Technology meets Adventure: Learnings from an Earthquake-Interrupted Mt. Everest Expedition

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ABSTRACT
HCI is increasingly interested in supporting people's physically active lifestyle. Adventure is part of this lifestyle, and to contribute an HCI perspective on adventure, we present an autoethnographical account of an expedition via Nepal to Mt. Everest. During this expedition, on the 25th and 26th April 2015, two devastating earthquakes struck the region. We believe we can learn from such extreme experiences and therefore reflect on this epic adventure through a set of themes to articulate two dimensions (expected-unexpected and instrumental-experiential) in order to identify four roles for adventure-technology: as coach, rescuer, documentarian and mentor. Our work aims to provide HCI designers with an initial conceptual lens to embrace adventure, and more generally, to expand our knowledge of supporting people's physically active lifestyle.

Author Keywords
Adventure; physical activity; trekking; climbing; extreme sports; exertion; whole-body interaction

ACM Classification Keywords
H.5.2. [Information Interfaces and Presentation]: User Interfaces - Miscellaneous.

INTRODUCTION
On 31 March 2015, Sarah Jane Pell left our lab and Florian 'Floyd' Mueller, who sits opposite her, to summit Mt. Everest. The planning required years of physical and mental training, logistical preparation with expert advisors, and acquiring competency in using alpine equipment, adventure and media technology. The goal was to climb to the summit of Mt. Everest at 8848m to explore extreme performance as part of Sarah's ongoing arts practice.

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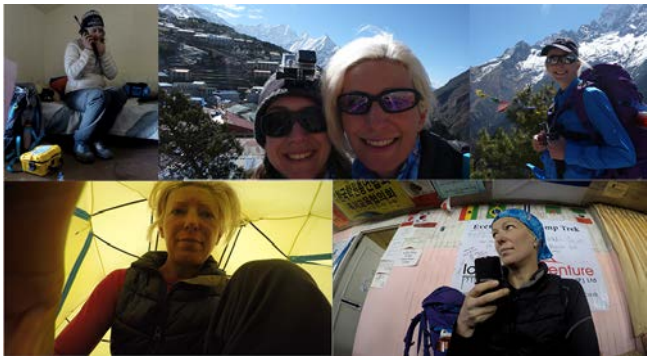

Figure 1. Sarah uses high-tech en route to Everest Base Camp and at Mt. Everest; Sarah relies on low-tech during the earthquakes.

Sarah has extensive experience leading novel technology-supported performance research in a range of extreme environments, for example 30 meters undersea [34], with limited oxygen [40], in remote locations [42] or space analogue conditions [4, 7]. It inspires live performance [7, 35, 40], broadcast media [34], and speculative fiction [36] predicting technologies for adaptation and critiquing human evolution. Mt. Everest was chosen as an extreme location for field research in a series of adventures designed to frame an analytical phenomenology of bodily experience "from Sea to Summit to Space" [35].

Sarah intended to capture HD 360-degree video and record artistic expressions made on site, paired with GPS location, altitude and body sensor data to create creative insights into the experience to express novel exploration phenomena. Sarah's art research enables the possibilities of imagining the expedition as a dynamic space of performance, with her audience spanning the fields of live art and performance, human factors, alpine as well as space analogue research.

Over 17 days, Sarah trekked from Lukla at 2840m to Everest Base Camp (EBC) at 5364m (Fig. 1), field-testing a range of commonly available technologies for supporting high altitude adventure while investigating interactions with these technologies and the environment [33]. Unexpected events, including the earthquakes that devastated the region, ultimately prohibited Sarah from reaching the summit. As such, it was a "failed" expedition, yet we believe we can

learn from the extreme character of this adventure. Herein, we discuss this event from an HCI perspective in order to sensitize the field to adventure, given the proliferation of technologies that associate themselves with adventure, such as action cameras, sports watches, fitness trackers, outdoor GPS-based equipment, sports tech apparel and wearable biofeedback systems. As we have previously investigated activities that can be also considered adventure activities according to Young [59] (such as rock-climbing [10] and skateboarding [38]), we believe we have a unique perspective on how the findings can be also applied to less extreme settings, resulting in a guide for a broad spectrum of future work.

This paper makes the following contributions: it presents an autoethnography of a unique epic adventure (as told in the first person) and provides an analysis of this personal account, complemented with related work, to derive a set of preliminary themes to scaffold a discussion around technology design and adventure. Through these themes, we articulate two dimensions: the first on how technology can support the instrumental and experiential aspects of adventure; the second how it can support the expected and unexpected aspects of adventure. Together, they demark an initial attempt to describe four roles technology can play during adventure: as coach, rescuer, documentarian and mentor. The target readers of this paper are researchers interested in understanding the role of technology when it comes to adventure in people's lives; industry designers interested in supporting adventurers by creating novel interactive systems; professionals working in the field of adventure travel and sports who want to be informed of future possibilities emerging for this field; and developers of wearable products who have not yet considered adventure uses of their devices. Ultimately, we hope our work provides HCI with an initial lens to embrace adventure, and more generally, contributes to our knowledge of supporting people's active lifestyle.

RELATED WORK: ADVENTURE

HCI researcher Saul Greenberg's story about his skiing adventure that included a technology-aided rescue from an avalanche, as described in Bill Buxton's book "Sketching User Experiences" [9], is a superb introduction to the intersection between interactive technology and adventure. By describing this adventure, Buxton refers to Hutchins' work on "Cognition in the Wild" [17], which follows Hutchins' open-ocean sailboat racing adventures. All three, Greenberg, Buxton and Hutchins, have drawn from adventure to contribute to HCI: they have used adventure to make a broader point outside of the adventure experience (such as the need for HCI to move beyond a desk-work focus), complementing this, we focus squarely on adventure itself to initiate a conversation about HCI and adventure.

