpine resort. The focus group was organized through a peer, conducted after a skiing day, and lasted 60 minutes.

Interviews

All the interviews focused on information sharing habits in relation to the sport practiced. Primarily, we asked what data they shared and what technical means they used (e.g. specialized apps or hardware). Examples of the opening questions include "How would you describe the ingredients for a good climbing/skiing day", "What information do you share about your running/skiing activity? With whom? Why?" We also inquired about their chosen audience and if they had any privacy concerns. Further questions focused on when information was shared in relation to the activity. The physical context of the sharing practices was important to us as well — we inquired whether particular surroundings elicited specific sharing behaviours. Finally, we asked the participants to reflect on the social dimension of information sharing in sports, and on the role information played in their sport groups. Having common interview questions allowed us to understand descriptively the commonalities and the differences among those sports. All the interviews were audio recorded and then transcribed. Moreover, during each interview we took field notes and reviewed them immediately after. Travelling back and forth between prior research findings, our field notes and the interview transcripts allowed us to quickly find emergent patterns in the collected data, and subsequently establish common themes between different disciplines.

Analysis

As the original data was in four different languages (English, Swedish, Polish and Italian), relevant passages representing the three sports in equal parts were later translated into English so that all authors could compare results and reflect on the differences and similarities of each data set. We established a coding tree by translating about 10% of the data set to English with equal parts representing the three sports. All four authors coded the data independently using thematic analysis [27]. Next, in two code-adjustment meetings, we iteratively reached agreement on the final coding tree that was later used to code the entire data set. The tree contained the five top-tier themes that are presented below. Finally, in order to reduce the language differences further, we created a data synopsis for each of the sports, which we linked to the most relevant quotes from our participants to support emerging empirical categories. The data reported below was derived from the synopses. These practical considerations enabled us to conduct a study spanning multiple sports and nationalities without the need for professional translators and language-level analysis.

THEMES

In this section, we present the themes that emerged across the three sports. Through these it was possible to identify the common and different attitudes that participants practising the different sports exhibited towards technology and information sharing. We chose to present the data separately for the three sports to highlight the differences and the commonalities.

Nature

Nature, or "the great outdoors", is the common thread in the three sports we considered. Skiing is inevitably an outdoor activity, and although running can be done in cities and climbing is practised worldwide thanks to indoor gyms, all our participants preferred to practise their sports outdoors, outside city areas.

Runners

All the participants have a developed relationship with nature:

'I love the freedom in running in the forest.'

They also exhibit strong a preference for exercising in non-city environments, which is not always possible:

'Unfortunately, there is not much you can do in the city, route-wise.'

One often-cited reason for preferring nature is the experience of being alone with oneself. Other reasons include the possibility to explore new places, to see how nature changes throughout the year, and the need for an environment that contrasts with an intensive work life. When asked about their ideal running routes, participants would mention the mountains, hilly forests, and other scenic environments.

Climbers

Climbers have an extremely direct relationship with nature; they move up the rock by grasping it with bare hands and pushing with their feet, while continuously searching for balance and the most effective movements. In particular, the tactile sensations climbers get from the rock influence their sense of self-confidence, performance, and enjoyment.

[2]French grading system.

'In mountain climbing, (what makes a good day) is the kind of rock, the kind of movements required by the wall...'

Isolation, together with immersion in nature, is considered positive. For example, to have the possibility to explore nature without other people except the climbing partners is considered a great privilege:

'SM: In my opinion, the environment matters a lot. For example, climbing on mount Sella is unpleasant because you can hear the motorbikes racing at the foot of the mountain.
DC: Being isolated is pleasant. (. . .)
SM: Yes indeed, to have someone climbing above you that makes stones fall is not pleasant at all. (. . .) I enjoy also the time spent approaching the start of the route. I prefer to spend two hours bringing the ropes in the backpack and climb a shorter route in an environment that is far from busy roads; it's more like an adventure!'

Part of the beauty of being immersed in the nature is also due to the challenges it provides. This aspect is reflected in the words of one participant addressing the proposal of another participant about having a system of augmented reality to show the route while climbing a mountain:

'Alpinists would assault you if you create something like that. You should know the path by yourself, that's the sense of going mountaineering.'

Skiers

Similarly, nature plays a profound role in skiers experience:

'I love quiet untouched slopes with a lot of powder, maybe some nice ways through the forest... where you have 20 minutes of a great ride.'