Historically, academic works have examined adventure and its significant cultural role and benefit. For example, philosophy has contributed to an understanding of the meaning behind adventure [24], sports science has provided knowledge about bodily performance in adventure [14], and education has contributed an understanding of the therapeutic benefits of adventure [16]. This prior research has already established that there is a range of adventure types, typically including travel adventure, outdoor adventure and adventure sports. We note that there is divergence (especially across fields such as adventure sport and adventure travel) on what constitutes adventure and consensus that "true" adventure is in conflict with popular representations of adventure tourism [55]. Furthermore, the definition of adventure has changed over the years [51]. In response, for the purpose of this paper we define adventure as an "*exciting experience involving hazardous action with uncertain outcomes based around physical exertion in a natural environment"*. Our definition leans on prior adventure work by Sung [51] and Puchan [43] and also fits with Buxton's, Greenberg's and Hutchins' understanding. For the purpose of this paper, our definition excludes indoor activities like bouldering or paintball and the navigation of escape rooms and mazes. We also define adventure technologies as technologies that aim to support the adventure, whether they were designed for the adventure or not (for example, adventurers might chose to use high-end smartphones for their expeditions although they are designed for corporate work, often resulting in devastating consequences when they break or lose connection).

Adventure and technology

The use of technology to support adventure has a long history; one only needs to think about the compass. However, technology also has the potential to reduce the sense of adventure, for example where previously a compass was needed to navigate to exotic places, planes now fly tourists there with ease. As such, adventure technology needs to reach a fine balance between supporting, but not impending, a sense of adventure. To achieve this, adventure technology needs to be designed well, and this includes the design of digital technology. In recent years, industry developments have emerged that claim to support adventure, including adventure shops that, once promoting activities to take refuge from digital technology by engaging in the great outdoors, are now stocking a range of digital technologies aimed to support adventure. For example, there are GPS devices that support navigation, satellite phones that allow for communication in remote areas and action cameras that allow for the documentation of the adventure. There also exists now smart watches that provide barometric and altimeter information, personal drones for aerial reconnaissance, guidance and documentation as well as emergency alert beacons. The rise of these products suggests that adventurers, who already have a history of engaging with non-digital support technologies such as compass, ropes and specialist clothing, can also embrace digital technology to support their experiences. However, most development advancements in this area are focused on technical improvements (such as better GPS accuracy), or on making existing technologies more robust (such as hard-shells for

mobile phones). By contrast, in this paper, we focus on the role digital technology can play to support the adventure experience, as we find little understanding in this area.

Related fields

Adventure in HCI feeds into current interaction design trends that highlight the role of the body and associated phenomenological experiences as shown by research in embodied interaction [13], exertion games [27], pervasive games [25] and sport [29]. Recent works have investigated the use of interactive devices in outdoor exertion activities, such as geocaching [30], cross-country skiing [28], outdoor running [19, 53], and hunting [18]. These projects remind us that the reason people engage in adventure is manifold, yet most research suggests that it has to do with people's appreciation of challenging themselves. The belief is that adventure can help personal growth and "extend our being" [16]. As such, adventure supports a human trait that values challenge-seeking for the purpose of personal growth and therefore fits within an experience-focused HCI agenda that aims to support human values [60].

In sum, although adventure can benefit from technology, and there is an increasing amount of digital technology available that targets the adventure community, little knowledge exists on how to design technology that aims to support the adventure experience across its multifaceted aspects. In response, this paper aims to start filling this gap by providing an initial understanding of HCI and adventure through answering the research question: how might interactive technology design support adventure? In order to answer this question, we begin by providing an autoethnographic account of Sarah's experience in Nepal before analyzing it in terms of initial implications for HCI. Before doing so, however, we detail the advantages and shortcomings of autoethnography as our method.

AUTOETHNOGRAPHY

Autoethnography is "a form of autobiographical personal narrative that explores the writer's experience of life" [15], in our case Sarah's adventure in Nepal. Autoethnography has the following advantages for this inquiry: first, it allows for the fullest account of an experience, as no information is lost in communication or interpretation between participant and researcher [8]. Secondly, prior research suggests that bodily experiences are best understood by going through them oneself [15]. Thirdly, since autoethnography's strength is qualitative, it reflects the personal nature of Sarah's adventure well. Fourthly, engaging more traditional methods may put study participants into dangerous situations, thereby raising ethical concerns [5]: of course we acknowledge that Sarah was also in a dangerous situation, and as such, we highlight that investigating adventure raises questions around the balance between risk and benefit in terms of threat to life and personal growth.

THE ADVENTURE

Emphasizing an autoethnographical approach, Sarah articulates how the expedition unfolded. Further first-person accounts can be found in her blog she maintained throughout her experience and also in her talks [32].

Preparing for Mt. Everest

I decided to climb Mt. Everest in 2010. During 4 years of planning, I studied alpine climbing on Everest by watching videos, reading accounts, researching art and collaborating with a five-time Everest summiteer to prepare physically and mentally. From 2014, I trained 6 days per week. I used wearable sensors linked to iOS apps to monitor my progress and set personal fitness milestones: a Jawbone UP fitness tracker paired with a digital sleep-improvement program featuring cognitive behavioral therapy called Sleepio; Tony Robbins Ultimate Edge: Hour of Power audio for mental conditioning during physical exercise; as well as a range of other neurosonic enhancement programs from the QDreams Mind Library and I Can Be Anything, Human Progress Apps. In later preconditioning stages, I recorded weight, hemoglobin and blood tests, and $V0_{2\ MAX}$ fitness results by the Beep Test (aka the Leger-test or 20m shuttle run) [50], then compared results each month.

Adventures like this often require fundraising and outreach. I used social media (Twitter, Facebook and LinkedIn), to launch a Kickstarter and Indiegogo fund-raising campaign and created my own website to inform followers of my plans and engage with my blog and Vimeo updates.

I packed a NeXUS-10 MK-II biofeedback kit, a laptop with Biomind software (to analyze the NeXUS-10 data), another laptop to augment my devices, and creative and alpine equipment. In Nepal, I bought two pre-paid (NCell) SIMs: one for my mobile phone and one for prepaid data for a Wifi router (called the BRCK). I also had to buy a "not-so-smart" 2G mobile phone because my 4G smartphone appeared locked (even though it was purchased in Asia).

On 2 April 2015, I flew from Katmandu to Lukla with 5 other summit climbers and 6 trekkers to meet our guide and professional expedition Sherpa and porters. Then began a scenic 10-day trek to EBC to slowly acclimatize to the altitude and test the equipment. The 2G mobile had reception in most villages while the Theraya satellite phone was often not functioning due to the mountains blocking satellite coverage. Charging any device via solar panels or a local generator took a long time: rarely was a half charge achieved in 24 hours. I had invited Emily Harridge to accompany me on the journey to EBC. We tackled many of the technical, practical and cultural challenges of adapting and performing in the Himalaya [33]. Issues with limited functionality, limited connectivity and limited power were continual themes with our "smart" technologies proving not so savvy in practice. Emily's support and good humor was invaluable, but her adventure ended abruptly at 5000m with altitude sickness. We measured her oxygen saturation level; it was critically low at 34%. She had to descend to safety and never made it to EBC.

Another unexpected event occurred that day: my expedition leader returned to India acting on mixed feelings from the

mountain, and alone as a consequence, I no longer qualified for a group permit. I continued to EBC to negotiate new terms to climb and seek a blessing to continue. My respect for the ecosystem on Everest National Park and the traditions, customs and beliefs of the Sherpa people are critical to any successful expedition, the ecology and tourism sustainability [6, 31].

Everest Base Camp: the glacier, the technology and me

By 10 April 2015, I reached EBC. I had to wait until "Puja", the blessing of all expedition equipment, summit climbers and Sherpa by the Lama; this meant that I had ten days to find additional financial blessings for a solo permit. I felt burdened by the stress of last-minute remote fund-raising and the high altitude and reduced oxygen made all bodily activity more strenuous [58]. The low air pressure was evident too: both my body and the equipment casings expanded, making it look like my laptop and face were going to explode [57] (Fig.1). I did not feel like making art, but I did make recordings:

11 April 2015: *Waking up bathed in a warm yellow light of the sun-bleached tent, I take a deep breath and peer out of my sleeping bag covered in ice. It is remarkable to be here and feel so alive. The temperature over night dropped to -10 degrees C but sleeping on the glacier for the first time, it feels colder. The glacier is encrusted with the rocks that we camp on. The little city here is colorful and full of joyous reunions. Each camp is erecting communications towers, dining tents, sleeping quarters, showers and toilet tents. Yaks, porters and trekkers come and go with bells, smiles and cameras. Water is collected from beautiful pools and streams around us. The landscape changes hour by hour with clouds, snow fall and ice from the Sorak falls. It will take time to get used to so many avalanches falling only a few hundred meters from our camp. During the day the inside of the tents can reach 40 degrees C but for now, it is perfect. As a diver, I feel at peace with a body of water. Hearing her breathe and creak as she moves 1 meter per day is as reassuring as a heartbeat or deep breath, like the crashing of waves along a shoreline.*

On 14 April, I must leave. It takes 3 days to walk to Lukla. In Kathmandu, I work to get a permit. On 25 April 2015, at 11:30 AM I transfer a deposit to the trekking company. By 11:40 AM my permit to proceed is confirmed and, as I am already acclimatized, a helicopter is booked to take me back to EBC. There, a Lama will perform the Puja. This ceremony would mark the end of the trekking and the beginning of the climbing phase. I feel elated. My bags are packed. 16 minutes later, more unexpected events unfolded.

Gorkha Earthquake

The official account states: at 11:56 local time on 25 April 2015, the Gorkha earthquake struck, with a magnitude of 8.1Ms and a maximum Mercalli Intensity of IX (Violent). The earthquake triggered an avalanche into EBC, killing 22 people, making it the deadliest day on the mountain in history. Aftershocks occurred throughout Nepal within 15–20 minute intervals, with the second quake reaching a magnitude of 6.7 on 26 April at 12:54. It was the worst natural disaster to strike Nepal since the 1934 earthquake. 8,617 people were killed and 16,808 people injured – while the number of people displaced was 2.8 million [3].