While, for some participants, skiing is about performance and getting the best out of the day:

'I love going skiing just for myself. So, I really like this independence. With great snow, I do hours of skiing, lunch on the lifts.'

For others, it is a social activity built around spending time outdoors with a group of people:

'I think (skiing as) the social construction where you can do something together without really being together is quite, I think, attractive. You have synchronization points where you are basically in a cable car or in the lift, you have the chance to talk to people for quite a while and mainly without much disturbance.'

Risk and planning

Safety and risk are important concerns in outdoor sports. Risk is a combination of environmental factors, personal conditions and self-confidence, and coordination between sport partners. Therefore, in the disciplines we explored, sportspeople often seek additional information prior to the activities to increase their safety and comfort. In particular, weather conditions and information about the area are searched as both affect outdoor practices significantly. However, the need for planning differs naturally between the sports; while backcountry skiers and mountain climbers go for longer trips, where careful planning is needed in order to mitigate risk and make the time investment count, runners often noted that one of the best aspects of running is that it can be done with minimal preparation. These attitudes were repeated during the activity, when the need for sharing in order to minimise risk is higher for backcountry skiers and mountain climbers - who always practise their sport in pairs or larger groups, and thus have to be coordinated - and lowest for the runners, where the majority of people prefer to run solo.

Runners

The runners used a variety of strategies for planning the run and integrating it into daily routines. Some made the decision on where to run during the day, indicating that they had already explored the nearby environment and were versed in the possible routes. Notably, discovering new routes and consulting with others on the matter was perceived as a labour-intensive task that could not be done properly using just a mobile phone. Some runners mentioned explicitly that they obtained simple weather information directly preceding a run:

'Before a longer run, I look at the weather forecast to see if a downpour is about to start.'

Furthermore, two runners highlighted that the choice of route and surface was often dictated by the specific training format one had planned for a given day. This, however, was also subject to change as perceived rates of exertion may have affected the final training format for the day. Another precaution that runners tend to take is staying in touch with friends and family:

'(regarding using the phone to orient oneself) I think there should exist better ways (in the app) to — well, it happens that you are out in the forest and hurt yourself, for example — that you would be able to quickly send your position to, well, your boyfriend or family or anyone, really — purely out of a safety perspective.'

Climbers

Information retrieval and accurate planning are especially important for this sport because climbing entails various types of risks. Climbers can be caught by thunder storms, rain showers, go out of the climbing route, fall, etc. Therefore, it is fundamental for them to have very accurate updates and reliable information.

'That's why is so important to know when a route was created. If you go to France and you find a 5th grade route but it was bolted in the 80s, you risk serious falls.'

Climbers are highly dependent on weather and the challenges posed by the chosen route. Consequently, they need to know a number of parameters that are solely controlled by nature:

'(we need to know) the time required to approach the route/crag, the difficulty grades, the weather, how slippery the rock is...'

Generally, to get this kind of information climbers rely on the Internet, guide books, or directly on friends who know the spot. Smartphone apps were not used often. Our participants affirmed to have used mobile applications for a while, but to have stopped later because the applications' primary focus was skiing or hiking. They ascribed a lot of importance to the source of information, which they needed to trust. For example, almost all of our participants relied upon a few websites

known to be reliable, but they preferred receiving information from friends rather than from strangers.

'DC: Well, I think that the word of mouth plays an important role. Climbers use much more the word of mouth than... of course on Google you can find the report, but...
MF: Or 5 different reports
DC: (laughing) or 5 different reports, together with variants!'

Another user was reluctant towards information obtained from internet forums:

'If someone has completed the same route, I ask him: how is it? Are there falling rocks? I try to get some hints about the situation so that I know what to expect. (...) I do not trust forums at all. There, it's all a competition between who is cooler and braver. It's very likely that they tell you 'sure, it's so easy and well-protected!' And then you find a bolt every pitch.'

During the ascent, communication between climbing partners was perceived as fundamental for managing risk. Apart from the need for coordination in joint actions that can be performed either verbally or non-verbally (e.g. by pulling the rope), there is also a decision-making process involved.

'Seeing the weather changing and taking a decision with your climbing partner like "Ok, we are a pitch away from the top but we need to turn back", being able to take such a decision and going back home alive, is not a trivial matter.'