25 April 2015: *I was on the 4th floor of a hotel in Thamel. Dogs had barked all morning and the pigeons had bugged me on the windowsill. Their sudden silence was welcomed as I wrote, when my room began to rock like a boat. A feeling so familiar to me, I continued typing on my laptop and raised it from the surface to stand as it passed just as I would on a vessel at sea. The rocking however was not smooth or predictable like a wave or surge. It became frenetic and increased intensity from side to side, and then up and down. I went to the doorway of my bathroom, where I heard screams outside. I sat down between the doorframe and braced myself, but the ruptures continued and the 40cm thick concrete walls began to bend and sway: this was clearly an earthquake. Technology still in one hand, I wrestled with the brass locks on my room door. I always keep myself locked in, but the building was contorting and so it was jammed. I tried to work with the timing of the movement rather than working against it. Shattering pottery, glass and ceramics became louder and louder. My bathroom vanity cracked and popped the marble bench. My focus sharpened. I opened the door, and braced myself down low in the room doorway. Across the hallway, I saw two male staff members screaming: backs to a wardrobe and feet on the wall, a broom jimmying their doorway open. I'd never experienced an earthquake but I had seen movies. The limit of my knowledge was quickly condensed, "should I get into the bathtub?" I called. "No madam, you need to evacuate." Just then, the eruption decreased momentarily, and though things were continuing to fall and crumble, we three stood to make a run for it… I carried my laptop like a flat pizza box, and shouted "hold my hand" to the staff to balance me as I leapt from a now violently shaking floor, to a semi-stable concrete stairwell. We ran down four flights of stairs to the foyer in the dark. I used my laptop to shield my head from falling debris as I ran from the solid stairwell through the swaying hotel lobby to the main glass doors. Once outside, the impact of the threat hit me, as visibly injured and distressed groups of people banded together in small open spaces; we were clutching to each other, looking up, and in all directions, for falling buildings and cracks opening beneath our feet…then all went quiet. An abrupt eerie aftermath of raw emotion followed. I felt alone, my stomach churned acutely aware, that in a third-world country, I may not be able to let outsiders know that I am alive, or that I may not be able to better resource myself before the aftershocks begin. As others hugged each other, or cried out in grief, I surveyed them (children, elderly, injured) noting limited mobility or encumbrances as a potential hazard if I needed to run quickly in their direction. I saw looters, and scanned for an abandoned scooter helmet to wear but feared moving away. I tried to post to Facebook, and called out for English speakers asking how far was it to the main square – too far.*

I remained fully dressed without access to secure shelter, sanitation, food or water for the next 72 hours. I was in a fight or flight mode of high adrenalin and exhaustive alertness. Sleep and a sense of security were neigh impossible. On 28 April, three-days later, I finally reached my embassy in Bansbari to plan for evacuation. The adventure did not end here: at Kathmandu airport, an airline staff member took exception to me for asking to board the plane while still wearing a GoPro action camera (which I had worn throughout the adventure): my equipment became a security threat, and a long argument arose whether I was allowed to board the plane. I made it home by 3 May 2015.

UNPACKING THE ADVENTURE

The first conversation Sarah had upon returning to her home country was with Floyd, allowing for a rare HCI perspective on a rather unique adventure that involved a whole gamut of both anticipated and unanticipated "hazardous actions" as per our definition. We recorded our conversations and used these, along with the data Sarah captured during the trip, however, much of the data gathered during the state of emergency exists in fragments as a result of the physical and emotional difficulty of recording during a catastrophic event, and the shift in priority from thinking about data collection to matters of survival. We grouped our findings into themes and then used these themes to articulate dimensions that describe key aspects of the use of technology as part of an adventure. Finally, by talking through these themes and dimensions, we were able to present an initial articulation of four roles that technology can play during adventure.

THEMES

We identified the following preliminary themes that are concerned with the use of technology in adventure.

Nature: Adventure technology can mediate the conversation with nature

We find that adventure is as much a conversation with nature as the self, and we propose that technology can play a role in mediating this conversation [6], drawing on prior work that examined mediated expressive engagements as conversations with media [61]. The notion of technology mediating conversations between people and the environment has been observed previously in the context of skateboarders [37, 48]: their exertion activity could be described as a conversation with the urban environment. In Sarah's case this conversation was trekking through the snow, where as she tried to make a path (in the form of steps), the terrain would push back (by adding snow in her way) in dialogue with her bodily action. Sarah assumed that she could rely on technology to mediate this conversation, for example by using satellite imagery to identify her route. Unfortunately, this mediation was hindered by limited technology, as Sarah could often not get enough satellite reception or the time-to-fix took too long.

From an experiential perspective, technology mediated the conversation with nature by providing Sarah with augmented and new ways to converse with and in particular listen to nature. She used her microphone to record the sound of the wind howling at night and artists playing traditional Dohori music. This sound has since been used both for reflection on the experience and in order to make a documentary film.

Right after the earthquake, when people were expecting aftershocks, Sarah observed how the locals used very simple "technologies" to sense if a further shock was near. They suspended water-filled plastic bags above their stove, which indicated the beginnings of trembling through ripples in the water (making people aware of upcoming shocks through visuals before they could be felt). The direction or swing of the suspended bag would also show the building's movement. This allowed people to remove hot items from the stove quickly, preventing burn injuries. Mobile phone apps could have provided similar functionality, and in fact earthquake-related apps exist, however, they were of no use for Sarah as she had not previously downloaded them, and there was no Internet power. We propose that technology design could learn from such ad-hoc low-tech solutions.

Preparedness: Adventure technology can facilitate a pleasurable feeling of being prepared

Prior work suggests that people engaged in exertion activities can gain pleasure from the knowledge that they have prepared well [19]. We believe that technology can facilitate this pleasurable feeling of being prepared when it comes to expeditions also. Sarah experienced this when a trekker in the party developed symptoms of altitude sickness. Sarah was able to offer an attending physician the NeXUS-10 to analyze the patient's oxygen levels. The diagnosis was confirmed, and an escort planned to get the patient to lower altitude. Although Sarah felt sad that a fellow adventurer had to descend, she also experienced a sense of reassurance that she was prepared for this unexpected situation. In contrast to non-digital technology, such as her boots and beanie, that also provided her with a pleasurable feeling of being prepared for the cold, the fact that the NeXUS-10 offered a wide range of functions (including oxygen sensing) appeared to provide more opportunities for this pleasure to occur (such as Sarah being prepared to help others). Another example of how technology can facilitate pleasure in this way arose from unexpected technology support: Sarah carried a bulky 510g "rugged, portable, WiFi hotspot and battery extender" called BRCK as it promised essential services supporting her goals. However, it did not connect to a network over the 17 days. Frustrated with this situation, Sarah contacted the developers in Nairobi who couriered an upgraded model. Although it did not arrive, the anticipation of access to this upgraded technology reassured her of preparedness, facilitating a sense of future pleasure.