The relevant things to be communicated in those cases are personal conditions (tiredness, loss of self-confidence, difficulties in climbing, etc.), and evaluation of external factors (e.g. weather change). This communication usually happens when climber and belayer meet at a belay station; otherwise they have to solve their difficulties on their own since environmental noise and distance hamper the communication. A new trend is to use walkie-talkies, but our participants considered these as tools for inexperienced people and not very efficient because the signal is disturbed by the many communications using the same channel. In case of extreme need, they would use their smartphones, but they do not really rely on them because mobile signal coverage is spotty in mountain areas. Smartphones were used primarily for taking pictures, to have a backup of the report of the route (while the main one is always on paper) and for security reasons, i.e. to make a phone call in case of need.

Skiers

Similarly to climbers, the skiers' experience was also highly affected by current weather. Snow conditions are important factors to get the best out of a skiing holiday. The amount of fresh snow at the resort, visibility, temperature, wind, condition of the slope and precipitation on the mountain were among the factors that influence the decision to choose where to ski the next day.

'I did not plan to go skiing there, I just saw one day before that prediction of 1 metre snow. So I call this friend of mine at the evening at 10pm: "What are you doing tomorrow? — Not so much. Do you have time until 2-3pm? So let's go there at 8-8.30 and ski for 5 hours."'

As backcountry skiing is known to be a high-risk sport, those practising the discipline develop a number of risk management measures. First, skiing groups have clearly defined roles. The lead, an experienced skier, chooses the path and the stops and provides immediate feedback to the rest of the group. Followers are mid-pack skiers that form the core of the group. Another experienced skier is at the end of the group and provides support to anyone struggling with the route. The skiers strive to keep the lead within their line of sight:

'The lead chooses a safe place and the rest follow. [...] it is important not to overload the slope.'

The route of descent is chosen by the group members collaboratively during every second stop and depends on the skills of the group members. Safety is a primary concern and it is the central element of group communication.

Audience selection

Participants in all three groups had thought about with whom they shared sports activities.

Runners

All the runners were conscious of whom they shared their running data with. Some communicated solely (or almost solely) with other runners:

'I don't seek out friends on Runkeeper. These (my Runkeeper friends) tend to be people I've run in the past with.'

The users either became members of established groups (e.g. Facebook running groups) or established their own well-defined groups in which they conducted regular sharing. The data varied from automatic sharing via Garmin and Runkeeper to more elaborated explicit forms e.g. direct messaging or taking screenshots of apps. Events or especially successful runs were given extra attention and intensified sharing. One user mentioned how they had posted their race result on Facebook and received multiple likes and comments which heightened the experience of achievement. Two runners were explicitly concerned about supplying too much content:

'When I noticed how I was spamming the wall, I stopped doing it.'

These runners endeavoured to limit the amount of data available publicly to not spam their followers with too many run reports. They also reflected on the days when they had been beginners and noted that they tended to share less over time.

Climbers

Climbers usually did not share their experiences publicly, despite their strong need for self-expression:

'(If you don't tell stories), why go in the mountains?!'

They preferred to share their experiences with friends or acquaintances who share their same passion, so that they could understand their commitment, effort, and satisfaction. This kind of sharing was done both as diary keeping and as a repository of known places, so that other people could ask information about a place they had been recently. This was mostly achieved through media with restricted access like Dropbox, closed groups on Facebook, or Whatsapp. It is worth noticing that within these groups reciprocity was expected:

'I usually put the routes on Facebook. I put one picture, the name of the route, the place... because I have these (closed) groups of friends, and I know the others will do the same.'

More general sharing on social networks was used almost solely for special achievements like climbing a certain route for the first time. Otherwise, sharing with bigger groups or even publicly happened when climbers had some role in the wider community, e.g. being route setters or alpine guides. For example, a participant mentioned a closed but crowded group on Facebook where members shared news and equipment reviews. Thus, we could say that the more public the sharing is, the more it acquires a value-driven purpose. In fact, climbing may also be used to communicate other values; for instance, a participant mentioned a blog of mountaineering girls who shared their achievements with the intent of being role-models and spreading feminist values.

Skiers

In the case of skiing, the primary sharing audience is the current skiing group on a given day. Location-based content is used extensively to coordinate skiing activities and set up meeting points when the group splits. Most of the sharing activities occur when the skiers are not directly engaged with skiing activity itself, e.g. during the breaks or in the cable car.

Users reflected that they did not want to overwhelm their social media audience with skiing pictures. Consequently, they used other means of sharing:

'I don't want to share it on Facebook with everybody, but (just) with the people who were in the picture. I usually send it immediately, because if I don't do it more or less immediately it's never going to happen.'

Another audience for skiers was friends who could possibly be skiing with them. They were hoping the friends could join next time, but careful not to elicit negative feelings:

'I share the track with friends I kind of like I guess to show them that you were there and sometimes you can even say like 'Hey, you should have joined!' or maybe sometimes you can make people jealous.'

Finally, backcountry skiers expressed a need for companion apps to have a comprehensive view of snow and road conditions to reach places with untouched powder. However, drawing on the excitement and exclusivity of discovering less known places, skiers did not want to share all the knowledge beyond their group to avoid bringing crowds to specific spots at the resort.

'For all of us would be great whether an app would show how to get to certain point in mind (to the bus, to the track), how many cm of snow in a desired location, track including a map, but then the ski resort will be too popular among others, and an exclusivity of such this small village we are in right now will be lost.'

Content selection

Depending on where and with whom the content was shared, participants had different sharing strategies. Practicalities, self-representation, and privacy were important, but also understanding that friends and acquaintances were not necessarily interested in all data.

Runners

Two runners noted that they were conscious that extended data (e.g. physiological measurements or gait features) may be meaningful only to those who have extensive experience running, and shared data (e.g. running routes or uphill run difficulty) explicitly for the purpose of helping other runners. One participant mentioned they only shared location data with established training partners they had met face-to-face. One participant also mentioned that other apps were already collecting location data in the background, so perhaps his concerns about running apps were unreasonable. Some relied on the default setting of the chosen running app for choosing what to share:

'I do the automatic sharing: that shares my average time, my heart rate, my elevation change... whatever, I'm not so concerned with that.'

One runner reflected that the content they shared evolved over time. As they gained more experience they appreciated subjective feedback more:

'I figured out I missed out on making notes. I should have taken notes on how tiring the run was early on.'

Climbers

We realized that climbers registered data primarily for their personal memory, as a form of diary keeping. It has to be noticed that very few applications for climbers are available on the commercial market. None of the climbers with whom we spoke used dedicated means for ascent tracking; they used generic tools or kept no record at all:

'R: Do you keep trace of your improvements in climbing and, if yes, what do you use?
LT: I remember the beautiful days, where I was, and what I did. Also the bad ones. But just in my mind.
R: So you don't use any device, not even a paper diary... Did you used to once? What did you used to write?
EM: I used to write down the routes I accomplished.'

The focus of attention on what to record depended strictly on the motivation for practising climbing and on whether one was a beginner or not. Usually, beginners are enthusiastic about their new experiences and sensations, and they achieve new results more often:

'At the beginning, you really want to share what you are doing, but then, after a while, you focus more on the practice and less on documenting.'

For more experienced climbers, some suggested leveraging on competitiveness to keep motivation high:

'Nowadays I don't climb so much anymore, but I'd like to have an app like Strava for climbing. The coolest thing Strava offers you is the comparison with the people you know. I know that Moon is currently trying to do something similar with the Moonboard.'

Moreover, our participants distinguished between the needs of people who climb for fun and those who train with the goal to improve or to take part in competitions:

'If you climb for fun but you want to have a track of your improvements it is enough to know how many routes you climbed (. . .) if you train seriously you might need to keep a more accurate track of what you do.'

Skiers

The skiers in our study shared a wide variety of data types. Sharing personal and group information during a day out skiing often included details such as location, photos and videos. Skiers share location primarily to coordinate activities on the slope. Smartphones or walkie-talkies are used to instantly communicate one's position. A location on a digital map is often sent through an instant message service, which may be followed by subsequent voice communication. Similar patterns may be used to manage the group composition:

'If we have some people who want to split, we give them the walkie-talkie and keep in touch.'

Aside from coordination, backcountry skiers also frequently document their descents: they create large amounts of content to review after the activity. They often carry high-performance equipment to record high quality video such as GoPro cameras or DSLRs. The equipment is used to stage particularly exciting moments (e.g. jumps). One skier reported that usually multiple members of the group would carry recording equipment, however only one would volunteer to maintain a coherent account of the activity and to create a final video clip.