Even during the earthquake Sarah experienced a small degree of confidence due to the life-supporting alpine equipment she had (personal protective equipment, a head-torch, pocketknife, first aid kit, portable solar chargers and thermal protection). This equipment supported her in the

earthquake, distinguishing her from all other (non-climbing) tourists, who were not as prepared, even though the equipment was meant to prepare Sarah for an alpine climb, not a natural disaster.

Protection: Protecting and being protected by technology is a reciprocal relationship in adventure

Sarah highlights that she experienced a sense of caring for her technology, protecting it from the harsh environments, so that in a case of emergency, the equipment would be able to care for and protect her in return. In particular, the quality of the protection appeared to be heightened because of the extreme nature of the experience, i.e. as Sarah knew that if her equipment would fail her, her expedition and in an extreme case her life could be threatened, in consequence she was intensely protecting her equipment, for example very different to the level of protection in her everyday life. This more intimate reciprocal relationship is best exemplified by the fact that Sarah put her mobile phone, laptop and hard drive into her sleeping bag at night to keep them as warm as possible. She also wrapped the NeXUS-10 and the laptop in a down jacket overnight to avoid it freezing inside metal casings (as they were too cold and bulky to sleep next to). It should be noted that of course people care for technical equipment, especially if it is costly, for example people put protective cases around their mobile phones. Similarly, preparations for the expedition involved organizing shock and waterproof casings, zip-locked bags and non-freeze material. However, what we did not expect was the degree of care Sarah would feel towards the equipment. For example, due to the lower pressure on the mountain, the equipment cases expanded and threatened the inner workings of her laptop, and Sarah knew that any malfunction threatened to forfeit her objective of documenting the adventure, which made her quite anxious, adding to the heightened bodily state that an expedition brings with it. As such, it seems that the intense nature of the experience heightened the reciprocal relationship between protecting and being protected by technology. This means in turn that designers of adventure technology need to be aware that protection of equipment can also take on an extreme character: for example, when wrapping equipment in clothing, down filament or feathers might enter through its vent slots and damage it, a malfunctioning event not necessarily anticipated on Mt. Everest: damage not due to snow or ice, but fluff.

The caring Sarah experienced towards her equipment was concerned with both instrumental and experiential needs. Sarah knew that if she would not protect the equipment, achieving her instrumental goals (i.e. getting to the summit) would be threatened. Similarly, caring for the technology was also a way to support the experiential aspects of the adventure: when Sarah realized at a picturesque spot that her 360-degree camera was not functioning due to condensation (as a result of the expanding casing due to the altitude), she perceived the equipment not only failing her expedition, but also failing her.

Furthermore, sleeping on a glacier for the first time at EBC, Sarah documented feeling a deep connection to the frozen moving body of water. She related it to her prior findings in embodied performance underwater [36]. The phenomenological shift strengthened her engagement with nature, and consequently reinforced that technology was a valuable resource and worth caring for to support her goal. As such, caring for her equipment was a way of caring for herself.

Control: Adventure technology facilitates control states

Another theme that emerged is that technology can facilitate out of bodily control experiences but also help regain bodily control. Adventure involves intense bodily action in a challenging environment, such as when climbing a difficult glacier or cliff face, often relying on a single piton. Prior work has described how one of the appeals of such activity is “the body passing kinetically in and out of control” [1]. We believe that this crossover of being in and out of bodily control is one of the key reasons why adventure is so exciting, and we now describe how technology might be able to facilitate it.

Besides the climbing gear that facilitated the being in and out of control through, for example, hanging over an icy abyss, technology in this context also relates to Sarah’s high-tech thermal clothing: without the insulating characteristics of the clothing, she would have felt colder quicker and in consequence would have perceived to be less in control of her body, because in the cold, the body uses more carbohydrates to produce lactic acid that, combined with the deceleration of the nervous system, forces the body to slow down and hence results in a loss of perceived control. Furthermore, the low temperatures limited Sarah’s motor control and hence her ability to draw with pen and paper, one of her favorite activities to do during her adventures. Similarly, the loss of dexterity affected her ability to operate her action camera buttons and hence did not give Sarah sufficient control for self-expression, leading to moments of frustration. Although her clothing was not interactive, advanced clothing could have sensed her biosignals (indicating out of control situations) in order to respond with actions to regain such control (for example by automatically engaging heat pads).

In the unexpected situation of the earthquake, Sarah often felt out of control of her body. Technology did not offer Sarah much reprieve in this regard; in fact, the earthquake situation was mostly characterized by moving away from any tangible matters including technology to avoid being injured from falling objects.

This theme reminds us of the work on the breath-controlled amusement ride [22]: the authors describe how wearable technology can enable engaging bodily experiences in which users are “playing” with being in and out of control. We extend this work by highlighting how unexpected situations can lead to out of control experiences that technology might facilitate.

Social connectedness: Adventure technology mediates unbalanced social connectedness

Another theme is concerned with the support technology offers to mediate social connectedness between adventurer and others. We see connectedness as a basic human need that describes a "feeling of being in touch" [44]. Although many famous adventures are recorded as solo endeavors they are still team pursuits: they involve social interaction when selecting or designing equipment, interactions with trainers, guides and fellow adventurers, and ritual ceremonies and celebrations [39]. We find that as adventure often takes place in remote locations (hence away from support networks), the "feeling of being in touch" is of particular importance: Sarah wanted to communicate her experiences to the people at home while the ones "left behind" wanted to hear her stories. For Sarah, there was a strong desire to be able to "send signs of life" from the very beginning, without impeding her ability to engage fully and to be in touch with nature. Technology was able to support this connectedness, but was also often the source of much frustration, mostly due to poor infrastructure or flat batteries. Sarah found while low-bandwidth telecommunication services operated locally, bandwidth and connectivity was scarce and did not permit international dialing or text messaging. Sarah also found that high-bandwidth services supporting blog posts with pictures were only available in the cities. This desire to utilize social networks as part of the adventure is likely to only increase, Sarah notes, as the use of social media is not a choice of the adventurer alone: nowadays financial and emotional supporters expect social media updates in return.

We find that although people were commenting on Sarah's posts during the trek, she generated most of the posts. However, this changed dramatically when the unexpected happened. The damage from the earthquake cut Sarah off from all communication channels. When the news of the quake broke around the world, loved ones and followers desperately posted update requests on Sarah's social media channels. The communication balance thus changed.

Sarah noted how right after the earthquake people shared mobile phones since not all phones were able to connect to the few remaining cell towers. Low-tech "non-smart" phones where highly sought after as they usually had better reception and battery capacities, making knowing people with "outdated" technology highly valuable.

It is noteworthy to mention that Sarah waited 8 hours for the aftershocks to subside before venturing into a damaged part of town to look for an open network to contact loved ones, putting herself in "unnecessary" danger. This highlights the need for technology to support adventurers in reassuring and providing ongoing signs of life to others [2].

Using computers to mediate communication is not new [54], and research notes that exerting participants can experience a stronger sense of connectedness compared to those not exerting [26]. Similarly, we find that technology can support an adventurer's social connectedness, however, the extreme nature of the adventure can significantly affect communication negatively, while the desire to communicate can in return lead to the adventurer engage in additional risky activity (as Sarah's experience suggests).

Body relation: Adventure technology's placement in relation to the body

Where technology is worn in relation to the adventurer's body can be key to what role it plays to support the experience. Packing correctly is a key challenge for any adventurer, which involves selecting the right equipment at the start, to then re-packing every morning, i.e. what goes in the backpack, what is put in pockets, what is attached to clothing etc. The adventurer needs to balance needs and practicalities in terms of weight and ability to comfortably wear it for hours. To help articulate this, we identify the following key technology placements: accessory to the body, extension of the body and part of the body.

Accessory to the body: Examples of accessories to the body are most items placed in a backpack, including laptops and charging devices. These less-essential items are further from the body so they do not inhibit physical activity such as hiking but they are within reach. Once in use, i.e. out of the backpack, however, they are unprotected and can be easily damaged or left behind.

Extension of the body: Technologies that extend the body are those that form part of the adventurer's clothing or support the bodily action directly, like the chest-mounted GoPro action camera. For example, Sarah quickly began to consider the harness a part of her clothing.

Part of the body: An example of technology that can form part of the body is an oxygen mask required for high altitude climbing. The technology can become such an elemental part of the body that it functions as life support or personal protection equipment. This is particularly relevant in hostile environments (underwater, at altitude, or underground).

We find that all three technology placements supported Sarah's adventure from an instrumental perspective: accessories such as weather alert systems supported Sarah in determining trekking routes; extensions in the form of walking sticks provided her with support on uneven surfaces; and an oxygen mask would provide her with life support at higher altitudes. Moreover, accessories and extensions also supported the adventure from an experiential perspective: accessories such as the creative tool kit offered opportunities for drawing; and extensions to the body such as the action camera afforded novel perspectives (e.g. the head mounted 360-degree camera supplemented handheld and tripod footage).

We note that placement of technology in regards to the body can be very context dependent: Sarah was considered a security threat at the airport because she was still wearing her camera harness. If she would have carried the same camera in her hand, the reaction may have been different.

Furthermore, it is important to note that the placement of technology supports adventure differently whether the adventurer encounters an expected or unexpected situation. For example, during earthquake shocks, there was rarely time to grab any "accessories of the body" as running outside was of the highest priority. In contrast, technology that served as "extension of the body" by default was readily available, for example the action camera harness was already attached so Sarah only needed to turn it on. However, recordings made during the earthquake served more documentation purposes (such as for insurance claims) rather than a desire for self-expression.

Prior work has highlighted that technology supporting exertion activities, such as adventure, could be examined through its relationship to the body [27], complementing work on wearable technologies in relation to the body [11]. We note that during adventure, especially in safety critical moments, technology in relation to the body is not only accessory or extension, but can also be part of the body by becoming essential life support. Furthermore, bodily placements serve different instrumental and experiential needs, and those can shift during unexpected situations.

2 DIMENSIONS FOR ADVENTURE TECHNOLOGY

Having articulated a set of themes, we can now identify two key dimensions based on Sarah's experiences and related work (Fig. 2). The first dimension relates technology to instrumental and experiential aspects of adventure. The second dimension relates technology to support expected and unexpected parts of adventure, as most adventures involve both (although to varying extent as we highlight).

Dimension 1: Instrumental and experiential

The first dimension relates to how adventure technology can support instrumental needs, i.e. helping the adventurer to achieve tangible objectives, and how adventure technology can support experiential needs, i.e. helping to enhance the adventure experience.

Instrumental: Technology often supports instrumental needs in adventure, helping the adventurer to achieve tangible goals. Related work previously found that technology can provide instrumental support to exertion activities [53]. Typical examples are quantified-self products such as Sarah's Jawbone UP. Providing users with such technology can help them improve performance [46] and therefore aid adventurers in achieving their objectives.