'When DM was at home, he had all the footage and made a great video cut about the trip.'

One group established a data policy where footage was synced to a single external hard drive:

'(At the end of the day) it is actually a great way to agree on transferring media [...] while we are still here.'

Privacy

Many respondents expressed privacy concerns, not only in relation to sports data but also regarding other sensors and apps that their smartphones were equipped with. Consequently, there was an understanding that this was unlikely to be solved within sports alone, but that sports apps should conform to a more comprehensive personal data privacy management.

Runners

While most users shared different forms of data, many established boundaries of what could be shared. Photos and playlists were considered easy to share and unlikely to pose a risk. In contrast, many users expressed concerns about sharing location data widely. They cited the fact that not only it affected them, but also their friends and family, and thus they did not feel entitled to decide on other people's privacy. Interestingly, one runner reflected on the need to balance risk-taking and privacy:

'I found a Swedish website that was doing just that (ID bracelets), but they actually stored the information. And then I felt: No, I don't want that.'

On the other hand, some users expressed the possibility of trading some privacy for good reasons. For instance, one user wanted to promote a local running location he enjoyed, so he was willing to publicly share routes from that location:

'I tell people about Skats to make them understand they should run here. I want to advertise Skats, it is fantastic.'

Climbers

Climbers' privacy concerns were related to the careful selection of the audience that they had to perform in order not to create conflict with other people. An example is offered by a participant who told about realizing the consequences of sharing on Facebook and adjusting their behaviour accordingly:

'I used to share a lot on social networks and I enjoyed having chats with climber friends that I did not see often, but then other people were envious or started to annoy me. I felt invaded in my privacy and I took everything off. Then, I restarted sharing because I wanted to share with friends I cant meet anymore, but now I put some limits (to who can see what I share).'

The need to pay attention to the people with whom they share information could explain also why climbers often retain facts to share them only face to face:

'Sure, face to face. At the bar, in the evening.'

Secondly, climbers' tendency to limit digital sharing was also linked to the dynamics of secrecy and competition. Providing certain information or experience could have simplified achievement for competitors or have made lose exclusivity to certain crags. Thus, climbers were wary not to share too much.

Skiers

Skiers differ from the previous two groups since performing the activity in a publicly available ski resort already implies a privacy trade-off. Modern ski resorts use RFID cards that trace lift usage, which is then available online, albeit in anonymous form. This is a compulsory service required for all skiers in the area. The skiers in our study reflected that they understood this data enabled the ski resort to run the facilities more efficiently, despite the fact that several concerns were raised that collected data should not be linked to a skier's identity. When it comes to the tracked activities using apps, the users expressed the desire to be fully in control on what events were shared:

'I think the system automatically posted something on Facebook, which I disabled, because, I mean, you don't always want other people to know where you are or what you were doing. So, I mean, I want to decide by myself what I want to share and what I want to keep private.'

As for sharing the extended footage backcountry skiers are likely to create during a trip, the photos and videos were considered private to the group. While the skiers recognised that uploading the content to the cloud would simplify sharing, they were determined to keep the footage exclusive to a closed group:

'Great if you could create a group page about the trip, which would include only people who were skiing there.'

RECOMMENDATIONS FOR DESIGN

Having reviewed our themes, we present the recommendations for design that emerge from the user needs evidenced in our qualitative analysis. By doing so, we aim to inspire future systems exploring gaps in current sports technology. Our five recommendations can also be used as entry points for specific design inquiries in the three sports. We link each recommendation with the themes above for clarity. While some aspects

of the recommendations may apply to more than just technology for running, skiing and climbing, designers should use them with caution in case of other sports. We imagine that the five recommendations below may function as a checklist for designers to ensure the information sharing aspects of their sports-oriented application are addressed thoroughly.

Augment, not obstruct the outdoor experience

The participants in our study felt a personal connection with the great outdoors, as shown in the NATURE theme. Irrespective of the discipline, the users were both motivated by the possibility of experiencing nature and concerned of being exposed to its forces (e.g. their activities were heavily affected by weather conditions). Future technologies should embrace this complicated balance and strengthen the connection with nature. This appears to be especially challenging as we have observed that the experience of nature often blends with the sense of achievement and creating personal memories. On one hand, we saw the users taking extensive footage of their activities (with backcountry skiers being the extreme case), while on the other hand, we observed that users tended to limit the number of devices they took with them to experience the mountains better and that technology interface in most cases is not designed for usage while involved in such physical activities (this was especially evident for climbers [26]).