Experiential: The other end of the dimension maps how technology can support the adventure experience, such as enabling a deeper engagement with the environment or a richer way of sharing the adventure story. An example is Sarah's camera: it did not aid her climb, but helped to enrich the process of observation, reflection and aesthetic engagement. Prior work has pointed to the potential of technology supporting experiential aspects of exertion activities. For example, Pijnappel et al. [37] investigated technology to support the experiential aspects of skateboarding. These and similar works [15, 52] highlight that designers should consider the experiential aspects of exertion activities, with previous work calling it a "lived-sense of performance" [53].

Dimension 2: Expected and unexpected

Our definition of adventure highlights that a key aspect that makes adventure exciting is the unexpected, and Sarah's experience is a case in point: during her adventure, many events were expected, but there were also unexpected events occurring, both positive and negative, with the most negative one being the earthquake. Nevertheless, all events combined made the experience an adventure, indeed an epic one. The second dimension is therefore concerned with the expected and unexpected aspects of adventure. Technology in adventure can, and most likely will, be used in both expected and unexpected situations. This in turn might lead to unexpected ways of technology supporting, and hindering, adventure. For example, Sarah's expedition started with expected uses of technologies, however, the expedition took an unexpected turn that resulted in unexpected uses of technology, i.e. when she used her laptop to shield her face from falling glass and ceiling plaster as she escaped the building.

Expected: Technology is often supporting the adventure in expected situations. These situations are often the "default" or anticipated usage scenario.

Unexpected: The other end of the dimension is concerned with how technology supports the unexpected situations of adventure. Sarah "hacked" her 2G mobile phone to receive BBC updates about the earthquake. When the NCell network went down, the antenna in Sarah's mobile remained in "roaming mode", so she changed the network settings to "never" (search for a network provider) and inserted the headphones to check for FM frequencies. Normally, the BBC Nepali radio news program is broadcasting via 250 FM partner stations but many of them were damaged, so the service was distributed on shortwave radio [41]. Sarah inserted a piece of wire into the audio port and created a shortwave magnetic loop around the device to receive BBC Life Line updates via shortwave radio frequencies. This was an unexpected use of the technology in order to manage within an unexpected situation.

We relate the use of technology in unexpected situations to HCI discussions on technology appropriation [12] as our experience suggests that these unexpected situations lend themselves to "using technology for purposes that had not been considered before" [47]. Prior work on this topic highlights that to support appropriation, the technology must "become a part of one's personal narrative" [23] and "become the users' own" [12]. This suggests that usage of technology in unexpected situations benefits from past experiences, these past experiences can be concerned with both the technology and unexpected situations. This matches Sarah's experience, where during the unexpected earthquake she drew extensively on her previous technology experiences but also past adventures.

4 ROLES OF TECHNOLOGY IN ADVENTURE

We now use the two dimensions to articulate 4 roles that technology can play during adventure (Fig. 2). These roles can serve to analyze existing technology but also act as guide to develop new systems. Our aim is to present a starting point that guides future investigations.

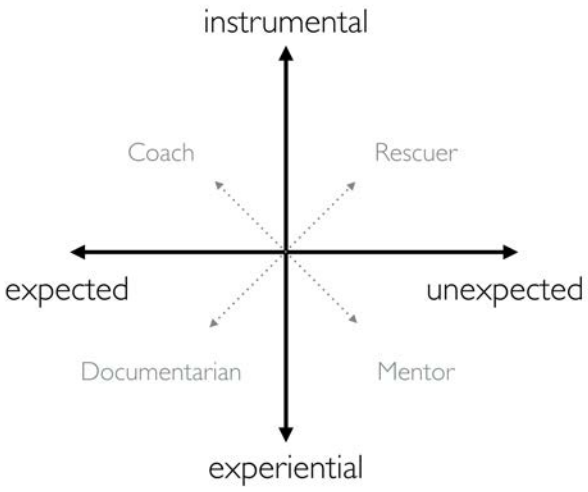

Figure 2. Four roles of adventure technology

Coach

Technologies can play the role of a coach during adventure, providing structured guidance in expected situations to improve instrumental aspects like enhancing performance. In Sarah's case, neurosonic apps served the role of a coach. She used them to enhance her mental fitness for the adventure. Many sports apps take on the role of a coach, with prior work suggesting that people can appreciate a virtual coach's instructional feedback [53].

We see an opportunity for technology to support the coach role by considering the theme *body relation*: we currently find several technologies in the marketplace that fall within our accessories and extensions category to offer coaching capabilities. However, technologies that are part of the body category rarely offer such coaching capabilities so far. We believe designers could readily integrate coaching functionality, for example, biosensors that train proper breathing techniques in an oxygen mask seems possible.

Rescuer

Adventure technologies can also take on the role of a rescuer, for example by providing emergency services during unexpected situations to keep the adventurer alive. Related work examined the use of technology to serve as rescuer or rescue support in the form of emergency response systems [21, 45]. Similarly, the earlier story by Greenberg is another example how technology can serve as rescuer. We find that many current design approaches begin by considering this role, yet while this is important, we highlight that it is not the only design aspect. We see a particular opportunity to support the rescuer role through the *social connectedness* theme: with the advancement of networking technologies, more and more ways to connect are possible, even in emergencies. The challenge, however, is to connect to robust networks that are disseminating verifiable, useful and timely information.

Documentarian

Technologies can act in the role of documentarian by providing the adventurer with support for the experiential aspects. In Sarah's case, her cameras were probably the best examples taking on the role of a documentarian, supporting her self-expression and storytelling afterwards. Another example is Sarah's laptop she used for blog entries and her traditional tools for sketching to document her adventure.