We believe that future systems should offer a large degree of freedom in terms of how many sensors to use and how one experiences nature. There appears to be a need for both minimalistic, unobtrusive tracking (e.g. through wearables) and extensive visible tracking (e.g. drone-mounted cameras). We learned that designers need to tread carefully as designs should balance the need for using technology with the need for experiencing nature without the filter of technology. Designing for periodic use [14] and relating to non-use [39] are design concepts that appear to be applicable in this case. Incorporating these aspects in future designs should be fundamental to augmenting, not superseding, the nature experience that motivates these users.

Provide explicit support for planning

A common feature shared by all three sports in our study was the need for planning. Also in trail running, which appears to be a more spontaneous discipline, participants often conducted preparatory activities. Our results show that current technology provides little to no support for planning activities in outdoor sports. The interviewees used generic tools both to obtain the necessary information and coordinate within groups. It also appears that social media provides little support as most users reported obtaining information from generic search engines. Coordination was also conducted through generic means such as e-mail, instant messaging or phone calls.

We see the lack of support for planning as a significant gap in current sport technology. Our participants did not use a tool to keep all the required information in a single space and resorted to alternative means. We envision that future outdoor sport support systems should easily be able to gather information such as geographical location, weather and group composition in a single interface. In the RISK AND PLANNING theme, we saw how users consider planning to be central to their safety and their enjoyment of the outdoor activities. It is worth noting that all three sports are constrained spatially by the accessible parts of the surroundings, available ascents, and lifts. Users require efficient means to negotiate those constraints and communicate their decisions. Finally, those who have more experience need ways to communicate their advice to novices already in the planning phase, which is now difficult. Consequently, designers should empower users to effectively contact their activity groups and coordinate plans prior to heading into the outdoors.

Incorporate risk management features

In our study, we observed that users often needed to reach consensus within the group to balance possible enjoyment and risk. They needed to consider their skills, personal plans for the day and external factors to decide on a course of action that would be safe and most enjoyable. Current technology offers little support for risk management. As a consequence, we saw users appropriate generic technologies to accomplish that task.

In the RISK AND PLANNING theme, we saw that users often required external information to fully assess risk. Weather information and opinions from others are often basic requirements to decide on a safe course of action. Yet given that risk management is often carried out across a group, there is the risk of some information being omitted and the assessment being wrong. Future technology should strive to minimise that possibility. We envision future applications that integrate multiple sport-specific information sources. For instance, climbers would benefit from weather, ascent rating and rescue service alerts being integrated. A dedicated system could also account for the intrinsic risks of the event such as weather and the ascent conditions. Users in our study often collected data manually, and out-of-date information may pose an additional risk that could be mitigated by group risk-assessment discussions. In summary, it appears that choosing a safe route is a sensemaking task, so we recommend that designers use the experiences of past sensemaking systems (e.g. [15, 19]) to build extensive support for risk management in outdoor sports applications.

Support multiple informal groups

Users were especially careful about with whom they shared their sport-related information. In the AUDIENCE SELECTION, we observed how users chose to share with different audiences at different times. All three sports benefit from a system of clubs and informal groups to maintain the users' motivation. Furthermore, we see an emergent need for future technology to empower users to quickly and efficiently select audiences for sharing sports data (e.g. [11]). Privacy control was discussed in the PRIVACY theme, with the conclusion that sport enthusiasts should be able to easily select the right target audience for a given piece of content, in order to prevent unwanted access. These findings are related to unwanted audience concerns in social media [43].

Prior research in personal sensing identified privacy concerns [20], especially when it comes to conversation logs or data

that describe private psychological states [36]. For instance, in our study, skiers were not highly concerned about sharing data with the resort that would eventually support their descents through lift operations, presuming anonymity. More frequently, they shared various digital content describing the overall activity within the group, where privacy restrictions are rather relaxed. On the whole, the need to differentiate between multiple groups most likely arises from the different purposes of sharing for sportspeople ranging from peer support [42] through self expression [31] to competitiveness [5]. The AUDIENCE SELECTION theme showed that many of our participants were part of small, informal cliques where they fully trusted their closest sports friends. Consequently, we believe that future sharing applications in sports should offer extensive tools for audience selection that consider the intricacies of cliques, bragging, privacy and competition. These applications should allow users to quickly and efficiently select audiences for sharing sports data (e.g. [11]), otherwise this may lead to hindering the enjoyment of the outdoor activities for competitive users.