Adventurers, in particular adventure sports enthusiasts, have increasingly embraced action cameras that are now able to capture at a high frame rate to allow for reviewing at different speeds (like slow motion), enabling a novel perspective that is otherwise not easily achieved. Another way to add value is providing alternative viewpoints, as demonstrated by Sarah's 360-degree lens that allowed documentation from an immersive perspective.

We see how technology can support the documentarian role particularly through the *control* theme: with advanced sensors, cameras could detect and record when the adventurer's body is in and out of control, documenting – and contrasting – these states to provide further insights that could support analysis and storytelling. The video capture system LAFCam [20] might provide inspiration here: it captures bodily responses, such as laughter and galvanic skin response during camera operation in order to present them in parallel during the editing process; such a system could support adventurers in identifying footage of interest based on personal experiences. We believe combining sensor data with documentarian functionality is an opportunity to support the adventure experience anew.

Mentor

Technologies can also take on the role of a mentor, providing the adventurer with support for critical reflection on what the experience means and what the adventurer learned from it. As such, it can support the adventure's opportunity for personal growth [16]. Our work on technology as mentor to support personal growth fits within the emerging area in HCI that investigates embodied interactions as a means for self-reflection. In particular the investigations into somaesthetics [49] seem relevant here as they aim to support reflecting on the "felt" experience of engaging one's body. In this paper we highlight the potential of technology to support reflection on unexpected situations and personal growth.

We believe the theme *nature* is particularly useful here because technology and associated environmental sensing can easily provide additional information to support the relationship with the natural environment, lining up with research that highlights that interaction with nature is key to personal growth in adventure activities [16, 39].

DISCUSSION

Our two design dimensions are reflective of an emerging trend in HCI that highlights why and how exertion activities should be examined from both an instrumental and experiential perspective [53]. We extend this prior work by adding that what is expected and unexpected should also be considered in an adventure context. Knaving et al. have highlighted how long-distance runners in a race scenario have to consider the unexpected (i.e. weather changes, cramps, etc.) and that this unexpectedness forms a major appeal [19]. We see an opportunity to design for this unexpectedness, as it seems it can have major appeal for adventure in specific, and exertion activities in general. We believe our four adventure roles can guide designers when undertaking such investigations.

Through four adventure roles, our work highlights that adventure is multifaceted and as such designers should anticipate that adventurers might appropriate technology. This appropriation is not new to HCI [12], however, we note that when it comes to appropriating in an outdoor scenario, Weiser's vision of ubiquitous experiences "in the woods" [56] has not quite yet emerged for adventurers, as most current technologies have so far not fully considered the adventurer's requirements, i.e. portability, robustness and conduciveness to the performed action and the outdoor environment.

Furthermore, we note that studying adventure can raise ethical concerns, as the unexpected parts of adventures can lead to situations in which significant risk is part of the experience and things can go terribly wrong. It would be naïve to believe that technology can eradicate all such risk, in fact, a reduction of risk would reduce the appeal of adventure for many participants, and as such, designers of technology need to carefully consider how they support risk and adventure and how they can derive knowledge that guides them in creating such support. We conclude that designers of adventure technology have a particular responsibility when developing their craft, whether this concerns studying adventurers or self-experiment by engaging in adventure themselves.

For this paper we have focused on just one adventure. Given the circumstances of Sarah's experience, however, we were able to explore both expected and unexpected situations during extreme circumstances. We acknowledge that other adventures (for example, involving sailing) and other unforeseen events (such as severe weather) could reveal further insights. Furthermore, we acknowledge that Sarah went to Mt. Everest with the intention of climbing for creating artwork, which is not necessarily representative of other kinds of adventures. The emphasis on contemporary performance arts within changing environments, cultures and technologies is reflected in the interdisciplinary vision of the adventure and scope of the outcomes. Nonetheless, adventure activities often involve self-expression elements much like Sarah's interest. Her performance research interweaves analysis, anecdote, polemic and criticism, navigating the oblique with the conflicting, the pivotal with the resistant, and the eclectic with the indispensable, or more simply: the expected and unexpected, and the utilitarian and aesthetic.

Our focus on presenting two dimensions lends itself to insights directly applicable to design practice. However, we acknowledge that our results are preliminary and other practices such as user-centered design processes could supplement our findings. Furthermore, future work could elicit feedback from other adventurers, complementing Sarah's personal account. Studies where adventurers test prototypes might also reveal further insights.

CONCLUSION

We have presented an autoethnographic account of experiences with technology during an adventure that involved an expedition to Mt. Everest and the Nepal earthquakes. We identified key occasions where technology supported as well as hindered the adventure. With this, we derived a set of themes to articulate two dimensions for the ability of technology to support adventure. We then used these dimensions to identify four key roles technology can play in adventure. As this work is an early investigation into adventure and HCI, we see our dimensions as a starting point towards future investigations. We believe the dimensions could also be beneficial for the design of a range of systems for related fields, such as rescue equipment, outdoor sports tools and exertion games. We hope our work might also inform the design of future technologies that so far do not consider adventure as a usage scenario, for example other body-focused technologies could be designed with adventure in mind using our *body relation* theme. Our dimensions might also contribute to the design of wearable sports technologies such as sports watches and heart rate monitors, highlighting opportunities to designers who want to consider adventure when supporting physical activity.

Our work aims to inspire designers to consider adventure in HCI. By doing so, we enhance our understanding of how technology can support a wider range of human activities, including striving for challenge and personal growth. Overall, we note that technology does not necessarily need to make everything "safe" and predictable. Rather, we believe that technology should support – and not just reduce – adventure, and that design can facilitate this. We hope that our work is able to inspire and guide designers interested in adventure and HCI, and ultimately contributes to our knowledge of supporting people's active lifestyles.

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