Enable multiple levels of content selection

Our last recommendation is closely tied to the CONTENT SELECTION and PRIVACY themes. We observed that most users differentiate between the kinds of data they share in different moments. Some relied on automated sharing and were unaware of what exactly was shared (e.g. runners) while others took great care in gathering and creatively modifying content before sharing (e.g. backcountry skiers). In line with the *Post Content* design dimension from the social sharing framework in personal informatics [11], we observed how different levels of control over information were required to allow users to effectively curate the content generated during sport activities. The need for an accurate content selection is often caused by the users different purposes for sharing in the social environment. Content is often adjusted to suit particular audiences. For instance, we saw users trying to convince others to join them at a precise location. This required simple information sharing without extensive exercise-related statistics. On the other hand, climbers may want to share the exact route and ascent time to gain recognition in their community. We observed that content often helped negotiate group status, future plans or training schedules. These social agreements may require data that may be considered confidential.

All in all, we believe that future systems for outdoor sports should offer more control over content; users need to be given the ability to explicitly share chosen aspects of their activities at particular moments with the cluster of people they want. In addition, content obfuscation strategies identified in prior research in personal informatics [11] such as restricting or abstracting the disclosure of temporal context [36] can be also explored in designing for sharing in outdoor sports since those strategies mitigate users' privacy concerns. Finally, providing awareness or restrictions about the data retention policies employed by tracking devices and applications, and providing visibility and control over the sensed data may contribute to the adoption of continuous tracking [20], hence potential sharing of personal content. Future research could also explore the impact and relation of personal content sharing generated from sport activity to social media platforms taking into consideration context collapse [44] and users' disclosure strategies [43] employed when posting content online.

LIMITATIONS

Our inquiry spans multiple sports and countries, but we still see a number of limitations inherent to our study. Firstly, all but one of our participants live in urban areas of Western Europe; this introduces a cultural bias. We see that especially the perception of the great outdoors in our study may be distinctively European. Hence, results should be interpreted with caution and account for racial and cultural peculiarities. The choice of the outdoor sports in our work is also somewhat subjective. We chose the three disciplines based on their widespread popularity and the fact that they all leverage the connection with nature. We can only wonder how different our study would be had we chosen other sports, yet we believe that the commonalities (i.e. usually practised in hilly regions and characterized by a strong relation between athlete and nature) and differences between them (i.e. the level of risk-taking attitude, overall safety concerns, different social settings of each activity) are generalizable across a wider range of sports and therefore provide a useful proxy.

Finally, we are also aware that language issues might have affected the outcome of our analysis, as it depends on the translations of source texts to English by the authors. We hope that any shortcomings and bias resulting from this are outweighed by the benefits of a study spanning multiple social environments.

CONCLUSION AND FUTURE WORK

In this paper, we described an inquiry into the intricacies of information sharing practices in three sports: trail running, climbing and skiing. Through extensive interview studies in multiple countries, we obtained a rich data corpus that we then analysed using thematic analysis. We discussed the five emerging themes: the relationship with the greater outdoors, the need for risk management, selecting with whom to share information, choosing what information to share and maintaining privacy. Based on our analysis, we elaborated five recommendations for the design of future systems that aim to support sharing in outdoor sports. With our work, we tried to build actionable insights that can be reused by designers to build future socially-embedded sport systems. We believe our inquiry can serve as a starting point for designing both tailormade technologies as well as designing sports-supportive features for already existing social platforms. We suggest that future designers embrace the whole outdoor experience in their design to minimise the risk of disrupting the holistic experience of practising outdoor sports. We also see an emergent need for systems that support planning and coordination prior to outdoor activities, as well as risk-management during the activity. Finally, we have provided recommendations to support the complex informal social constructs that emerge around outdoor sports practices by helping users to manage the content they share with different audiences. In our view, the natural unfolding of the work presented here would be a participatory design process based on the recommendations we elicited.

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